★	Category	Sub-category	First author	Country	Year	Journal	Title	Study type	Sub-category 2 / animal model	Results: positive ☺ / unclear/modest ☺ / negative ☹ ↑ ↓ →	Link
☎	Adipose tissue	Inflammation	Yoshimura	Brazil (São Paulo)	2016	J Biophotonics	**Photobiomodulation reduces abdominal adipose tissue inflammatory infiltrate of diet-induced obese and hyperglycemic mice.**	Mouse	LED phototherapy	"Non-irradiated control animals display inflammatory areas almost five times greater than the treated group ($p < 0.001$). This result on inflammatory infiltrate may have caused impacts on the significant lower blood glucose level from irradiated animals ($p = 0.04$), twenty-four hours after the last irradiation session."	PubMed
★	Autoimmunity	Multiple sclerosis	Gonçalves	Brazil (Araranguá)	2016	Autoimmunity	**Low-level laser therapy ameliorates disease progression in a mouse model of multiple sclerosis.**	Mouse	Experimental autoimmune encephalomyelitis	"Our results showed that LLLT consistently reduced the clinical score of EAE and delayed the disease onset, and also prevented weight loss induced by immunization. Furthermore, these beneficial effects of LLLT seem to be associated with the down-regulation of NO levels in the CNS, although the treatment with LLLT failed to inhibit lipid peroxidation and restore antioxidant defense during EAE.	PubMed
	Autoimmunity	Multiple sclerosis	Muili	USA (Milwaukee, WI)	2013	PLoS One	**Photobiomodulation induced by 670 nm light ameliorates MOG35-55 induced EAE in female C57BL/6 mice: a role for remediation of nitrosative stress.**	Mouse	Experimental autoimmune encephalomyelitis	"Cell culture experiments demonstrated that 670 nm light-mediated photobiomodulation attenuated antigen-specific nitric oxide production by heterogenous lymphocyte populations isolated from MOG immunized mice. Experiments in the EAE model demonstrated down-regulation of inducible nitric oxide	PubMed
★	Autoimmunity	Multiple sclerosis	Muili	USA (Milwaukee, WI)	2012	PLoS One	**Amelioration of experimental autoimmune encephalomyelitis in C57BL/6 mice by photobiomodulation induced by 670 nm light.**	Mouse	Experimental autoimmune encephalomyelitis	"Disease was induced with myelin oligodendrocyte glycoprotein (MOG) according to standard laboratory protocol. Mice received 670 nm light or no light treatment (sham) administered as suppression and treatment protocols. 670 nm light reduced disease severity with both protocols compared to sham treated mice.	PubMed
	Bone	Bone grafts	de Oliveira Gonçalves	Brazil (Bauru)	2016	J Photochem Photobiol B	**Effects of low-level laser therapy on autogenous bone graft stabilized with a new heterologous fibrin sealant.**	Rat		"In conclusion, low-level laser therapy stimulated bone regeneration and accelerated the process of integration of autogenous bone grafts."	PubMed
	Bone	Bone metabolism	Sayuri Suzuki	Brazil (São Paulo)	2016	J Biophotonics	**Low-level laser therapy stimulates bone metabolism and inhibits root resorption during tooth movement in a rodent model.**	Rat	Alveolar bone	"Taken together, our results indicate that LLLT can stimulate bone remodeling reducing root resorption in a rat model. LLLT improves tooth movement via bone formation and bone resorption in a rat model."	PubMed
★	Bone	Bone metabolism	Patrocínio-Silva	Brazil (São Carlos)	2016	Arch Endocrinol Metab	**Low-level laser therapy associated to a resistance training protocol on bone tissue in diabetic rats.**	Rat	Diabetic rats Exercise+LLLT on bone tissue	"In conclusion, it can be suggested that the resistance exercise program stimulated bone metabolism, culminating in increased cortical tibial area, bone mineral content, bone mineral density and biomechanical properties. Furthermore, the association of physical exercises and LLLT produced higher values for bone mineral content and stiffness."	PubMed
	Bone	Bone repair	Atasoy	Turkey (Trabzon)	2017	Braz Oral Res	**The efficacy of low-level 940 nm laser therapy with different energy intensities on bone healing.**	Rat		"No significant change was observed in the number of osteocytes, osteoblasts, osteoclasts and newly formed vessels at either time period across all laser groups. Although LLLT with the 10 J/cm2 energy density increased fibroblast activity at the 4th week in comparison with the 5 and 20 J/cm2 groups, no significant change was observed between the laser groups and the control group. "	PubMed
	Bone	Bone repair	Mohsenifar	Iran (Tehran)	2016	Lasers Med Sci	**Evaluation of the effects of pulsed wave LLLT on tibial diaphysis in two rat models of experimental osteoporosis, as examined by stereological and real-time PCR gene expression analyses.**	Rat	Ovariectomized rats Pulsed LLLT	"Concurrent treatments of PW LLLT and alendronate produced the same effect on osteoporotic bone. Since the PW LLLT has osteogenic effects, different parameters should be investigated to verify whether an appropriate PW LLLT protocol in combination with a proper(s) anti osteoporotic agent(s) might reverse the detrimental effects of OP."	PubMed
	Bone	Bone repair	de Almeida	Brazil (Araçatuba)	2016	Arch Oral Biol	**Influence of low-level laser therapy on the healing process of autogenous bone block grafts in the jaws of systemically nicotine-modified rats: A histomorphometric study.**	Rat	Autogenous bone block graft	"Nicotine harms bone formation in the bed-graft interface and LLLT action can mitigate this."	PubMed
	Bone	Bone repair	Medalha	Brazil (São Paulo)	2016	J Photochem Photobiol B	**Low level laser therapy accelerates bone healing in spinal cord injured rats.**	Rat	Spinal cord injury (SCI) --> Tibial bone defect	"The results of the histological and morphometric evaluation demonstrated that the SL group showed a larger amount of newly formed bone compared to the SC group. Moreover, a significant immunoexpression of runt-related transcription factor 2 (RUNX2) was observed in the SL group. There was no statistical difference in the biomechanical evaluation.	PubMed
	Bone	Bone repair	Rajaei Jafarabadi	Iran (Tehran)	2016	Lasers Med Sci	**The effects of photobiomodulation and low-amplitude high-frequency vibration on bone healing process: a comparative study.**	Rat	A transverse critical size defect (CSD) to femur	"The biostimulation effects of PBM or LLLT and of low-amplitude high-frequency WBV both had a positive impact on bone healing process, for critical size defects in the presence of a stainless steel implant. But their combination, i.e., low-level laser therapy and low-amplitude high-frequency whole body vibration (LV), interestingly did not accelerate the fractured bone healing process."	PubMed
	Bone	Bone repair	Medalha	Brazil (São Paulo)	2016	J Photochem Photobiol B	**Low level laser therapy accelerates bone healing in spinal cord injured rats.**	Rat	Spinal cord injury (SCI) --> Tibial bone defect	"The results of the histological and morphometric evaluation demonstrated that the SL group showed a larger amount of newly formed bone compared to the SC group. Moreover, a significant immunoexpression of runt-related transcription factor 2 (RUNX2) was observed in the SL group. There was no statistical difference in the biomechanical evaluation. In conclusion, the results suggest that LLLT accelerated the process of bone repair in rats with complete SCI."	PubMed

	Bone	Bone repair	Freddo	Brazil (Porto Alegre)	2016	J Oral Maxillofac Surg	**Influence of a Magnetic Field and Laser Therapy on the Quality of Mandibular Bone During Distraction Osteogenesis in Rabbits.**	Rabbit		"The LLLT group exhibited a larger amount of newly formed bone and a larger number of osteoblasts in the cell division phase, but the difference was not statistically relevant compared with the control group."	PubMed
	Bone	Bone repair	Bosco	Brazil (Araçatuba)	2016	J Photochem Photobiol B	**Effects of low-level laser therapy on bone healing of critical-size defects treated with bovine bone graft.**	Rat	Bone graft	"LLLT can improve bone formation process in CSD filled or not with BBG in rat calvaria, but it is not able to accelerate particles resorption of this material in the interior of bone defect."	PubMed
	Bone	Bone repair	Acar	Turkey	2016	Arch Oral Biol	**Bone regeneration by low-level laser therapy and low-intensity pulsed ultrasound therapy in the rabbit calvarium.**	Rabbit		LLLT enhanced new bone formation in comparison to the untreated controls.	PubMed
	Bone	Bone repair	Havlucu	Turkey (Istanbul)	2015	J Oral Implantol	**Effects of Light-Emitting Diode Photobiomodulation Therapy and BioOss as Single and Combined Treatment in an Experimental Model of Bone Defect Healing in Rats.**	Rat		"Within the limitations of this study, LPT has positive effects on bone healing histopathologically and histomorphometrically for the defects filled with BioOss 3 weeks after the rats' femora injury."	PubMed
	Bone	Bone repair	Soares	Brazil (Salvador, Bahia)	2015	Braz Dent J	**Repair of surgical bone defects grafted with hydroxylapatite + β-TCP and irradiated with λ=850 nm LED light.**	Rat	Surgical bone defect LED phototherapy Bone graft (HA + β-	"It may be concluded that the use of LED phototherapy was effective in positively modulating the process of bone repair of bone defects in the femur of rats submitted or not to biomaterial grafting."	PubMed
	Bone	Bone repair	Sella	Brazil (São Paulo)	2015	Lasers Med Sci	**Effect of low-level laser therapy on bone repair: a randomized controlled experimental study.**	Rat		"Microscopic analysis revealed a significant decrease in inflammatory infiltration, intense trabecular bone matrix and periosteal formation, and an increase in newly formed bone after laser irradiation."	PubMed
	Bone	Bone repair	Marques	Brazil (Bauru)	2015	Lasers Med Sci	**New LLLT protocol to speed up the bone healing process-histometric and immunohistochemical analysis in rat calvarial bone defect.**			"The results suggest LLLT using the protocol 2 hastened the bone healing process in the early periods after surgery." Comment: At 45 days, there was no difference between the groups, but at 15 days, the	PubMed
★	Bone	Bone repair	Magri	Brazil (São Paulo)	2015	Lasers Med Sci	**Photobiomodulation and bone healing in diabetic rats: evaluation of bone response using a tibial defect experimental model.**	Rat	Diabetic rats Tibial bone healing	"In the histological and morphometric evaluation, all laser-treated groups showed a better histological pattern and a higher amount of newly formed bone compared to DCG. An intense RUNX2 immunoexpression was observed in the laser-treated groups, 15 days after the surgery.	PubMed
	Bone	Bone repair	Batista	Brazil (Uberlândia)	2015	Lasers Med Sci	**Low-level laser therapy on bone repair: is there any effect outside the irradiated field?**	Rat	Systemic effects?	"Laser therapy presented a positive local biostimulative effect in the early stage of bone healing, but the LLLT effect was not observed a long distance from the evaluated area."	PubMed
	Bone	Bone repair	Altan	Turkey (Kocaeli)	2015	Lasers Med Sci	**The effect of dosage on the efficiency of LLLT in new bone formation at the expanded suture in rats.**	Rat	Suture expansion	"Low-level laser therapy with both 5 and 6,300 J/cm(2) doses was found to be significantly effective, while the 20 J/cm(2) dose did not show a significant effect in increasing new bone formation. This finding reveals that the efficiency of the therapy is affected by the dosage."	PubMed
	Bone	Bone repair	Akyol	Turkey (Rize)	2015	Lasers Med Sci	**The influence of low-level laser therapy with alendronate irrigation on healing of bone defects in rats.**	Rat	Alendronate potentiation	"Our findings demonstrated that Aln has a more positive effect with LLLT on bone healing in rats. It was concluded that combining LLLT with Aln irrigation has a beneficial effect in bone	PubMed
	Bone	Bone repair	Batista	Brazil (Uberlândia)	2014	Lasers Med Sci	**Effect of low-level laser therapy on repair of the bone compromised by radiotherapy.**	Rat	Radiotherapy	"The result demonstrated a positive local biostimulative effect of LLLT in normal bone. However, LLLT was not able to revert the bone metabolic damage due to ionizing radiation." Note: The parameters in the abstract seemed to contradict the parameters given in the full text.	PubMed
	Bone	Bone repair	Barbosa	Brazil (São Paulo)	2014	Acta Ortop Bras	**Laser therapy in bone repair in rats: analysis of bone optical density.**	Rat		"Based on the radiographic findings, G (830nm) showed more complete bone regeneration, as shown in the gray shades of the images."	PubMed
	Bone	Bone repair	Fazilat	Iran (Tehran)	2014	Photomed Laser Surg	**Cellular effect of low-level laser therapy on the rate and quality of bone formation in mandibular distraction osteogenesis.**	Rabbit		"This study shows that a low-level GaAlAs (λ:810 nm; P, 200 mW) laser hastens new bone formation only in the early stages of the consolidation period in distraction osteogenesis, and has no significant effect in later stages." Comment: This paper had beautiful scanning electron microscope (SEM) pictures.	PubMed
★	Bone	Bone repair	El-Maghraby	Egypt (Cairo)	2013	Arch Oral Biol	**Assessment of the effect of low-energy diode laser irradiation on gamma irradiated rats' mandibles.**	Rat	Gamma radiation	"Thin irregular bone trabeculae and widened marrow spaces were identified in the control group. The lased sides of groups 1 and 2 demonstrated regular, thick and continuous bone trabeculae." "Normal-sized osteocytic lacunae were seen in the lased groups, as compared to the wide lacunar spaces noted in the control group. Histomorphometric analysis showed a	PubMed
	Bone	Bone repair	Mota	Brazil (Uberlândia)	2013	Res Vet Svi	**Low-power laser therapy for repairing acute and chronic-phase bone lesions.**	Rat		"Laser-treated animals showed significant increases in serum alkaline phosphatase levels and had an effect on biomechanical property, resulting in a gradual increase in bone stiffness. Laser therapy aided the bone consolidation process and favored the physiopathologic mechanisms involved in bone tissue repair, and its effects were more prominent when treatment started during the acute phase of the injury."	PubMed

Bone	Bone repair	Ekizer	Turkey (Kayseri)	2013	Lasers Med Sci	**Light-emitting diode photobiomodulation: effect on bone formation in orthopedically expanded suture in rats--early bone changes.**	Rat	LED phototherapy	"New bone formation area (p = 0.024, 1.48-fold), number of osteoblasts (p < 0.001, 1.59-fold), number of osteoclasts (p = 0.004, 1.43-fold), and number of vessels (p = 0.007, 1.67-fold) showed higher values in the experimental group than the control. Bone histomorphometric measurements revealed that bone architecture in the LPT group was improved."	PubMed
Bone	Bone repair	Omasa	Japan (Tokyo)	2012	Photomed Laser Surg	**Low-level laser therapy enhances the stability of orthodontic mini-implants via bone formation related to BMP-2 expression in a rat model.**	Rat	Orthodontic mini-implant in tibia bone	"Periotest values were significantly lower (0.79- to 0.65-fold) and the volume of newly formed bone was significantly higher (1.53-fold) in the LLLT group. LLLT also stimulated significant BMP-2 gene expression in peri-implant bone (1.92-fold)." "LLLT enhanced the stability of mini-implants placed in rat tibiae and accelerated peri-implant bone formation by increasing the gene expression of BMP-2 in surrounding	PubMed
Bone	Bone repair	Bossini	Brazil	2012	Exp Gerontol	**Low level laser therapy (830nm) improves bone repair in osteoporotic rats: similar outcomes at two different dosages.**	Rat		LLLT treatment led to higher amount of newly formed bone and granulation tissue compared to control.	PubMed
Bone	Bone repair	Kocyigit	Turkey (Kirikkale)	2012	Photomed Laser Surg	**A comparison of the low-level laser versus low intensity pulsed ultrasound on new bone formed through distraction osteogenesis.**	Rabbit		"LIPUS and LLLT applied during the distraction period accelerated the DO treatment."	PubMed
Bone	Bone repair	Pires-Oliveira	Brazil (São Paulo)	2010	Osteoporos Int	**Laser 904 nm action on bone repair in rats with osteoporosis.**	Rat		"Low-level 904-nm laser (50 mJ/cm(2)) accelerated the repair process of osteopenic fractures, especially in the initial phase of bone regeneration."	PubMed
Bone	Bone repair	Nascimento	Brazil (São Paulo)	2010	Photomed Laser Surg	**Effect of low-level laser therapy and calcitonin on bone repair in castrated rats: a densitometric study.**	Rat		"The La and CaLa had significantly higher bone mineral density than the control and Ca groups."	PubMed
Bone	Bone repair	Oliveira	Brazil (São Carlos)	2010	J Mater Sci Mater Med	**Low level laser therapy does not modulate the outcomes of a highly bioactive glass-ceramic (Biosilicate) on bone consolidation in rats.**	Rat		"Our findings suggest that although Biosilicate exerts some osteogenic activity during bone repair, laser therapy is not able to modulate this process."	PubMed
Bone	Bone repair	Medalha	Brazil (São Paulo)	2010	Photomed Laser Surg	**Comparison of the effects of electrical field stimulation and low-level laser therapy on bone loss in spinal cord-injured rats.**	Rat		"We conclude that the mentioned treatments were able to initiate a positive bone-tissue response, maybe through stimulation of osteoblasts, which was able to determine the observed morphometric modifications. However, the evoked tissue response could not determine either biomechanical or densitometric modifications."	PubMed
Bone	Bone repair	Bashardoust Tajali	Canada (London)	2010	J Orthop Surg Res	**Effects of low power laser irradiation on bone healing in animals: a meta-analysis.**	Meta-analysis			PubMed
Bone	Bone repair	Pinheiro	Brazil (Salvador, Bahia)	2009	Lasers Med Sci	**Bone repair following bone grafting hydroxyapatite guided bone regeneration and infra-red laser photobiomodulation: a histological study in a rodent model.**	Rat		"When the groups irradiated with implant and membrane were compared, it was observed that the repair of the defects submitted to LPBM was also processed faster, starting from the 15th day. At the 30th day, the level of repair of the defects was similar in the irradiated groups and those not irradiated. New bone formation was seen inside the cavity, probably by the osteoconduction of the implant, and, in the irradiated groups, this new bone formation was incremental."	PubMed
Bone	Bone repair	Pinheiro	Brazil (Salvador, Bahia)	2008	Photomed Laser Surg	**Infrared laser light further improves bone healing when associated with bone morphogenetic proteins and guided bone regeneration: an in vivo study in a rodent model.**	Rat	BMPs + LLLT	"The results showed histological evidence of increased deposition of collagen fibers (at 15 and 21 d), as well as an increased amount of well-organized bone trabeculi at the end of the experimental period (30 d) in irradiated animals compared to non-irradiated controls." Note: This paper seems quite similar as Gerbi's paper, even though they were	PubMed
Bone	Bone repair	Torres	Brazil (Salvador, Bahia)	2008	Photomed Laser Surg	**Does the use of laser photobiomodulation, bone morphogenetic proteins, and guided bone regeneration improve the outcome of autologous bone grafts? An in vivo study in a rodent model.**	Rat		"The results showed that in all treatment groups, new bone formation was greater and qualitatively better than the untreated subjects. Control specimens showed a less advanced repair after 40 d, and this was characterized by the presence of medullary tissue, a small amount of bone trabeculi, and some cortical repair." "We conclude that LPBM has a positive biomodulatory effect on the healing of bone	PubMed
Bone	Bone repair	Márquez Martínez	Brazil (Camaragibe)	2008	Lasers Med Sci	**Effect of IR laser photobiomodulation on the repair of bone defects grafted with organic bovine bone.**	Rat	Bone grafts + LLLT	"There was histological evidence of improved collagen fiber deposition at early stages of the healing; increased amount of well-organized bone trabeculae at the end of the experimental period on irradiated animals. It is concluded that LPBM has positive biomodulative effect on the healing process bone defects."	PubMed
Bone	Bone repair	Gerbi	Brazil (Recife)	2008	Photomed Laser Surg	**Infrared laser light further improves bone healing when associated with bone morphogenic proteins: an in vivo study in a rodent model.**	Rat	BMPs + LLLT	"The results showed histological evidence of increased deposition of collagen fibers (at 15 and 21 d), as well as an increased amount of well-organized bone trabeculae at the end of the experimental period (30 d) in the irradiated animals versus the non-irradiated controls."	PubMed

Bone	Bone repair	Lopes	Brazil (São José dos Campos)	2007	Photomed Laser Surg	**Infrared laser photobiomodulation (lambda 830 nm) on bone tissue around dental implants: a Raman spectroscopy and scanning electronic microscopy study in rabbits.**	Rabbit	Dental titanium implant on the tibia	"It is concluded that infrared laser photobiomodulation does improve bone healing, and this may be safely assessed by Raman spectroscopy or SEM."	PubMed
Bone	Bone repair	Pinheiro & Gerbi	Brazil (Salvador, Bahia)	2006	Photomed Laser Surg	**Photoengineering of bone repair processes.**	Review			PubMed
Bone	Bone repair	Blaya	Brazil (Santa Maria)	2006	J Contemp Dent Pract	**Histologic study of the effect of laser therapy on bone repair.**			"Greater degrees of new bone formation and vertical regeneration were found in the irradiated groups than in the control group."	PubMed
Bone	Bone repair	Gerbi	Brazil (Salvador, Bahia)	2005	Photomed Laser Surg	**Assessment of bone repair associated with the use of organic bovine bone and membrane irradiated at 830 nm.**	Rat		"The results of the present investigation showed histological evidence of improved amount of collagen fibers at early stages of the bone healing (15 days) and increased amount of well organized bone trabeculae at the end of the experimental period (30 days) on irradiated animals compared to non irradiated ones."	PubMed
Bone	Bone repair	Rochkind	Israel (Tel Aviv)	2004	Photomed Laser Surg	**Molecular structure of the bony tissue after experimental trauma to the mandibular region followed by laser therapy.**	Rat		"The results suggest that low-power laser irradiation alone and in combination with Bio-Oss enhances bone healing and increases bone repair."	PubMed
Bone	Bone repair	Pinheiro	Brazil (Salvador, Bahia)	2003	Braz Dent J	**Effect of low level laser therapy on the repair of bone defects grafted with inorganic bovine bone.**	Rat	Bone graft	"We conclude that LLLT had a positive effect on the repair of bone defects implanted with inorganic bovine bone." Note: The authors might have accidentally misreported radiant energy (J) as energy density (J/cm2)	PubMed
Bone	Bone repair	Pinheiro	Brazil (Salvador, Bahia)	2003	J Clin Laser Med Surg	**Effect of 830-nm laser light on the repair of bone defects grafted with inorganic bovine bone and decalcified cortical osseus membrane. (Oct 2003)**	Rat		"The results showed more advanced repair of the irradiated groups when compared to the non-irradiated ones. The repair of the irradiated group was characterized by both increased bone formation and on the amount of collagen fibers around the graft within the cavity, as early as the 15th day after surgery, considering the osteoconductive capacity of the Gen-ox and the	PubMed
Bone	Bone repair	Barbos Pinheiro	Brazil (Salvador, Bahia)	2003	J Clin Laser Med Surg	**Effect of 830-nm laser light on the repair of bone defects grafted with inorganic bovine bone and decalcified cortical osseous membrane. (Dec 2003)**	Rat	Bone graft	"The results showed evidence of a more advanced repair on the irradiated groups when compared to non-irradiated ones. The repair of irradiated groups was characterized by both increased bone formation and amount of collagen fibers around the graft within the cavity since the 15th day after surgery, through analysis of the osteoconductive capacity of the Gen-ox and the	PubMed
Bone	Bone repair	Barushka	Israel	1995	Bone	**Effect of low-energy laser (He-Ne) irradiation on the process of bone repair in the rat tibia.**	Rat		Histomorphometrical analysis revealed a more rapid accumulation of reparative new bone in the hole injury of the laser-irradiated rats.	PubMed
Bone	Cell proliferation	Amid	Iran (Tehran)	2014	J Lasers Med Sci	**Effect of low level laser therapy on proliferation and differentiation of the cells contributing in bone regeneration.**	Review			PubMed
Bone	Cell proliferation	Huertas	Spain	2014	Biol Res Nurs	**Effect and clinical implications of the low-energy diode laser on bone cell proliferation.**	In vitro MG-63 cells		LLLT increased cell proliferation.	PubMed
Bone	Cell proliferation	Mesquita-Ferrari	Brazil (São Paulo)	2011	Indian J Exp Biol	**No effect of low-level lasers on in vitro myoblast culture.**	In vitro C2C12 myoblasts		"There were no significant differences in cell proliferation between laser-treated myoblasts and control cultures for any of the parameters and incubation periods." "Further studies are necessary to determine the correct laser parameters for optimizing the biostirhulation of myoblasts."	PubMed
Bone	Cell proliferation	Renno	Brazil	2010	Photomed Laser Surg	**Effect of 830 nm laser phototherapy on osteoblasts grown in vitro on Biosilicate scaffolds.**			"Despite successful seeding of bioscaffolds with osteoblasts, laser phototherapy resulted in a reduction in cell growth compared to non-irradiated controls."	PubMed
Bone	Cell proliferation	Renno	Brazil	2007	Photomed Laser Surg	**The effects of laser irradiation on osteoblast and osteosarcoma cell proliferation and differentiation in vitro.**			"Based on the conditions of this study, we conclude that each cell line responds differently to specific wavelength and dose combinations."	PubMed

	Bone	Cell proliferation	Martinasso	Italy	2007	Minerva Stomatol	**Effect of superpulsed laser irradiation on bone formation in a human osteoblast-like cell line.**			LLLT stimulated cell proliferation in human osteoblast-like cells and increased the expression of proteins essential for bone formation.	PubMed
	Bone	Cell proliferation	Stein	Israel	2005	Photomed Laser Surg	**Low-level laser irradiation promotes proliferation and differentiation of human osteoblasts in vitro.**	In vitro		LLLT promoted proliferation and maturation of human osteoblasts.	PubMed
	Bone	Cell proliferation	Ueda & Shimizu	Japan	2001	J Oral Sci	**Pulse irradiation of low-power laser stimulates bone nodule formation.**	In vitro		LLLT in both groups increased cell proliferation, bone nodule formation, ALP activity and ALP gene expression. Pulsed irradion had a stronger effect.	PubMed
	Bone	Cell proliferation	Ozawa	Japan	1998	Bone	**Low-energy laser irradiation stimulates bone nodule formation at early stages of cell culture in rat calvarial cells.**	In vitro		LLLT increased cell profliferation, ALP activity and osteocalcin gene expression. LLLT at earlier stages of culture also led to a greater number and larger area of bone nodules.	PubMed
★	Bone	Fractures	Chang	Taiwan (Taichung)	2014	Photomed Laser Surg	**Therapeutic outcomes of low-level laser therapy for closed bone fracture in the human wrist and hand.**	Human RCT/SB		"After treatment and at the follow-up, the laser group exhibited significant changes in all of the parameters compared with the baseline ($p<0.05$). The results of comparing the two groups after treatment and at the follow-up indicated significant between-group differences among all of the parameters ($p<0.05$)." Comment: The results are quite remarkable.	PubMed
	Bone	Gene expression	Tim	Brazil (Sao Carlos)	2016	J Photochem Photobiol B	**Effects of low level laser therapy on inflammatory and angiogenic gene expression during the process of bone healing: A microarray analysis.**	Rat		"Our findings indicate that LLLT was efficient on accelerating the development of newly formed bone probably by modulating the inflammatory and angiogenic gene expression as well as COX2 and VEGF immunoexpression during the initial phase of bone healing."	PubMed
	Bone	Gene expression	Fernandes	Brazil	2013	J Biomed Opt	**Effects of low-level laser therapy on the expression of osteogenic genes related in the initial stages of bone defects in rats.**	Rat		"We concluded that LLLT modulated the inflammatory process and accelerated bone repair, and this advanced repair pattern in the laser-treated groups may be related to the higher mRNA expression of genes presented by these animals."	PubMed
	Bone	Gene expression	Fávaro-Pípi	Brazil	2011	Photomed Laser Surg	**Low-level laser therapy induces differential expression of osteogenic genes during bone repair in rats.**	Rat	Surgical bone defect	Laser therapy improved bone repair in rats as depicted by differential histopathological and osteogenic genes expression, mainly at the late stages of recovery.	PubMed
	Bone	Implants	Obradović	Serbia (Niš)	2009	Lasers Med Sci	**Influence of low-level laser therapy on biomaterial osseointegration: a mini-review.**	Review			PubMed
	Bone	Implants	Freddo	Brazil (Porto Alegre)	2009	Lasers Med Sci	**Effect of low-level laser therapy after implantation of poly-L-lactic/polyglycolic acid in the femurs of rats.**	Rat	Implantation of poly-L-lactic/polyglycolic acid	"Results showed that the laser irradiation had had a positive photobiomodulation effect on inflammation, confirmed by a better histologic pattern than that of the control group at 3 days and 7 days. Semiquantitative analysis revealed that groups A and B had a histologic score significantly greater than that of the control group at 3 days. At 21 days, histomorphometric analysis revealed a more intense inflammation in the red laser group than in the other groups.	PubMed
	Bone	Implants	Khadra M	Norway (Oslo)	2005	Swed Dent J Suppl	**The effect of low level laser irradiation on implant-tissue interaction. In vivo and in vitro studies.**	Rat + in vitro		"The following conclusions are drawn from the results of these five studies: LLLT can promote bone healing and bone mineralization and thus may be clinically beneficial in promoting bone formation in skeletal defects. It may be also used as additional treatment for accelerating implant healing in bone.	PubMed
	Bone	In vitro	Ülker	Turkey (Ankara)	2016	Lasers Med Sci	**Polychromatic light-induced osteogenic activity in 2D and 3D cultures.**	In vitro		"Cell culture studies under static conditions indicated that polychromatic light significantly stimulated bone nodule formation via the prolonged cell survival and stimulated differentiation of MC3T3-E1 preosteoblastic cells in both TCPS and chitosan scaffold groups."	PubMed
	Bone	Osteoblasts	Son	Korea (Ulsan)	2017	Lasers Med Sci	**A novel combination treatment to stimulate bone healing and regeneration under hypoxic conditions: photobiomodulation and melatonin.**	In vitro	Photobiomodulation + melatonin	"Therefore, we concluded that laser irradiation could promote the effect of melatonin on the differentiation and mineralization of MC3T3-E1 cells under hypoxic conditions, and that this process is mediated through melatonin 1/2 receptors and PKRD/p38 signaling pathways."	PubMed
	Bone	Osteoblasts	Shin	Korea (Yangsan)	2016	Maxillofac Plast Reconstr Surg	**Effect of low-level laser therapy on bisphosphonate-treated osteoblasts.**	In vitro		"The LLLT does not affect the OPG expression in the hFOB cell line, but it may increase the RANKL and M-CSF expressions, thereby resulting in positive effects on osteoclastogenesis and bone remodeling."	PubMed

	Bone	Osteoblasts	Tschon	Italy (Bologna)	2015	J Biomed Opt	**Photobiomodulation with low-level diode laser promotes osteoblast migration in an in vitro micro wound model.**	In vitro		"This study demonstrated that laser photobiomodulation at 915 nm promoted wound healing mainly through stimulation of cell migration and collagen deposition by osteoblasts."	PubMed
	Bone	Osteoblasts	Saracino	Italy	2009	Lasers Surg Med	**Superpulsed laser irradiation increases osteoblast activity via modulation of bone morphogenetic factors.**	In vitro		LLLT (904-910nm) had various effects on osteoblast-like cells.	PubMed
	Bone	Osteoclastogenesis	Lee	Korea (Gwangju)	2016	Photomed Laser Surg	**Regulation of RANKL-Induced Osteoclastogenesis by 635-nm Light Emitting Diode Irradiation Via HSP27 in Bone Marrow-Derived Macrophages.**	In vitro		"The 635-nm irradiation treatment significantly increased HSP27 expression and decreased intracellular ROS generation, as well as p38 and AKT phosphorylation, leading to reductions in the expression of c-fos, NFATc1, and DC-STAMP and TRAP activation and osteoclastic bone resorption in RANKL-induced BMMs. However, in HSP27-silenced BMMs, no change was observed."	PubMed
	Bone	Review	Pinheiro	Brazil (Salvador, Bahia)	2015	BOOK: Lasers in Dentistry: Guide for Clinical Practice	**Bone biomodulation**	Review			Wiley
★	Brain	Alzheimer's Disease	Lu	USA (Georgia)	2017	Neurobiol Aging	**Low-level Laser Therapy for Beta-Amyloid Toxicity in Rat Hippocampus**	Rat	Beta-amyloid injection to hippocampus	"LLI treatment suppressed Aβ-induced hippocampal neurodegeneration and long-term spatial and recognition memory impairments. Molecular studies revealed that LLI treatment: a) restored mitochondrial dynamics, by altering fission and fusion protein levels thereby suppressing Aβ-induced extensive fragmentation;	PubMed
	Brain	Alzheimer's Disease	Oron	Israel	2016	Photomed Laser Surg	**Low-Level Laser Therapy to the Bone Marrow Ameliorates Neurodegenerative Disease Progression in a Mouse Model of Alzheimer's Disease: A Minireview.**	Mouse	Systemic effects	"MSCs from wild-type mice stimulated with LLLT showed to increase their ability to maturate towards a monocyte lineage and to increase phagocytosis activity towards soluble amyloid beta (Aβ). Furthermore, weekly LLLT to BM of AD mice for 2 months, starting at 4 months of age (progressive stage of AD), improved cognitive capacity and spatial learning, as	PubMed
	Brain	Alzheimer's Disease	Purushothuman	Australia (Sydney)	2015	Neurosci Lett	**Near infrared light mitigates cerebellar pathology in transgenic mouse models of dementia.**	Mouse	Cerebellar injury	"One month of NIr treatment mitigated the deposition of β-amyloid in cerebellar cortex of APP/PS1 mice, and the formation of neurofibrillary tangles, the hyperphosphorylation of tau, the damage caused by oxidative stress and the downregulation of cytochrome oxidase expression by Purkinje cells in the cerebellar cortex of K3 mice.	PubMed
☹	Brain	Alzheimer's Disease	Farfara	Israel	2015	J Mol Neurosci	**Low-level laser therapy ameliorates disease progression in a mouse model of Alzheimer's disease.**	Mouse	5XFAD transgenic mice Systemic effects	"MSCs from wild-type mice stimulated with LLLT demonstrated an increased ability to maturate toward a monocyte lineage and to increase phagocytosis of soluble Aβ in vitro. Furthermore, weekly LLLT for 2 months to the BM, starting at 4 months of age (progressive stage of the disease in these 5XFAD transgenic male mice), improved memory and spatial learning, compared to a sham-treated AD mouse model. Histology revealed a significant reduction in Aβ brain burden in the laser-treated mice compared	PubMed
★	Brain	Alzheimer's Disease	Purushothuman	Australia (Sydney)	2014	Alzheimers Res Ther	**Photobiomodulation with near infrared light mitigates Alzheimer's disease-related pathology in cerebral cortex - evidence from two transgenic mouse models.**	Mouse	Transgenic mice: - K3 - APP/PS1	"In the K3 mice, NIr treatment was associated with a reduction in hyperphosphorylated tau, neurofibrillary tangles and oxidative stress markers (4-hydroxynonenal and 8-hydroxy-2'-deoxyguanosine) to near wildtype levels in the neocortex and hippocampus, and with a restoration of expression of the mitochondrial marker cytochrome c oxidase in surviving neurons."	PubMed
	Brain	Alzheimer's Disease	Duggett & Chazot	UK (Durham)	2014	Biology and Medicine	**Low-Intensity Light Therapy (1068 nm) Protects CAD Neuroblastoma Cells from β-Amyloid-Mediated Cell Death**	In vitro		"IR1068 exposure was found to consistently significantly reduce cell death caused by Aβ, by up to 24%, over the range of Aβ concentrations (1-25 μM). The range of Aβ concentrations used would not necessarily be found in vivo." "The use of IR1068 as a treatment for Alzheimer's disease is under investigation, with recruitment of patients initiated in December 2010 (double-blind, placebo-controlled	OMICS
	Brain	Alzheimer's Disease	Grillo	UK (Durham)	2013	J Photochem Photobiol B	**Non-invasive infra-red therapy (1072 nm) reduces β-amyloid protein levels in the brain of an Alzheimer's disease mouse model, TASTPM.**	Mouse		"Chronic IR1072 treatment of female TASTPM mice elicited significant increases in HSP60, 70 and 105 and phosphorylated-HSP27 (P-HSP27) (50-139%), together with a concomitant profound decrease in αB-crystallin, APP, tau-P, Aβ1-40 and Aβ1-42 (43-81%) protein levels at 7 months of age. Furthermore, IR1072 treatment elicited a modest, but significant, reduction in Aβ1-42 plaques in the cerebral cortex."	PubMed
	Brain	Alzheimer's Disease	Zhang	China (Guangzhou)	2012	Cell Signal	**Inhibition of Aβ(25-35)-induced cell apoptosis by low-power-laser-irradiation (LPLI) through promoting Akt-dependent YAP cytoplasmic translocation.**	In vitro PC12 cells		"LPLI inhibits Aβ25–35-induced apoptosis through Akt/YAP/p73 pathway."	PubMed
	Brain	Alzheimer's Disease	Sommer AP	Germany	2012	Photomed Laser Surg	**670 nm laser light and EGCG complementarily reduce amyloid-β aggregates in human neuroblastoma cells: basis for treatment of Alzheimer's disease?**	In vitro		"In irradiated cells, Aβ(42) aggregate amounts were significantly lower than in nonirradiated cells."	PubMed
	Brain	Alzheimer's Disease	De Taboada	USA (CA)	2011	J Alzheimers Dis	**Transcranial laser therapy attenuates amyloid-β peptide neuropathology in amyloid-β protein precursor transgenic mice.**	Mouse	Transgenic mice (amyloid-β protein precursor)	"All TLT doses produced an increase in sAβPPα and a decrease in CTFβ levels consistent with inhibition of the β-secretase activity. In addition, TLT showed an increase in ATP levels, mitochondrial function, and c-fos suggesting an overall improvement in neurological function. These studies suggest that TLT is a potential candidate for treatment of AD."	PubMed

	Brain	Alzheimer's Disease	Yang	USA (Columbia, MO)	2010	Neuroscience	**Low energy laser light (632.8 nm) suppresses amyloid-β peptide-induced oxidative and inflammatory responses in astrocytes.**	In vitro Rat astrocytes		"Our data showed that laser light at 632.8 nm suppressed Aβ-induced superoxide production, colocalization between NADPH oxidase gp91(phox) and p47(phox) subunits, phosphorylation of cPLA(2,) and the expressions of IL-1β and iNOS in primary astrocytes. We demonstrated for the first time that 632.8 nm laser was capable of suppressing	PubMed
	Brain	Brain injury	Naeser	USA (Boston, MA)	2016	Photomed Laser Surg	**Transcranial, Red/Near-Infrared Light-Emitting Diode Therapy to Improve Cognition in Chronic Traumatic Brain Injury.**	Review	Vielight for intranasal treatment		PubMed
	Brain	Brain injury	Thunshelle & Hamblin	USA (Cambridge, MA)	2016	Photomed Laser Surg	**Transcranial Low-Level Laser (Light) Therapy for Brain Injury.**	Review			PubMed
	Brain	Brain injury	Henderson TA	USA (Centennial, CO)	2016	Neural Regen Res	**Multi-watt near-infrared light therapy as a neuroregenerative treatment for traumatic brain injury.**	Perspective			PubMed
	Brain	Brain injury	Xuan	USA (Boston, MA)	2016	J Biophotonics	**Repeated transcranial low-level laser therapy for traumatic brain injury in mice: biphasic dose response and long-term treatment outcome.**	Mouse		"We conclude that an excessive number of laser-treatments delivered to mice can temporarily inhibit the process of brain repair stimulated by tPBM, but then the inhibitory effect ceases, and brain repair can resume. The mechanism may be temporary induction of reactive gliosis."	PubMed
	Brain	Brain injury	Xuan	USA (Boston, MA)	2015	J Biophotonics	**Low-level laser therapy for traumatic brain injury in mice increases brain derived neurotrophic factor (BDNF) and synaptogenesis.**	Mouse		"The data suggest that the benefit of LLLT to the brain is partly mediated by stimulation of BDNF production, which may in turn encourage synaptogenesis. Moreover the pleiotropic benefits of BDNF in the brain suggest LLLT may have wider applications to neurodegenerative and psychiatric disorders."	PubMed
	Brain	Brain injury	Naeser & Hamblin	USA (Boston, MA)	2015	Photomed Laser Surg	**Traumatic Brain Injury: A Major Medical Problem That Could Be Treated Using Transcranial, Red/Near-Infrared LED Photobiomodulation.**	Review or Editorial?			PubMed
	Brain	Brain injury	Morries	USA (Lakewood, CO)	2015	Neuropsychiatr Dis Treat	**Treatments for traumatic brain injury with emphasis on transcranial near-infrared laser phototherapy.**	Review Case series		"In ten patients with chronic TBI (average time since injury 9.3 years) given ten treatments over the course of 2 months using a high-power NIR laser [...], symptoms of headache, sleep disturbance, cognition, mood dysregulation, anxiety, and irritability improved."	PubMed
	Brain	Brain injury	Henderson&Morries	?	2015	Adv Mind Body Med	**SPECT Perfusion Imaging Demonstrates Improvement of Traumatic Brain Injury With Transcranial Near-infrared Laser Phototherapy.**	Human Case report		Clinical application of these levels of infrared energy for this patient with TBI yielded highly favorable outcomes with decreased depression, anxiety, headache, and insomnia, whereas cognition and quality of life improved. Neurological function appeared to improve based on changes in the SPECT by quantitative analysis.	PubMed
★	Brain	Brain injury	Dong	USA (Boston, MA)	2015	J Cereb Blood Flow Metab	**Low-level light in combination with metabolic modulators for effective therapy of injured brain.**	Mouse		"We found high levels of glycolysis, reduced adenosine triphosphate generation, and increased formation of reactive oxygen species and apoptosis in neurons under hypoxia. Strikingly, these adverse events were reversed significantly by noninvasive exposure of injured brain to low-level light (LLL). Low-level light illumination sustained the mitochondrial membrane potential, constrained cytochrome c leakage in hypoxic cells, and protected them from apoptosis, underscoring a unique property of LLL. The	PubMed
	Brain	Brain injury	Zhang	USA (Boston, MA)	2014	J Cereb Blood Flow Metab	**Low-level laser therapy effectively prevents secondary brain injury induced by immediate early responsive gene X-1 deficiency.**	Mouse		"The low-level laser therapy (LLLT) suppressed proinflammatory cytokine expression like interleukin (IL)-1β and IL-6 but upregulated TNF-α. Moreover, although lack of IEX-1 compromised ATP synthesis, LLLT elevated its production in injured brain. The protective effect of LLLT may be ascribed to enhanced ATP production and selective modulation of proinflammatory mediators. This new closed head injury model provides an excellent tool to investigate the pathogenesis of secondary brain injury as well as the	PubMed
	Brain	Brain injury	Xuan	USA (Boston, MA)	2014	J Biomed Opt	**Transcranial low-level laser therapy enhances learning, memory, and neuroprogenitor cells after traumatic brain injury in mice.**	Mouse		"Our study results suggest that tLLLT may improve TBI both by reducing cell death in the lesion and by stimulating neurogenesis."	PubMed
	Brain	Brain injury	Naeser	USA (Boston, MA)	2014	J Neurotrauma	**Significant improvements in cognitive performance post-transcranial, red/near-infrared light-emitting diode treatments in chronic, mild traumatic brain injury: open-protocol study.**	Human Open-protocol study	Chronic TBI patients	"Each LED cluster head had a 5.35 cm diameter (9 red diodes, 633 nm, and 52 NIR diodes, 870 nm were embedded into each LED cluster head); 22.48 cm2 in size; 500 mW total power; 22.2 mW/cm2 power density; continuous wave." "A significant linear trend was observed for the effect of LED treatment over time for the Stroop test for Executive Function, Trial 3 inhibition (p=0.004); Stroop, Trial 4	PubMed
	Brain	Brain injury	Giacci	Australia (Adelaide & Crawley)	2014	PLoS One	**Differential effects of 670 and 830 nm red near infrared irradiation therapy: a comparative study of optic nerve injury, retinal degeneration, traumatic brain and spinal cord injury.**	Rat		"Treatment of fluid-percussion TBI with 670 nm or 830 nm R/NIR-IT did not result in improvements in motor or sensory function or lesion size at 7 days (P>0.05)."	PubMed

	Brain	Brain injury	Xuan	USA (Boston, MA)	2013	PLoS One	**Transcranial low-level laser therapy improves neurological performance in traumatic brain injury in mice: effect of treatment repetition regimen.**	Mouse			PubMed
	Brain	Brain injury	Nawashiro	Japan	2012	Photomed Laser Surg	**Focal increase in cerebral blood flow after treatment with near-infrared light to the forehead in a patient in a persistent vegetative**	Case report	LED phototherapy (23 diodes)	"Transcranial LED might increase rCBF with some improvement of neurological condition in severely head-injured patients."	PubMed
	Brain	Brain injury	Wu	USA (Boston, MA)	2012	Lasers Surg Med	**Low-level laser therapy for closed-head traumatic brain injury in mice: effect of different wavelengths.**	Mouse		"Mice with moderate-to-severe TBI treated with 665 and 810 nm laser (but not with 730 or 980 nm) had a significant improvement in Neurological Severity Score"	PubMed
	Brain	Brain injury	Quirk	USA (Milwaukee, WI)	2012	Photomed Laser Surg	**Near-infrared photobiomodulation in an animal model of traumatic brain injury: improvements at the behavioral and biochemical levels.**	Rat		"These results show statistically significant, preclinical outcomes that support the use of NIR treatment after TBI in effecting changes at the behavioral, cellular, and chemical levels."	PubMed
	Brain	Brain injury	Oron	Israel	2012	J Neurotrauma	**Near infrared transcranial laser therapy applied at various modes to mice following traumatic brain injury significantly reduces long-term neurological deficits.**	Mouse		LLLT (808nm) protected mice against traumatic brain injury (TBI).	PubMed
	Brain	Brain injury	Khuman	USA (Charlestown, MA)	2012	J Neurotrauma	**Low-level laser light therapy improves cognitive deficits and inhibits microglial activation after controlled cortical impact in mice.**	Mouse	Microgliosis	"Injured mice treated with 60 J/cm² (500 mW/cm²×2 min) either transcranially or via an open craniotomy had modestly improved latency to the hidden platform ($p<0.05$ for group), and probe trial performance ($p<0.01$) compared to non-treated controls. The beneficial effects of LLLT in open craniotomy mice were associated with reduced	PubMed
	Brain	Brain injury	Naeser	USA (Boston, MA)	2011	Photomed Laser Surg	**Improved cognitive function after transcranial, light-emitting diode treatments in chronic, traumatic brain injury: two case reports.**	Case report		"Transcranial LED may improve cognition, reduce costs in TBI treatment, and be applied at home."	PubMed
	Brain	Brain injury	Huang	USA (Boston, MA)	2012	J Biophotonics	**Transcranial low level laser (light) therapy for traumatic brain injury.**	Review			PubMed
	Brain	Brain injury	Ando	USA (Boston, MA)	2011	PLoS One	**Comparison of therapeutic effects between pulsed and continuous wave 810-nm wavelength laser irradiation for traumatic brain injury in mice.**	Mouse		"The brain lesion volume of mice treated with 10-Hz pulsed-laser irradiation was significantly lower than control group at 15-days and 4-weeks post-TBI. Moreover, we found an antidepressant effect of LLLT at 4-weeks as shown by forced swim and tail suspension tests."	PubMed
★	Brain	Brain injury	Moreira	Brazil	2009	J Photochem Photobiol B	**Effect of phototherapy with low intensity laser on local and systemic immunomodulation following focal brain damage in rat.**	Rat	Cryogenic brain injury	"Thus, although some alterations of the local and systemic levels of the studied cytokines in the cryolesioned rats were observed, at this point it is difficult to conclude if these changes would be beneficial or deleterious to the CNS healing. Hence, more studies are needed in order to further explore the possibility of using laser phototherapy	PubMed
	Brain	Brain injury	Oron	Israel	2007	J Neurotrauma	**Low-level laser therapy applied transcranially to mice following traumatic brain injury significantly reduces long-term neurological deficits.**	Mouse		"The lesion volume of the laser treated mice was significantly lower (1.4%) than the non-treated group (12.1%). Our data suggest that a non-invasive transcranial application of LLLT given 4 h following TBI provides a significant long-term functional neurological benefit."	PubMed
	Brain	Circulation	Tian	USA (Arlington, TX)	2016	Lasers Surg Med	**Transcranial laser stimulation improves human cerebral oxygenation.**	Human		In both experiments, transcranial laser stimulation induced an increase of oxygenated hemoglobin concentration (Δ[HbO2]) and a decrease of deoxygenated hemoglobin concentration (Δ[Hb]) in both cerebral hemispheres.	PubMed
	Brain	CNS	Fitzgerald	Australia (Crawley)	2013	Rev Neurosci	**Red/near-infrared irradiation therapy for treatment of central nervous system injuries and disorders.**	Review			PubMed
	Brain	Cognitive performance	Grover	USA (Denver, CO)	2016 epub	Photomed Laser Surg	**Acute Effects of Near Infrared Light Therapy on Brain State in Healthy Subjects as Quantified by qEEG Measures.**	Human	LED phototherapy LED array (784)	"Change in reaction time significantly differed between treated and control, with a mean of 23.8 msec improvement compared with controls ($p = 0.035$). Amplitude increased an average of 0.81 μV in treatment versus 0.22 μV in controls and did not reach significance."	PubMed
	Brain	Cognitive performance	Hwang	USA (Austin, TX)	2016	Lasers Med Sci	**Cognitive enhancement by transcranial laser stimulation and acute aerobic exercise.**	Human RCT		"The transcranial infrared laser stimulation and acute aerobic exercise treatments were similarly effective for cognitive enhancement, suggesting that they augment prefrontal cognitive functions similarly."	PubMed
	Brain	Cognitive performance	Barrett & Gonzalez-Lima	USA (Austin, TX)	2013	Neuroscience	**Transcranial infrared laser stimulation produces beneficial cognitive and emotional effects in humans.**	Human RCT		"Reaction time in a sustained-attention psychomotor vigilance task (PVT) was significantly improved in the treated (n=20) vs. placebo control (n=20) groups, especially in high novelty-seeking subjects.	PubMed
★	Brain	Cognitive performance	Rojas	USA (Austin, TX)	2012	J Alzheimers Dis	**Low-level light therapy improves cortical metabolic capacity and memory retention.**	Rat		"Experiment 1 verified that LLLT increased the rate of oxygen consumption in the prefrontal cortex in vivo. Experiment 2 showed that LLLT-treated rats had an enhanced extinction memory as compared to controls. Experiment 3 showed that LLLT reduced fear renewal and prevented the reemergence of extinguished conditioned fear	PubMed
	Brain	Cognitive performance	Michalikova	UK (Sunderland)	2008	Neurobiol Learn Mem	**Emotional responses and memory performance of middle-aged CD1 mice in a 3D maze: effects of low infrared light.**	Mouse		"Exposure to IR appeared to have no significant effects upon exploratory activity or anxiety responses. However, it elicited significant effects on working memory, with the IR middle-aged mice being more considerate in their decision making, which results in an overall improved cognitive performance which is comparable to that of young CD-1	PubMed
	Brain	Depression	Cassano	USA (Boston, MA)	2016	Neurophotonics	**Review of transcranial photobiomodulation for major depressive disorder: targeting brain metabolism, inflammation, oxidative stress, and neurogenesis.**	Review			PubMed
	Brain	Depression	Disner	USA (Austin, TX)	2016	Brain Stimul	**Transcranial Laser Stimulation as Neuroenhancement for Attention Bias Modification in Adults with Elevated Depression Symptoms.**	Human RCT/SB (?)		"A significant three-way interaction between LLLT condition, ABM response, and time indicated that right LLLT led to greater symptom improvement among participants whose attention was responsive to ABM (i.e., attention was directed away from negative stimuli). Minimal change in depression was observed in the left and sham LLLT." "The results suggest that larger clinical trials examining the efficacy of using photoneuromodulation to augment cognitive training are warranted."	PubMed
	Brain	Depression	Mohammed HS	Egypt	2016	Lasers Med Sci	**Transcranial low-level infrared laser irradiation ameliorates depression induced by reserpine in rats.**	Rat	Biphasic dose response	Low power (80 mW) ameliorated depressive symptoms. High power (400 mW) exacerbated depressive symptoms.	PubMed

	Brain	Depression	Xu	China (Jiangsu)	2016	Mol Neurobiol	**Low-Level Laser Irradiation Improves Depression-Like Behaviors in Mice.**	Mouse		"Our results revealed that LLLT effectively improved depression-like behaviors, in the two depression mice models, by decreasing immobility duration in behavioral despair tests. In addition, ATP biosynthesis and the level of mitochondrial complex IV expression and activity were significantly elevated in prefrontal cortex (PFC) following LLLT. Intriguingly, LLLT has no effects on ATP content and mitochondrial complex I-IV levels in other tested brain regions, hippocampus and hypothalamus. As a whole, these findings shed light on a novel strategy of transcranial LLLT on depression improvement by ameliorating neurotransmitter abnormalities and promoting mitochondrial function in PFC."	PubMed
	Brain	Depression	Salehpour	Iran (Tabriz)	2016	Lasers Surg Med	**Therapeutic effects of 10-HzPulsed wave lasers in rat depression model: A comparison between near-infrared and red wavelengths.**	Rat		"This study showed that non-invasive tLLLT using 10-Hz pulsed NIR laser light was as effective as Citalopram and more effective than red laser in the treatment of depressive-like behaviors and may help improve tLLLT as an alternative non-pharmacological treatments of psychological disorders such as depression."	PubMed
	Brain	Depression	Wu	USA (Bethesda, MD)	2012	Lasers Surg Med	**Pulsed light irradiation improves behavioral outcome in a rat model of chronic mild stress.**	Rat	Chronic mild stress model	"TLT was comparable to fluoxetine in improving the behavioral outcome after CMS. TLT did not cause weight loss, which is consistently seen in patients treated with fluoxetine. This study demonstrates that TLT has potential as an effective treatment for depression."	PubMed
	Brain	Depression	Tanaka	Japan (Oita)	2011	Brain Stimul	**Infrared radiation has potential antidepressant and anxiolytic effects in animal model of depression and anxiety.**	Rat		"Acutely exposed rats were treated with an infrared radiation machine for one session, whereas chronically exposed animals were treated with an infrared radiation for 10 sessions."	PubMed
	Brain	Depression	Schiffer	USA (Harvard; Belmont, MA)	2009	Behav Brain Funct	**Psychological benefits 2 and 4 weeks after a single treatment with near infrared light to the forehead: a pilot study of 10 patients with major depression and anxiety.**	Human Pilot study	Major depression and anxiety	"At 2-weeks post treatment 6 of 10 patients had a remission (a score </= 10) on the HAM-D and 7 of 10 achieved this on the HAM-A."	PubMed
	Brain	Depression	Tsai	Taiwan (Hualien)	2007	Prog Neuropsychopharmacol Biol Psychiatry	**Infrared irradiation has potential antidepressant effect.**	Mouse	Far-infrared (non-LLLT)	"This is the first study using an experimental animal design to evaluate the potential antidepressant effect of the infrared irradiation. The result suggests that daily 60 min infrared irradiation for 4 weeks has potential	PubMed
	Brain	Depression	Meesters	Netherlands	1999	Biol Psychiatry	**Prophylactic treatment of seasonal affective disorder (SAD) by using light visors: bright white or infrared light?**	Human		"Almost every light fixture produces light with an infrared component. So, our data indicate that, if light is crucial to the response, it must be that component which is crucial. However, infrared light is beyond the visible range of the spectrum. The 720 nm filter in our light visor still transmitted some visible light. However, its visibility was	PubMed
	Brain	Energy metabolism	Mochizuki-Oda	Japan (Hirakata)	2002	Neurosci Lett	**Effects of near-infra-red laser irradiation on adenosine triphosphate and adenosine diphosphate contents of rat brain tissue.**	Rat		"These results suggest that the increase in tissue ATP content did not result from the thermal effect, but from a specific effect of the laser operated at the 830-nm wavelength."	PubMed
	Brain	Microglia	von Leden	USA (Bethesda, MD)	2013	Lasers Surg Med	**808 nm wavelength light induces a dose-dependent alteration in microglial polarization and resultant microglial induced neurite growth.**	In vitro	Biphasic dose response	"Specifically, PBM with energy densities between 4 and 30 J/cm(2) induced expression of M1 markers in microglia. Markers of the M2 phenotype, including CD206 and TIMP1, were observed at lower energy densities of 0.2-10 J/cm(2)"	PubMed
★	Brain	Parkinson's disease	Johnstone	Australia & France	2016	Front Neurosci	**Turning On Lights to Stop Neurodegeneration: The Potential of Near Infrared Light Therapy in Alzheimer's and Parkinson's Disease.**	Review			PubMed
★	Brain	Parkinson's disease	Reinhart	France & Australia	2016	Neurosci Res	**The behavioural and neuroprotective outcomes when 670 nm and 810 nm near infrared light are applied together in MPTP-treated mice**	Mouse	MPTP	Note: In this paper, they had 6 different active treatment groups, and all of them fared better than the MPTP group!	NOT IN PUBMED
★📷	Brain	Parkinson's disease	Reinhart	France & Australia	2016	Exp Brain Res	**Near-infrared light (670 nm) reduces MPTP-induced parkinsonism within a broad therapeutic time window.**	Mouse	MPTP	"In summary, irrespective of whether it was applied before, at the same time as or after MPTP insult, NIr reduced both behavioural and structural measures of damage by a similar magnitude."	PubMed
	Brain	Parkinson's disease	Reinhart	France & Australia	2016	J Neurosurg	**Intracranial application of near-infrared light in a hemi-parkinsonian rat model: the impact on behavior and cell survival.**	Mouse	6-OHDA	"In summary, when delivered at the appropriate power, delivery mode, and dosage, NIr treatment provided both improved behavior and neuroprotection in 6-OHDA-lesioned rats."	PubMed
	Brain	Parkinson's disease	Moro	France & Australia	2016	Brain Res	**Effects of a higher dose of near-infrared light on clinical signs and neuroprotection in a monkey model of Parkinson's disease.**	Monkey	MPTP	Higher dose of 125J was not as beneficial to MPTP-treated monkeys as compared to the lower doses of 25J and 35J.	PubMed
	Brain	Parkinson's disease	El Massri	Australia & France	2016	Int J Neurosci	**The effect of different doses of near infrared light on dopaminergic cell survival and gliosis in MPTP-treated mice.**	Mouse	MPTP	"In summary, we showed that neuroprotection by NIr irradiation in MPTP-treated mice was dose-dependent; with increasing MPTP toxicity, higher doses of NIr were required to protect cells and reduce astrogliosis."	PubMed
	Brain	Parkinson's disease	El Massri	Australia & France	2016	Exp Brain Res	**Near-infrared light treatment reduces astrogliosis in MPTP-treated monkeys.**	Monkey	MPTP	"Our results showed that NIr treatment reduced dramatically (~75 %) MPTP-induced astrogliosis in both the SNc and striatum. Among microglia, however, NIr had a more limited impact in both nuclei; although there was a reduction in overall cell size, there	PubMed
★	Brain	Parkinson's disease	Darlot	France & Australia	2016	Ann Neurol	**Near-infrared light is neuroprotective in a monkey model of Parkinson disease.**	Monkey	MPTP	"Our findings indicate NIr to be an effective therapeutic agent in a primate model of the disease and create the template for translation into clinical trials."	PubMed
	Brain	Parkinson's disease	Reinhart	France & Australia	2015	Neurosci Res	**810nm near-infrared light offers neuroprotection and improves locomotor activity in MPTP-treated mice.**	Mouse	MPTP LED phototherapy	"Our results showed that MPTP-treated mice that were irradiated with 810nm NIr had both greater locomotor activity (~40%) and number of dopaminergic cells (~20%) than those that were not. In summary, 810nm (as with 670nm) NIr offered neuroprotection and improved locomotor activity in MPTP-treated mice."	PubMed
	Brain	Parkinson's disease	Oueslati	Switzerland	2015	PLoS One	**Photobiomodulation Suppresses Alpha-Synuclein-Induced Toxicity in an AAV-Based Rat Genetic Model of Parkinson's Disease.**	Rat	Genetic model	"In this model, daily exposure of both sides of the rat's head to 808-nm near-infrared light for 28 consecutive days alleviated α-syn-induced motor impairment, as assessed using the cylinder test. This treatment also significantly reduced dopaminergic neuronal loss in the injected substantia nigra and preserved dopaminergic fibers in the ipsilateral striatum."	PubMed
🧰	Brain	Parkinson's disease	Moro	France & Australia	2014	J Neurosurg	**Photobiomodulation inside the brain: a novel method of applying near-infrared light intracranially and its impact on dopaminergic cell survival in MPTP-treated mice.**	Mouse	MPTP LED phototherapy vs	"Measurements showed that the NIr intensity declined as distance from the source increased across the brain (65% per mm) but was detectable up to 10 mm away. At neuroprotective (0.16 mW) and much higher (67 mW) intensities, the NIr caused no observable behavioral deficits, nor was there evidence of tissue necrosis at the fiber tip, where radiation was most intense. Finally, the intracranially delivered NIr protected SNc	PubMed
	Brain	Parkinson's disease	Johnstone	Australia (Sydney)	2014	Neuroscience	**Indirect application of near infrared light induces neuroprotection in a mouse model of parkinsonism – An abscopal neuroprotective effect**	Mouse	MPTP Systemic effects	"In summary, the findings suggest that treatment of a remote tissue with NIr is sufficient to induce protection of the brain, reminiscent of the 'abscopal effect' sometimes observed in radiation treatment of metastatic cancer. This discovery has implications for the clinical translation of light-based therapies, providing an improved mode of delivery over transcranial irradiation."	PubMed

	Brain	Parkinson's disease	Jang & Han	Korea (Gyeongbuk)	2014	Photomed Laser Surg	**Can phototherapy ameliorate the progression of Parkinson's disease?**	Guest Editorial			PubMed
	Brain	Parkinson's disease	Moro	France (Grenoble)	2013	BMC Neurosci	**Photobiomodulation preserves behaviour and midbrain dopaminergic cells from MPTP toxicity: evidence from two mouse strains.**	Mouse		"In summary, our results revealed the neuroprotective benefits of NIr treatment after parkinsonian insult at both cellular and behavioural levels and suggest that Balb/c strain, due to greater penetration of NIr through skin and fur, provides a clearer model of protection than the C57BL/6 strain."	PubMed
	Brain	Parkinson's disease	Vos	Belgium	2013	PLoS One	**Near-infrared 808 nm light boosts complex IV-dependent respiration and rescues a Parkinson-related pink1 model.**	Fruit fly	Pink1 730nm -> no effect	"We tested the hypothesis that 808 nm infrared light that effectively penetrates tissues rescues pink1 mutants. We show that irradiating isolated fly or mouse mitochondria with 808 nm light that is absorbed by ETC-Complex IV acutely improves Complex IV-dependent oxygen consumption and ATP production, a feature that is wavelength-specific. Irradiating Drosophila pink1 mutants using a single dose of 808 nm light results	PubMed
	Brain	Parkinson's disease	Purushothuman	Australia (Sydney)	2013	Brain Res	**The impact of near-infrared light on dopaminergic cell survival in a transgenic mouse model of parkinsonism.**	Mouse	Transgenic	"Our results showed immunoreactivity for 4-HNE, 8-OHDG and AT8 within the SNc was increased in K3 mice compared to WT, and that this increase was mitigated by NIr. Results further showed that TH$^+$ cell number was lower in K3 mice than in WT, and that this loss was mitigated by NIr. In summary, NIr treatment reduced the oxidative stress caused by the tau transgene in the SNc of K3 mice and saved SNc cells from	PubMed
	Brain	Parkinson's disease	Shaw	Australia (Sydney)	2012	Parkinsons Dis	**Patterns of Cell Activity in the Subthalamic Region Associated with the Neuroprotective Action of Near-Infrared Light Treatment in MPTP-Treated Mice.**	Mouse	MPTP	"In summary, our results indicated that NIr had long lasting effects on the activity of cells located deep in the brain and had repaired partially the abnormal activity generated by the parkinsonian toxin."	PubMed
	Brain	Parkinson's disease	Quirk	USA (Milwaukee, WI)	2012	Front Biosci (Elite Ed)	**Therapeutic effect of near infrared (NIR) light on Parkinson's disease models.**	Review			PubMed
	Brain	Parkinson's disease	Peoples	Australia (Sydney)	2012	ISRN Neurol	**Survival of Dopaminergic Amacrine Cells after Near-Infrared Light Treatment in MPTP-Treated Mice.**	Mouse	MPTP LED phototherapy	"In summary, we showed that NIr treatment was able to both protect (simultaneous series) and rescue (posttreatment series) TH(+) cells of the retina from parkinsonian insult."	PubMed
	Brain	Parkinson's disease	Peoples	Australia (Sydney)	2012	Parkinsonism Relat Disord	**Photobiomodulation enhances nigral dopaminergic cell survival in a chronic MPTP mouse model of Parkinson's disease.**	Mouse	Retinal damage (eyes) MPTP LED phototherapy	"In summary, exposure to NIr either at the same time or well after chronic MPTP insult saved many SNc dopaminergic cells from degeneration."	PubMed
★	Brain	Parkinson's disease	Shaw	Australia (Sydney)	2010	J Comp Neurol	**Neuroprotection of midbrain dopaminergic cells in MPTP-treated mice after near-infrared light treatment.**	Mouse	LED phototherapy	"In summary, our results indicate that NIr light treatment offers neuroprotection against MPTP toxicity for dopaminergic cells in the SNc, but not in the ZI-Hyp."	PubMed
	Brain	Parkinson's disease	Trimmer	USA (Virginia)	2009	Mol Neurodegener	**Reduced axonal transport in Parkinson's disease cybrid neurites is restored by light therapy.**	In vitro (human cells)		"The results from this study support our proposal that axonal transport is reduced in sporadic PD and that a single, brief treatment with near-infrared light can restore axonal transport to control levels."	PubMed
	Brain	Parkinson's disease	Ying	USA (Milwaukee, WI)	2008	Brain Res	**Pretreatment with near-infrared light via light-emitting diode provides added benefit against rotenone- and MPP+-induced neurotoxicity.**	In vitro (striatal and cortical	Neurotoxins LED phototherapy	"Results indicate that pretreatment with NIR-LED significantly suppressed rotenone- or MPP(+)-induced apoptosis in both striatal and cortical neurons (P<0.001), and that pretreatment plus LED treatment during neurotoxin exposure was significantly better	PubMed
	Brain	Parkinson's disease	Liang	USA (Milwaukee, WI)	2008	Neuroscience	**Near-infrared light via light-emitting diode treatment is therapeutic against rotenone- and 1-methyl-4-phenylpyridinium ion-induced neurotoxicitv.**	In vitro	MPTP LED phototherapy	"Results indicated that LED treatments twice a day significantly increased cellular ATP content, decreased the number of neurons undergoing cell death, and significantly reduced the expressions of reactive oxygen species and reactive nitrogen species in	PubMed
	Brain	Review	Hamblin MR	USA (Boston, MA)	2016	BBA Clin	**Shining light on the head: Photobiomodulation for brain disorders.**	Review			PubMed
	Brain	Stroke	Lee	Korea (Yangsan)	2016	Restor Neurol Neurosci	**Pre-conditioning with transcranial low-level light therapy reduces neuroinflammation and protects blood-brain barrier after focal cerebral ischemia in mice.**	Mouse		"LLLT significantly reduced infarct size and edema and improved neurological and motor function 24 h after ischemic injury. In addition, LLLT markedly inhibited Iba-1- and GFAP-positive cells, which was	PubMed
	Brain	Stroke	Lapchak & Boitano	USA (Los Angeles, CA)	2016	Acta Neurochir Suppl	**Transcranial Near-Infrared Laser Therapy for Stroke: How to Recover from Futility in the NEST-3 Clinical Trial.**	Review		"There is especially extensive attenuation of light energy penetration across the human calvaria, compared with animal skulls, which suggests that the power density setting used in stroke clinical trials may not have optimally stimulated neuroprotection and repair pathways.	PubMed
	Brain	Stroke	Zivin	USA (San Diego, CA)	2014	Int J Stroke	**NeuroThera® Efficacy and Safety Trial-3 (NEST-3): a double-blind, randomized, sham-controlled, parallel group, multicenter, pivotal study to assess the safety and efficacy of transcranial laser therapy**	Study protocol			PubMed
	Brain	Stroke	Hacke	Multiple countries	2014	Stroke	**Transcranial laser therapy in acute stroke treatment: results of neurothera effectiveness and safety trial 3, a phase III clinical end point device trial.**	Human RCT/DB Multicenter		"The study was terminated on recommendation by the Data Monitoring Committee after a futility analysis of 566 completed patients found no difference in the primary end point (transcranial laser therapy 140/282 [49.6%] versus sham 140/284 [49.3%] for good functional outcome; modified Rankin Scale, 0-2)."	PubMed
	Brain	Stroke	Huisa	USA (Albuquerque, NM)	2013	Lasers Med Sci	**Incremental treatments with laser therapy augments good behavioral outcome in the rabbit small clot embolic stroke model.**	Rabbit	Embolic stroke		PubMed
	Brain	Stroke	Boonswang	USA (Easton, PA)	2012	BMJ Case Rep	**A new treatment protocol using photobiomodulation and muscle/bone/joint recovery techniques having a dramatic effect on a stroke patient's recovery: a new weapon for clinicians.**	Case report	LED phototherapy	"The patient in this case report experienced a dramatic recovery/rehabilitation outcome after being treated with the treatment protocol."	PubMed
	Brain	Stroke	Lapchak & De Taboada	USA (La Jolla, CA)	2010	Brain Res	**Transcranial near infrared laser treatment (NILT) increases cortical adenosine-5'-triphosphate (ATP) content following embolic strokes in rabbits.**	Rabbit	Dose response Pulsed vs continous	"Embolization decreased cortical ATP content in ischemic cortex by 45% compared to naive rabbits, a decrease that was attenuated by CW NILT which resulted in a 41% increase in cortical ATP content compared to the sham embolized group (p>0.05). The absolute increase in ATP content was 22.5% compared to naive rabbits.	PubMed
	Brain	Stroke	Lapchak PA	USA (Los Angeles, CO)	2010	Ann Med	**Taking a light approach to treating acute ischemic stroke patients: transcranial near-infrared laser therapy translational science.**	Review			

Brain	Stroke	Zivin	USA (San Diego, CA)	2009	Stroke	**Effectiveness and safety of transcranial laser therapy for acute ischemic stroke.**	Human RCT/DB	Acute ischemic stroke	"TLT within 24 hours from stroke onset demonstrated safety but did not meet formal statistical significance for efficacy. However, all predefined analyses showed a favorable trend, consistent with the previous clinical trial (NEST-1)."	PubMed
Brain	Stroke	Lapchak	USA (San Diego, CA)	2008	Stroke	**Safety profile of transcranial near-infrared laser therapy administered in combination with thrombolytic therapy to embolized rabbits.**	Rabbit		"TLT did not significantly alter hemorrhage incidence after embolization, but there was a trend for a modest reduction of hemorrhage volume (by 65%) in the TLT-treated group compared with controls."	PubMed
Brain	Stroke	Lapchak	USA (San Diego, CA)	2007	Neuroscience	**Transcranial near-infrared light therapy improves motor function following embolic strokes in rabbits: an extended therapeutic window study using continuous and pulse frequency delivery modes.**	Rabbit	Embolic stroke Transcranial LLLT	"TLT may be administered safely either alone or in combination with tPA because	PubMed
Brain	Stroke	Lampl	Israel (Holon)	2007	Stroke	**Infrared laser therapy for ischemic stroke: a new treatment strategy: results of the NeuroThera Effectiveness and Safety Trial-1 (NEST-1).**	Human RCT/DB/MS		"The NEST-1 study indicates that infrared laser therapy has shown initial safety and effectiveness for the treatment of ischemic stroke in humans when initiated within 24 hours of stroke onset. A larger confirmatory trial to demonstrate safety and effectiveness is warranted."	PubMed
Brain	Stroke	Lampl	Israel (Holon)	2007	Expert Rev Neurother	**Laser treatment for stroke.**	Review			PubMed
Brain	Stroke	Oron (A)	Israel (Zerifin)	2006	Stroke	**Low-level laser therapy applied transcranially to rats after induction of stroke significantly reduces long-term neurological deficits.**	Rat	Atherothrombotic stroke	"Our data suggest that a noninvasive intervention of LLLT issued 24 hours after acute stroke may provide a significant functional benefit with an underlying mechanism possibly being induction of neurogenesis."	PubMed
Brain	Stroke	DeTaboada	USA (Carlsbad, CA)	2006	Lasers Surg Med	**Transcranial application of low-energy laser irradiation improves neurological deficits in rats following acute stroke.**	Rat	Transcranial LLLT Atherothrombotic stroke	Note: "Application of the laser at 4 hours poststroke did not affect the neurological "In all three laser-treated groups, a marked and significant improvement in neurological deficits was evident at 14, 21, and 28 days post stroke relative to the non-treated group."	PubMed
Brain	Stroke	Streeter		2004	Mitochondrion	**Mechanisms of action of light therapy for stroke and acute myocardial infarction.**	Review	Transcranial LLLT	"These observations suggest that LLLT applied at different locations in the skull and in	PubMed
Brain	Stroke	Lapchak	USA (San Diego, CA)	2004	Stroke	**Transcranial infrared laser therapy improves clinical rating scores after embolic strokes in rabbits.**	Rabbit	Embolic stroke	"This study shows that laser treatment improved behavioral performance if initiated within 6 hours of an embolic stroke and the effect of laser treatment is durable. Therefore, transcranial laser treatment may be useful to treat human stroke patients and should be further developed."	PubMed
Brain	Stroke	Samosiuk NI	Russia	2003	Vopr Kurortol Fizioter Lech Fiz Kult	**[Magnetic and laser therapy of acute ischemic stroke]. [Article in Russian]**				PubMed
Brain	Stroke	Leung	China (Hong Kong)	2002	Lasers Surg Med	**Treatment of experimentally induced transient cerebral ischemia with low energy laser inhibits nitric oxide synthase activity and up-regulates the expression of transforming growth factor-beta 1**	Rat		"Low energy laser could suppress the activity of NOS and up-regulate the expression of TGF-beta1 after stroke in rats."	PubMed
Brain		Konstantinović	Serbia (Belgrade)	2013	Lasers Surg Med	**Transcranial application of near-infrared low-level laser can modulate cortical excitability.**	Human		"The average MEP size was significantly reduced during the first 20 minutes following the TLS. The pattern was present in 10 (71.5%) of the participants. The MEP size reduction correlated negatively with the motor threshold at rest."	PubMed
Breast	Mastitis	Wang	China (Daqing)	2014	J Vet Med Sci	**Low-level laser therapy attenuates LPS-induced rats mastitis by inhibiting polymorphonuclear neutrophil adhesion.**	Rat		"The results showed that LPS-induced secretion of IL-1β and IL-8 significantly decreased after LLLT (650 nm, 2.5 mW, 30 mW/cm(2)). LLLT also inhibited	PubMed
Carpal tunnel	Carpal tunnel syndrome	Fusakul	Thailand (Bangkok)	2014	Lasers Med Sci	**Low-level laser therapy with a wrist splint to treat carpal tunnel syndrome: a double-blinded randomized controlled trial.**	Human RCT/DB		"Improvements were significantly more pronounced in the LLLT-treated group than the placebo group especially for grip strength at 5- and 12-week follow-ups. At 12-week	PubMed
Carpal tunnel	Carpal tunnel syndrome	Lazovic	Serbia (Belgrade)	2014	Photomed Laser Surg	**Placebo-controlled investigation of low-level laser therapy to treat carpal tunnel syndrome.**	Human RCT/DB		"Significant reduction in pain, reduction in the percentage of patients with a positive Tinel's sign, and shortening of sensory and motor latency time in the NCS examination	PubMed
Carpal tunnel	Carpal tunnel syndrome	Barbosa	Brazil (Ribeirão Preto)	2012	BMC Musculoskelet	**Effectiveness of low-level laser therapy for patients with carpal tunnel syndrome: design of a randomized single-blinded controlled**	Study design			PubMed
Carpal tunnel	Carpal tunnel syndrome	Tascioglu	Turkey (Eskisehir)	2012	Rheumatol Int	**Low-level laser in the treatment of carpal tunnel syndrome: clinical, electrophysiological, and ultrasonographical evaluation.**	Human		"There was no significant difference in any of the outcome measures among the groups. With the chosen laser type and dose regimen, the results suggested that LLLT	PubMed
Carpal tunnel	Carpal tunnel syndrome	Dakowicz	Poland (Bialystok)	2011	Adv Med Sci	**Comparison of the long-term effectiveness of physiotherapy programs with low-level laser therapy and pulsed magnetic field in**	Human RCT		"Although after LLL as well as PMF therapy clinical improvement was observed, the most significant differences were registered after the second series and persisted for	PubMed
Carpal tunnel	Carpal tunnel syndrome	Yagci	Turkey (Istanbul)	2009	Clin Rheumatol	**Comparison of splinting and splinting plus low-level laser therapy in idiopathic carpal tunnel syndrome.**	Human RCT		"In the third-month control, SLLLT group had significant improvements on both clinical and [nerve conduction study] parameters (median motor nerve distal latency, median	PubMed
Carpal tunnel	Carpal tunnel syndrome	Dincer	Turkey (Istanbul)	2009	Photomed Laser Surg	**The effectiveness of conservative treatments of carpal tunnel syndrome: splinting, ultrasound, and low-level laser therapies.**	Human		"It appeared that the combinations of US or LLL therapy with splinting were more effective than splinting alone in treating CTS. However, LLL therapy plus splinting was	PubMed
Carpal tunnel	Carpal tunnel syndrome	Shooshtrai	Iran (Shiraz)	2008	Electromyogr Clin Neurophysiol	**The effects of low level laser in clinical outcome and neurophysiological results of carpal tunnel syndrome.**	Human RCT		"There was a significant improvement in clinical symptoms and hand grip in group A ($p < 0.001$). Proximal median sensory latency, distal median motor latency and median	PubMed
Carpal tunnel	Carpal tunnel syndrome	Evcik	Turkey (Afyonkarahisar)	2007	Photomed Laser Surg	**Laser therapy in the treatment of carpal tunnel syndrome: a randomized controlled trial.**	Human RCT/SB		"In using LLLT, (1) there was no difference relative to pain relief and functional capacity during the follow-up in CTS patients; (2) there were positive effects on hand and pinch	PubMed
Carpal tunnel	Carpal tunnel syndrome	Elwakil	Egypt (Cairo)	2007	Lasers Med Sci	**Treatment of carpal tunnel syndrome by low-level laser versus open carpal tunnel release.**	Human		"The patients were evaluated clinically and by nerve conduction studies (NCSs) about 6 months after the treatment.	PubMed
Carpal tunnel	Carpal tunnel syndrome	Naeser MA	USA (Boston, MA)	2006	Photomed Laser Surg	**Photobiomodulation of pain in carpal tunnel syndrome: review of seven laser therapy studies.**	Review			PubMed
Carpal tunnel	Carpal tunnel syndrome	Naeser	USA (Boston, MA)	2002	Arch Phys Med Rehabil	**Carpal tunnel syndrome pain treated with low-level laser and microamperes transcutaneous electric nerve stimulation: A**	Human RCT/DB		"Eleven mild to moderate CTS cases who failed standard medical or surgical treatment for 3 to 30 months.""	PubMed
Cells	Energy metabolism	Quirk	USA (Milwaukee, WI)	2016	J Clin Orthop Trauma	**Effect of near-infrared light on in vitro cellular ATP production of osteoblasts and fibroblasts and on fracture healing with**	In vitro	Osteoblasts Fibroblasts	"All groups gave significant increase in ATP within 5-10 min, with decay to baseline by 45 min. 660 nm NIR was significantly more effective than 830 nm with fibroblasts or	PubMed
Cells	Energy metabolism	Tsai	USA & Taiwan	2015	Photodiagnosis Photodyn Ther	**Low-level light therapy potentiates NPe6-mediated photodynamic therapy in a human osteosarcoma cell line via increased ATP.**	In vitro	Osteosarcoma cell line'	"Taken together, these results demonstrate that LLLT potentiates NPe6-mediated PDT via increased ATP synthesis and is a potentially promising strategy that could be	PubMed

Cells	Energy metabolism	Sharma	USA (Boston, MA)	2011	Lasers Surg Med	**Dose response effects of 810 nm laser light on mouse primary cortical neurons.**		Biphasic dose response	"Light induced a significant increase in calcium, ATP and MMP at lower fluences and a decrease at higher fluences." "The results suggest that LLLT at lower fluences is capable of inducing mediators of cell signaling processes which in turn may be responsible for the beneficial stimulatory effects of the low level laser. At higher fluences beneficial mediators are reduced and high levels of Janus-type mediators such as ROS and NO (beneficial at low concentrations and harmful at high concentrations) may be responsible for the damaging effects of high-fluence light and the overall biphasic dose response."	PubMed
Cells	Energy metabolism	Benedicenti	Italy (Milan)	2008	Photomed Laser Surg	**Intracellular ATP level increases in lymphocytes irradiated with infrared laser light of wavelength 904 nm.**	In vitro	Lymphocytes	"The amount of ATP in irradiated cell cultures was 10.79 +/- 0.15 microg/L (SD; n = 10), and in non-irradiated cell cultures it was 8.81 +/- 0.13 microg/L (SD; n = 10). The average percentage increase of irradiated versus control cell cultures was about 22.4% +/- 0.56% SD ($p < 0.001$)." "This significant increase is probably due to laser irradiation; it cannot be attributed to any thermal effect, as the temperature during irradiation was maintained at 37.0 degrees +/- 0.5 degrees C."	PubMed
Cells	Energy metabolism	Oron	Israel (Tel Aviv) / USA (CA)	2007	Photomed Laser Surg	**Ga-As (808 nm) laser irradiation enhances ATP production in human neuronal cells in culture.**	In vitro	Human neural progenitor (NHNP) cells	"ATP was determined at 10 min after laser application." "The quantity of ATP in laser-treated cells was 7513 +/- 970 units, which was significantly higher ($p < 0.05$) than the non-treated cells, which comprised 3808 +/- 539 ATP units."	PubMed
Cells	Energy metabolism	Karu	Russia (Troitsk)	1995	J Photochem Photobiol B	**Irradiation with He-Ne laser increases ATP level in cells cultivated in vitro.**	In vitro	HeLa cells	"The amount of ATP in the log phase of cultured cells remained at the control level (0.79 +/- 0.09) x 10(-15) mol per cell) during the first 15 min after irradiation; it then increased sharply and, after reaching a maximum (170.8%) 20 min after irradiation, decreased slowly to the control level."	PubMed
Cells	Energy metabolism	Karu	Russia (Troitsk)	1993	Biull Eksp Biol Med.	**[Changes in the amount of ATP in HeLa cells under the action of He-Ne laser radiation].** **[Article in Russian]**	In vitro	HeLa cells	"In cells of the exponential phase of growth, the amount of ATP (basal level 8 x 10(-16) mole/cell) starts to increase in 15 min after the irradiation with a maximum (170% above the basal level) at 20 min, and then decreases gradually to the basal level."	PubMed
Cells	Fibrosis	Sassoli	Italy (Florence)	2016	Lasers Surg Med	**Low intensity 635 nm diode laser irradiation inhibits fibroblast-myofibroblast transition reducing TRPC1 channel expression/activity: New perspectives for tissue fibrosis treatment.**	In vitro	Fibroblasts	"Low intensity irradiation with 635 ± 5 nm diode laser inhibited TGF-β1/Smad3-mediated fibroblast-myofibroblast transition and this effect involved the modulation of TRPC1 ion channels. These data contribute to support the potential anti-fibrotic effect of LLLT and may offer further informations for considering this therapy as a promising therapeutic tool for the treatment of tissue fibrosis."	PubMed
Cells	Nitric oxide	Silva	Brazil (Recife)	2016	Lasers Med Sci	**Increase in the nitric oxide release without changes in cell viability of macrophages after laser therapy with 660 and 808 nm lasers.**	In vitro	Macrophages Cell viability	"LLLT promoted statistically significant changes in NO release and MTT value only at the wavelength of 660 nm ($p < 0.05$). LLLT also promoted an increase in the NO release and cell viability when the energy densities 64 ($p = 0.04$) and 214 J/cm2 ($p = 0.012$), respectively, were used."	PubMed
Cells	Nitric oxide	Ankri	Israel (Ramat Gan)	2010	Lasers Surg Med	**Visible light induces nitric oxide (NO) formation in sperm and endothelial cells.**	In vitro	Sperm cells Endothelial cells	"Visible light illumination increased NO concentration both in sperm and endothelial cells. Blue light was more effective than red." "Light induces NO formation in endothelial and sperm cells. In endothelial cells, NO formation may explain previous results demonstrating enhanced wound healing and pain relief following illumination. In illuminated sperm cells, NO formation may account for the enhanced fertilization rate."	PubMed
Cells	Nitric oxide	Lindgård	Sweden (Gothenburg)	2007	Lasers Med Sci	**Irradiation at 634 nm releases nitric oxide from human monocytes.**			"Irradiation resulted in elevated levels of NO but had no effect on iNOS or eNOS. Irradiation also caused a decrease in levels of intracellular ROS and had no effect on cell viability. Our studies indicate that irradiation at 634 nm releases NO, possibly from a preformed store, and reduces the production of intracellular ROS without affecting cell viability. Irradiation at 634 nm may have a wide range of clinical applications, including a reduction in oxidative stress-mediated injury in the vasculature." "The intracellular ATP concentration was not significantly affected by irradiation (Fig. 5)."	PubMed
Cells	Olfactory ensheathing cells	Byrnes	USA (Washington)	2005	Lasers Surg Med	**Low power laser irradiation alters gene expression of olfactory ensheathing cells in vitro.**	In vitro		"These results demonstrate that low and high dosages of PBM alter OEC activity, including upregulation of a number of neurotrophic growth factors and extracellular matrix proteins known to support neurite outgrowth. Therefore, the application of PBM	PubMed
Cells	Proliferation	Ren	China (Hong Kong)	2016	Lasers Med Sci	**Effect of diode low-level lasers on fibroblasts derived from human periodontal tissue: a systematic review of in vitro studies.**	Systematic review	Inflammation Differentation		PubMed
Cells	Proliferation	Marques	Brazil (São José dos Campos)	2014	Exp Biol Med (Maywood)	**Evaluation of the photobiomodulation in L929 cell culture.**	In vitro		"Our results showed that low-level laser therapy stimulates effect when the energy density is 5 to 3030 J/cm(2) and inhibits effects on energy density 0.1 to 3 J/cm(2). This inhibitory effect was evidenced by the absence of dead cells labeled, decreased cell density, and by the absorption of neutral red in intact cells."	PubMed
Cells	Proliferation	Peplow	New Zealand (Dunedin)	2010	Photomed Laser Surg	**Laser photobiomodulation of proliferation of cells in culture: a review of human and animal studies.**	Systematic review			PubMed
Cells	Proliferation	Pires-Oliveira	Brazil (São Paulo)	2010	Photomed Laser Surg	**Laser biomodulation on L 929 cell culture.**		Biphasic dose response	"Irradiation of L929 cells with pulsed laser in the near infrared region (904 nm) at two quite distinct energy densities allowed the observation of increased cell proliferation in both cases. The result was slightly higher for an energy density of 50 mJ=cm2 than for 6 J=cm2 . as demonstrated by fluorescence microscopy. Cell response was also found	PubMed
Cells	Proliferation	Taniguchi	Japan (Kyoto)	2009	Lasers Surg Med	**Low-energy laser irradiation promotes synovial fibroblast proliferation by modulating p15 subcellular localization.**	In vitro	HIG-82 rabbit synovial fibroblasts	"LELI promoted HIG-82 synovial fibroblast proliferation and induced cytoplasmic localization of cyclin-dependent kinase inhibitor p15 (INK4B/CDKN2B)." "Our findings suggest that cAMP may be involved in the effect of LELI on synovial	PubMed
Cells	Proliferation	Brondon	USA (Rochester, NY)	2005	Lasers Surg Med	**A study of the effects of phototherapy dose interval on photobiomodulation of cell cultures.**	In vitro	Human HEP-2 Murine L-929	"Cellular response to dose frequency varies. More frequent treatments (2/24 hours) increased metabolism and proliferation in both cell lines. Further investigation of dose fractionation in phototherapy is warranted."	PubMed
Cells	Proliferation	van Breugel	Netherlands (Utrecht)	1992	Lasers Surg Med	**Power density and exposure time of He-Ne laser irradiation are more important than total energy dose in photo-biomodulation of human fibroblasts in vitro.**	In vitro	Human fibroblasts Biphasic dose	"Collagen type I production (as determined by an ELISA) was affected in the opposite direction to cell proliferation: when the cell proliferation was increased, collagen type I production was decreased."	PubMed
Cells	Protection	Spitler	USA (Irvine, CA)	2015	J Biomed Opt	**Combination of low level light therapy and nitrosyl-cobinamide accelerates wound healing.**	In vitro	U2OS human osteosarcoma cells	"LLLT-enhanced wound healing proceeded through an electron transport chain-C-ox-dependent mechanism with a reduction of reactive oxygen species and increased adenosine triphosphate production. C-ox was validated as the primary photoacceptor by three observations: increased oxygen consumption, reduced wound healing in the	PubMed

Cells	Protection	Spitler & Berns	USA (Irvine, CA)	2014	J Biomed Opt	**Comparison of laser and diode sources for acceleration of in vitro wound healing by low-level light therapy.**	In vitro	Wound healing LED phototherapy /	"The laser and LED sources were found to be comparable when equal doses of light were applied. The biological response measured was similar in most cases."	PubMed
Cells	Protection	Huang	USA (Boston, MA)	2013	J Biophotonics	**Low-level laser therapy (LLLT) reduces oxidative stress in primary cortical neurons in vitro.**	In vitro	Primary cortical neurons	"Although LLLT increases ROS in normal neurons, it reduces ROS in oxidatively-stressed neurons. In both cases MMP is increased. These data may explain how LLLT can reduce clinical oxidative stress in various lesions while increasing ROS in cells in vitro."	PubMed
Cells	Protection	Sekhejane	South Africa (Johannesburg)	2011	Photomed Laser Surg	**Irradiation at 636 nm positively affects diabetic wounded and hypoxic cells in vitro.**	In vitro	Diabetes / hypoxia / wound	"Phototherapy resulted in hastened wound closure, increased proliferation, and normalization of cellular function. The decrease in the different pro-inflammatory cytokines and NF-κB translocation was model and time dependent. Overall, laser irradiation resulted in a reduction in inflammatory cytokines and directed cells into the	PubMed
Cells	Protection	Hodgson	USA (Milwaukee, WI)	2011	Photomed Laser Surg	**Effect of photobiomodulation on vinblastine-poisoned murine HERS cells.**	In vitro	Chemotherapy (vinblastine)	"Photobiomodulation demonstrated an improvement in proliferation and glutathione levels in vinblastine-poisoned murine HERS cells."	PubMed
Cells	Protection	Zungu	South Africa (Johannesburg)	2009	Photochem Photobiol	**Mitochondrial responses of normal and injured human skin fibroblasts following low level laser irradiation--an in vitro study.**	In vitro	Human skin fibroblasts Biphasic dose response	"The study confirmed that laser irradiation with 5 J cm(-2) stimulated an increase in intracellular Ca2+ which resulted in an increase in MMP, ATP and cAMP, which ultimately results in photobiomodulation to restore homeostasis of injured cells." Comment: Irradiation with 5 J/cm2 was beneficial, but 16 J/cm2 wasn't. Therefore there seems to be a biphasic dose response.	PubMed
Cells	Protection	Hawkins & Abrahamse	South Africa (Johannesburg)	2006	Lasers Surg Med	**The role of laser fluence in cell viability, proliferation, and membrane integrity of wounded human skin fibroblasts following helium-neon laser irradiation.**	In vitro	Wounded fibroblasts	"Results show that 5 J/cm(2) stimulates mitochondrial activity, which leads to normalization of cell function and ultimately stimulates cell proliferation and migration of wounded fibroblasts to accelerate wound closure. Laser irradiation can modify cellular processes in a dose or fluence (J/cm(2)) dependent manner."	PubMed
Cells	Protection	Liang	USA (Milwaukee, WI)	2006	Neuroscience	**Photobiomodulation partially rescues visual cortical neurons from cyanide-induced apoptosis.**	In vitro	Neurotoxins	"These results indicate that light-emitting diode pretreatment partially protects neurons against cyanide-induced caspase-mediated apoptosis, most likely by decreasing reactive oxygen species production, down-regulating pro-apoptotic proteins and activating anti-apoptotic proteins, as well as increasing energy metabolism in neurons as reported previously."	PubMed
Cells	Protection	Hawkins & Abrahamse	South Africa (Johannesburg)	2006	Photomed Laser Surg	**Effect of multiple exposures of low-level laser therapy on the cellular responses of wounded human skin fibroblasts.**	In vitro	Biphasic dose response	"A single dose of 5.0 J/cm(2), and two or three doses of 2.5 J/cm(2) had a stimulatory or positive effect on wounded fibroblasts with an increase in cell migration and cell proliferation while maintaining cell viability, but without causing additional stress or damage to the cells. Multiple exposures at higher doses (16 J/cm(2)) caused additional stress, which reduces cell migration, cell viability, and ATP activity, and inhibits cell proliferation."	PubMed
Cells	Protection	Wong-Riley	USA (Milwaukee, WI)	2005	J Biol Chem	**Photobiomodulation directly benefits primary neurons functionally inactivated by toxins: role of cytochrome c oxidase.**	In vitro	Neurotoxins	670nm LED light protected primary cultured neurons against potassium cyanide (KCN) and tetrodotoxin (TTX).	PubMed
Cells	Protection	Wong-Riley	USA (Milwaukee, WI)	2001	Neuroreport	**Light-emitting diode treatment reverses the effect of TTX on cytochrome oxidase in neurons.**	In vitro	Neurotoxins	670nm LED light protected cultured primary neurons against tetrodotoxin (TTX).	PubMed
Cells	ROS	Chen	USA (Boston, MA)	2011	PLoS One	**Low-level laser therapy activates NF-kB via generation of reactive oxygen species in mouse embryonic fibroblasts.**	In vitro	Mouse embronic fibroblasts Dose response (biphasic?)	"We conclude that LLLT not only enhances mitochondrial respiration, but also activates the redox-sensitive NFkB signaling via generation of ROS. Expression of anti-apoptosis and pro-survival genes responsive to NFkB could explain many clinical effects of LLLT." "However, LLLT, unlike mitochondrial inhibitors, induced increased cellular ATP levels, which indicates that LLLT also upregulates mitochondrial respiration."	PubMed
Circulation	Aneurysm	Gavish	Israel (Jerusalem)	2014	Lasers Surg Med	**Arrest of progression of pre-induced abdominal aortic aneurysm in apolipoprotein E-deficient mice by low level laser phototherapy.**	Mouse	Ang-II-infused Apo-E(-/-) mice	"LLL not only prevents de novo development of AAA, but, from this study, also arrests further progression of pre-induced AAA and its associated deterioration in the biomechanical integrity of the aortic wall in Apo-E(-/-) mice."	PubMed
Circulation	Aneurysm	Gavish	Israel (Jerusalem)	2012	Lasers Surg Med	**Low level laser arrests abdominal aortic aneurysm by collagen matrix reinforcement in apolipoprotein E-deficient mice.**	Mouse	Ang-II-infused Apo-E(-/-) mice	"Transmural disruptions of the aorta occurred with distinct predilection for branch orifices. In the LLLI-treated animals, the frequency of these disruptions was lower (#branches with break points: 17 of 40 vs. 32 of 48, P = 0.023 by Chi-squared), their size smaller (length [mm]: 0.48 ± 0.26 vs. 0.98 ± 1.42, P = 0.044 by ANOVA with FPLSD), and the number of Mac-2-positive macrophages in the intramural areas of these disruptions lower than in the non-treated control (#Macrophages/0.01 mm(2) at break points: 11.6 ± 7.2 vs. 26.0 ± 15.7, P = 0.016 by Kruskal-Wallis). The average size of the medial SMCs was larger reflecting a heightened synthetic state (SMC size [μm(2)]: 463.9 ± 61.4 vs. 354.9 ± 71.7, P = 0.001 by ANOVA with FPLSD). Furthermore, at sites of transmural disruption, the %area occupied by collagen of the overall area of attempted repair (%Col/WO) was significantly greater in the LLLI-treated animals versus control (%Col/WO: 41 ± 13 vs. 32 ± 16, P = 0.009 by ANOVA with FPLSD)."	PubMed
Circulation	Aneurysm	Gavish	Israel (Jerusalem)	2009	Cardiovasc Res	**Low-level laser irradiation inhibits abdominal aortic aneurysm progression in apolipoprotein E-deficient mice.**	Mouse	Ang-II-infused Apo-E(-/-) mice	"At 4 weeks, seven of 15 non-irradiated, but none of the 13 LLLI, mice had aneurysmal dilatation in the suprarenal aneurysm-prone segments that had progressed to >or=50% increase in maximal cross-sectional diameter (CSD) over baseline (P = 0.005 by Fisher's exact test). The mean CSD of the suprarenal segments (normalized individually to inter-renal control segments) was also significantly lower in irradiated animals (LLLI vs. non-irradiated: 1.32 +/- 0.14 vs. 1.82 +/- 0.39, P = 0.0002 by unpaired, two-tailed t-test) with a 94% reduction in CSD at 4 weeks compared with baseline. M-mode ultrasound data showed that reduced radial wall velocity seen in non-treated was significantly attenuated in the LLLI mice, suggesting a substantial effect on arterial	PubMed
Circulation	Angiogenesis	de Sousa	Brazil (Salvador, Bahia)	2013	Lasers Med Sci	**Laser and LED phototherapies on angiogenesis.**	Rat	Cutaneous wounds LED phototherapy LLLT vs LED	"Quantitative results showed that green LED (λ530 ± 20 nm), red LED (λ700 ± 20 nm), λ790 nm laser and λ660 nm laser caused significant increased angiogenesis when compared to the control group. It is concluded that both laser and LED light are capable of stimulating angiogenesis in vivo on cutaneous wounds and that coherence was not decisive on the outcome of the treatment."	PubMed
Circulation	Angiogenesis	Mirsky	Israel	2002	Antioxid Redox Signal	**Promotion of angiogenesis by low energy laser irradiation.**	Rat	Myocardial infarction	"Laser irradiation caused a 3.1-fold significant increase in newly formed blood vessels 6 days post infarction, as compared with nonirradiated rats."	PubMed

Circulation	Arterial restenosis	Derkacz	Poland (Wroclaw)	2014	Photomed Laser Surg	**Effects of intravascular low-level laser therapy during coronary intervention on selected growth factors levels.**	Human RCT		"LLLT decreases levels of TGF-β1 and FGF-2 in patients undergoing coronary intervention, which may explain smaller neointima formation." Note: This study seems to be based on the same patients as in the two other Derkacz et al. studies.	PubMed
Circulation	Arterial restenosis	Derkacz	Poland (Wroclaw)	2013	Lasers Med Sci	**Effect of the intravascular low energy laser illumination during percutaneous coronary intervention on the inflammatory process in vascular wall.**	Human Controlled		"Irradiation of the lesion with low-energy laser radiation during the PCI procedure results in a decrease in the levels of pro-inflammatory IL 1β and IL 6 as well as in an increase in the levels of anti-inflammatory IL 10, which may result in decreased risk for restenosis."	PubMed
Circulation	Arterial restenosis	Derkacz	Poland (Wroclaw)	2010	Am J Cardiol	**Usefulness of intravascular low-power laser illumination in preventing restenosis after percutaneous coronary intervention.**	Human Controlled		"Follow-up coronary angiography was performed after 6 months. The difference in the restenosis rate was insignificant (15.0% vs 32.4%); however, significant differences were observed in the minimal lumen diameter (2.18 ± 0.70 vs 1.76 ± 0.74 mm; p < 0.05), late lumen loss (0.53 ± 0.68 vs 0.76 ± 0.76 mm; p < 0.01), and the late lumen loss index (0.28 ± 0.39 vs 0.46 ± 0.43; p < 0.005) in favor of the laser group. In conclusion, the new therapy seemed effective and safe. Marked differences between late loss, late loss index, and minimal lumen diameter were observed."	PubMed
Circulation	Arterial restenosis	Kipshidze	USA (New York, NY)	2001	Circulation	**Effect of short pulsed nonablative infrared laser irradiation on vascular cells in vitro and neointimal hyperplasia in a rabbit balloon injury model.**	Rabbit		"Morphometry showed that the luminal area was significantly greater in the arteries subjected to laser treatment (1.92±0.21 mm2 in the treated arteries and 0.49±0.09 mm2 in the control animals, P=9.1×10−14) (Table). Similar significant differences were demonstrated in the neointimal areas (0.76±0.18 and 1.85±0.30 mm2 in laser and control arteries, respectively, P=2.2×10−11). The ratio EELinj/EELref was greater in laser than control vessels (1.41±0.08 versus 1.09±0.08, P=9.4×10−9)." "The present study also shows that endoluminal NIL has a significant effect on restenosis (Figures 5 and 6⇓; Table)." "When delivered endoluminally, NIL reduces neointimal hyperplasia in the rabbit injury model. This study, however, should not be regarded as definitive preclinical data, and further experiments in the porcine coronary model are necessary to further establish the efficacy of this therapy. Ultimately, these data may lead to the development of new methods for the prevention of restenosis."	PubMed
Circulation	Arterial restenosis	Kipshidze	USA (Milwaukee, WI)	1998	J Am Coll Cardiol	**Photoremodeling of arterial wall reduces restenosis after balloon angioplasty in an atherosclerotic rabbit model.**	Rabbit		"Endoluminal [low power red laser light] therapy was performed using a laser-balloon catheter with a 200 μm fiberoptic with a diffuse tip at the end to provide a uniform distribution of light in the radial and axial directions of the balloon (Fig. 1)." "Morphometric analysis demonstrated that intimal area was five times greater in the areas subjected to balloon treatment alone (25.3 ± 1.9 mm2) than in the balloon plus laser treatment sites (4.2 ± 0.7 mm2)" "Our experimental data indicate that endoluminal irradiation with [low power red laser light] prevents restenosis after balloon angioplasty in an atherosclerotic rabbit model. Endoluminal [low power red laser light] therapy may have a significant role in interventional cardiology, not only to prevent restenosis after coronary interventions but also to stabilize vascular endothelium so that progression or redevelopment of the disease is inhibited. Randomized studies are required to establish this as an effective clinical tool in humans." Comment: This paper was published in a very-high impact journal (IF = 17.8). The paper is also Open Access.	PubMed
Circulation	Arterial restenosis	Deckelbaum	USA (New Haven, CT)	1993	Lasers Surg Med	**Photoinhibition of smooth muscle cell migration: potential therapy for restenosis.**	In vitro		"We conclude that 594-600 nm light inhibits smooth muscle cell migration in vitro and may potentially be used in vivo to decrease fibrointimal thickening following arterial injury. This application of photoinhibition may be useful in retarding restenosis following angioplasty."	PubMed
Circulation	Artery collateralization	Lohr	USA (Milwaukee, WI)	2013	J Mol Cell Cardiol	**Far red/near infrared light treatment promotes femoral artery collateralization in the ischemic hindlimb.**	Rabbit Mouse In vitro		"R/NIR significantly increased collateral vessel number which could not be attenuated with L-NAME. R/NIR induced collateralization was abolished with c-PTIO. In vitro, NO production increased in endothelial cells with R/NIR exposure, and this finding was independent of NOS inhibition. Similarly R/NIR induced proliferation and tube formation in a NO dependent manner. Finally, nitrite supplementation accelerated R/NIR collateralization in wild type C57Bl/6 mice. In an eNOS deficient transgenic mouse model, R/NIR restores collateral	PubMed
Circulation	Atherosclerosis	Park	Korea (Cheongju)	2012	Lab Anim Res	**Anti-hypercholesterolemic and anti-atherosclerotic effects of polarized-light therapy in rabbits fed a high-cholesterol diet.**	Rabbit	Atherosclerosis (high cholesterol diet) Polarized light of tungsten lamp (60W)	"The results indicate that PLT attenuates atherosclerosis not only by lowering blood cholesterol and LDL levels, but also by improving blood flow without adverse effects. Therefore, it is suggested that PLT could be a safe alternative therapy for the improvement of hypercholesterolemia and atherosclerosis."	PubMed
Circulation	Brain	Salgado	Brazil (São Paulo)	2015	Lasers Med Sci	**The effects of transcranial LED therapy (TCLT) on cerebral blood flow in the elderly women.**	Human	Cerebral blood flow	"Paired t-test results showed that there was a significant improvement after TCLT with increase in the systolic and diastolic velocity of the left middle cerebral artery (25 and 30%, respectively) and basilar artery (up to 17 and 25%), as well as a decrease in the pulsatility index and resistance index values of the three cerebral arteries analyzed (p < 0.05). TCD parameters showed improvement in the blood flow on the arteries analyzed. TCLT promoted a blood and vasomotor behavior of the basilar and middle cerebral arteries in healthy elderly women."	PubMed

	Circulation	Endothelium	Szymczyszyn	Poland (Wroclaw)	2016	Lasers Med Sci	**Effect of the transdermal low-level laser therapy on endothelial function.**	Human		"In the LG, a significant increase in GSH levels and considerable decrease in angiostatin concentration following the LLLT were observed. No significant differences in levels of the VEGF, FGF, SDMA, ADMA were observed.LLLT modifies vascular endothelial function by increasing its antioxidant and angiogenic potential. We found no significant differences in levels of the nitric oxide pathway metabolites within 24 h following the LLLT irradiation."	PubMed
	Circulation	Microcirculation	Mak & Cheing	China (Hong Kong)	2012	Photomed Laser Surg	**Immediate effects of monochromatic infrared energy on microcirculation in healthy subjects.**	Human RCT	MIRE treatment with "Anodyne" LED pad device	"A 30-min MIRE produced a significantly greater increase in the capillar blood velocity (CBV) and flux of the feet in the active MIRE group than in the placebo and control groups."	PubMed
	Circulation	Microcirculation	Maegawa	Japan (Kyoto)	2000	Lasers Surg Med	**Effects of near-infrared low-level laser irradiation on microcirculation.**	Rat	Mesenteric circulation Dose response	"LLLI caused potent dilation in the laser-irradiated arteriole, which led to marked increases in the arteriolar blood flow." "The circulatory changes observed seemed to be mediated largely by LLLI-induced reduction of [Ca2+]i in VSMCs, in addition to the involvement of NO in the initial phase."	PubMed
	Circulation	Nitric oxide	Mitchell & Mack	USA (Provo, UT)	2013	Am J Phys Med Rehabil	**Low-level laser treatment with near-infrared light increases venous nitric oxide levels acutely: a single-blind, randomized clinical trial of efficacy.**	Human RCT/SB	MIRE treatment with "Anodyne" LED pad device	"LLLT increased NO levels in venous blood draining from the treatment site in healthy subjects. The peak increase in NO occurred 5 mins into the treatment, after which it slowly waned. Further research is necessary to assess NO increases with LLLT in patients with pathologies."	PubMed
	Circulation	Red blood cells	Luo	China (Guangzhou)	2015	Lasers Med Sci	**The effects of low-intensity He-Ne laser irradiation on erythrocyte metabolism.**	In vitro		"In hypertonic RBCs, LHNL irradiation may decrease the activity of energy-consuming enzymes, but increases the activity of energy-generating enzymes in glycolysis, to improve the RBC deformability."	PubMed
	Circulation	Red blood cells	Walski	Poland (Wrocław)	2015	Photochem Photobiol Sci	**Near infrared light induces post-translational modifications of human red blood cell proteins**	In vitro		"The exposure of intact RBCs to NIR light causes quaternary transitions in Hb, dehydration of proteins and decreases the amount of physiologically inactive methemoglobin, as detected by Raman spectroscopy. These effects are accompanied by a lowering of the intracellular pH (pHi) and changes in the cell membrane topography, as documented by atomic force microscopy (AFM). All those changes are in line with our previous studies where alterations of the membrane fluidity and membrane potential were attributed to NIR action on RBCs. The rate of the above listed changes depends strictly on the dose of NIR light that the cells receive, nonetheless it should not be considered as a thermal effect."	PubMed
	Circulation	Red blood cells	Lin'kova	Russia (St. Petersburg)	2008	Bull Exp Biol Med	**Effect of low-intensity laser radiation of the red spectrum on some properties of erythrocytes in Wistar rats.**			"An increase in the radiation power from 2.2 to 25 mW/cm2 was accompanied by a decrease in the erythrocyte sedimentation rate and an increase in erythrocyte filtration index. Radiation of 50 mW/cm2 induced abnormal erythrocyte aggregation. Increasing the time of irradiation at power intensity of 2.2 mW/cm2 did not potentiate its effect on the blood."	PubMed
	Circulation	Red blood cells	Kujawa	Poland	2004	J Clin Laser Med Surg	**Effect of low-intensity (3.75-25 J/cm2) near-infrared (810 nm) laser radiation on red blood cell ATPase activities and membrane structure.**	In vitro (RBC)		NIR LLLT changed the ATPase activities of the membrane ion pumps in the dose- and fluence rate-dependent manner.	PubMed
	Circulation	Red blood cells	Spodaryk	Poland (Krakow)	2001	Clin Hemorheol Microcirc	**The influence of low-power laser energy on red blood cell metabolism and deformability.**	In vitro		"This study revealed that the low-power laser at 632.8, 780 and 904 nm wavelengths have little biological effects on red blood cells in vitro." Comment: Since RBCs don't have mitochondria, LLLT isn't expected to have significant effects on these cells.	PubMed
	Circulation	Smooth muscle cells	Gavish	Israel (Jerusalem)	2006	Lasers Surg Med	**Low-level laser irradiation modulates matrix metalloproteinase activity and gene expression in porcine aortic smooth muscle cells.**	In vitro		"LLLI stimulates SMC proliferation, stimulates collagen synthesis, modulates the equilibrium between regulatory matrix remodeling enzymes, and inhibits pro-inflammatory IL-1-beta gene expression. These findings may be of therapeutic relevance for arterial diseases such as aneurysm where SMC depletion, weakened extracellular matrix, and an increase in pro-inflammatory markers are major pathologic components."	PubMed
★	Circulation	Thrombocytopenia	Zhang	USA (Boston, MA)	2016	Sci Transl Med	**Noninvasive low-level laser therapy for thrombocytopenia.**	Mice & in vitro	Biphasic dose response	"This safe, drug-free, donor-independent modality represents a paradigm shift in the prophylaxis and treatment of thrombocytopenia. " "We demonstrate here that noninvasive whole-body LLL illumination increases platelet generation and completely cures or greatly ameliorates thrombocytopenia caused by γ-irradiation (IR), ITP (induced by anti-CD41 antibody), or chemotherapy in mice."	PubMed
	Circulation	Thrombocytopenia	Yang	USA (Boston, MA)	2016	Sci Rep	**Low-level light treatment ameliorates immune thrombocytopenia.**	Mice & in vitro	LED phototherapy Biphasic dose response	"These adverse effects of anti-CD41 antibody were all mitigated by LLLT to varying degrees, owing to its ability to enhance mitochondrial biogenesis and activity in megakaryocytes and preserve mitochondrial functions in platelets in the presence of the antibody. The observations argue not only for contribution of mitochondrial stress to the pathology of ITP, but also clinical potentials of LLLT as a safe, simple, and cost-effective modality of ITP."	PubMed
	Circulation	Vasoconstriction	Gal	USA (Boston/MA)	1992	Circulation	**Percutaneous delivery of low-level laser energy reverses histamine-induced spasm in atherosclerotic Yucatan microswine.**	Microswine		LLLT (633 or 1064nm) seemed to locally relieve vasoconstriction inYucatan microswine.	PubMed
	Circulation	Vasorelaxation	Kihshidze	USA (New York, NY)	2000	Photochem Photobiol	**Photoactivation of vascular iNOS and elevation of cGMP in vivo: possible mechanism for photovasorelaxation and inhibition of restenosis in an atherosclerotic rabbit models.**	Rabbit	Aterosclerotic rabbit	"Our study demonstrated that intravascular low dose laser irradiation induces iNOS and elevates vascular cGMP in an in vivo atherosclerotic rabbit model." "We think that endoluminal laser irradiation of PTCA-treated arteries modulates relaxation, migration and prolif-eration of SMC, which in turn reduces the incidence of restenosis."	PubMed
	Cosmetic medicine	Body contouring	Caruso-Davis	USA (Baton Rouge, LA)	2011	Obes Surg	**Efficacy of low-level laser therapy for body contouring and spot fat reduction.**	Human RCT	LAPEX 2000 LipoLaser	"Cumulative girth loss after 4 weeks was −2.15 cm (−0.78 ± 2.82 vs. 1.35 ± 2.64 cm for the control group,p < 0.05). A blinded evaluation of standardized pictures showed statistically significant cosmetic improvement after 4 weeks of laser treatment."	PubMed
	Cosmetic medicine	Cellulite	Jackson	USA (Marion, IN)	2013	Lasers Surg Med	**A double-blind, placebo-controlled randomized trial evaluating the ability of low-level laser therapy to improve the appearance of cellulite.**	Human RCT/DB	Green light	"Low-level laser therapy using green 532 nm diodes is safe and effective for improving the appearance of cellulite in the thighs and buttocks."	PubMed
	Dermatology	Herpes labialis	de Paula Eduardo	Brazil (São Paulo)	2014	Lasers Med Sci	**Laser treatment of recurrent herpes labialis: a literature review.**	Review			PubMed

	Dermatology	Herpes labialis	Dougal & Lee	UK (Durham)	2013	Clin Exp Dermatol	**Evaluation of the efficacy of low-level light therapy using 1072 nm infrared light for the treatment of herpes simplex labialis.**	Human RCT		"The median time to healing for the active group was 129 h, compared with 177 h for the control group, which was significant (P = 0.01)."	PubMed
★	Dermatology	Herpes labialis	Muñoz Sanchez	Cuba (Cienfuegos)	2012	Photomed Laser Surg	**The effect of 670-nm low laser therapy on herpes simplex type 1.**	Human		"LLLT of herpes simples virus 1 (HSV-1) appears to be an effective treatment modality without any observed side effects."	PubMed
	Dermatology	Herpes labialis	Eduardo Cde	Brazil (São Paulo)	2012	Lasers Med Sci	**Prevention of recurrent herpes labialis outbreaks through low-intensity laser therapy: a clinical protocol with 3-year follow-up.**	Case series		"Based on the outcomes observed in this study, it is possible to conclude that the preventive protocol proposed may represent an alternative treatment for patients presenting recurrent herpes labialis infection."	PubMed
	Dermatology	Herpes labialis	Ferreira	Brazil (Rio de Janeiro)	2011	Rev Soc Bras Med Trop	**Recurrent herpes simplex infections: laser therapy as a potential tool for long-term successful treatment.**	Case series		"Two clinical cases are described with recurrent labial herpes for which LLLT was used. Following treatment, both patients remained symptom free during the 17-month clinical follow-up period."	PubMed
	Dermatology	Herpes labialis	de Carvalho	Brazil (São Paulo)	2010	Lasers Med Sci	**Effect of laser phototherapy on recurring herpes labialis prevention: an in vivo study.**	Human	LLLT vs aciclovir	"Patients in the experimental group presented a significant decrease in dimension of herpes labialis lesions (P = 0.013) and inflammatory edema (P = 0.031). The reduction in pain level (P = 0.051) and monthly recurrences (P = 0.076) did not reach statistical significance. This study represents an in vivo indication that this treatment should be further considered as an effective alternative to therapeutic regimens for herpes labialis lesions."	PubMed
	Dermatology	Herpes labialis	Hargate	UK (Middlesbrough)	2006	Clin Exp Dermatol	**A randomised double-blind study comparing the effect of 1072-nm light against placebo for the treatment of herpes labialis**	Human RCT/DB	LED phototherapy	"The 1072-nm light-emitting diode device reduced cold-sore healing time to 6.3 days compared with 9.4 days for placebo (P = 0.048)."	PubMed
	Dermatology	Herpes labialis	Dougal & Kelly	UK (Stockton-on-Tees)	2001	Clin Exp Dermatol	**A pilot study of treatment of herpes labialis with 1072 nm narrow waveband light**	Human Pilot study	LED phototherapy vs aciclovir	"The results demonstrated that a single 5 min light treatment significantly reduced cold sore healing time by 4 days; 1072 nm light healed cold sores in 4.3 ± 1.8 days (mean ± SD) as compared with aciclovir applied five times daily, 8.5 ± 3.0 days (P < 0.0001)."	PubMed
★	Dermatology	Herpes labialis	Schindl & Neumann	Austria (Vienna)	1999	J Invest Dermatol	**Low-intensity laser therapy is an effective treatment for recurrent herpes simplex infection. Results from a randomized double-blind placebo-controlled study.**	Human RCT		"The median recurrence-free interval in the laser-treated group was 37.5 wk (range: 2-52 wk) and in the placebo group 3 wk (range: 1-20 wk). This difference was found to be statistically significant (p < 0.0001; Wilcoxon's Rank Sum Test). In conclusion, we demonstrated that a total of 10 irradiations with low-intensity laser therapy significantly lowers the incidence of local recurrence of herpes simplex infection."	PubMed
	Dermatology	Herpes zoster	Chen	Taiwan (Taipei)	2016	J Am Acad Dermatol	**Early application of low-level laser may reduce the incidence of postherpetic neuralgia (PHN).**	Human Retrospective data	Postherpetic neuralgia	"Applying LLLT within the first 5 days of herpes zoster eruption significantly reduced the incidence of PHN. LLLT may have the potential to prevent PHN, but further well-designed randomized controlled trials are required."	PubMed
☹	Dermatology	Herpes zoster	Fan & Wang	China (Xi'an)	2015	Dermatol Surg	**A Novel Treatment of Herpes Zoster Pain With Pulsed Laser Irradiation.**	Letter		"In summary, the authors found in the treatment of 5 herpes zoster patients that 1,064-nm Nd:YAG laser irradiation could significantly alleviate herpetic pain with persisting effect and no apparent adverse effect." Comment: The parameters were poorly reported.	PubMed
★	Dermatology	Herpes zoster	Knapp DJ	USA (Sarasota, FL)	2013	Clin J Pain	**Postherpetic neuralgia: case study of class 4 laser therapy intervention.**	Human Case report		"Weekly laser therapy treatment over 8 weeks resulted in reduced 0 to 10 Numeric Pain Scale score from 8 to 0, Neuropathy Pain Scale Questionnaire total score from 39 to 4, and allodynia over a 60 cm surface area of the upper trunk and posterior arm totally resolved, with resolution continued at 14-month follow-up."	PubMed
	Dermatology	Radiation dermatitis	Censabella	Belgium (Hasselt)	2016	Support Care Cancer	**Photobiomodulation for the management of radiation dermatitis: the DERMIS trial, a pilot study of MLS(®) laser therapy in breast cancer patients.**	Human Pilot study	MLS(®) laser therapy	"Skin toxicity was equivalent between the groups before the start of LT but significantly differed at the end of radiotherapy, with an aggravation in the control but not in the LT group (e.g., 29 versus 3 % of RTOG grade 2 RD, respectively, P < 0.005). We found no significant group differences with respect to quality of life. However, the RISRAS subjective score decreased in the LT group only, implying a decreased impact of RD on patients' quality of life. Finally, patients' ratings were significantly higher for LT than for standard care."	PubMed
	Dermatology	Radiation dermatitis	Fife	USA (Irvine, CA)	2010	Dermatol Surg	**A randomized, controlled, double-blind study of light emitting diode photomodulation for the prevention of radiation dermatitis in patients with breast cancer.**	Human RCT/DB		"LED photomodulation did not reduce the incidence of radiation-induced skin reactions or interruptions in therapy. ." Note: DeLand published a letter, wondering why the results were so different in this study. He suggests it might be related to the treatment parameters... Metelitsa's commentary also mentions this issue, and also focuses on some differences between the treatments in these two studies.	PubMed
	Dermatology	Radiation dermatitis	DeLand	USA (Lafayette, LA)	2007	Lasers Surg Med	**Treatment of radiation-induced dermatitis with light-emitting diode (LED) photomodulation.**	Human		"In LED-treated patients, 18 (94.7%) had grade 0 or 1 reaction and 1 (5.3%) had grade 2 reaction. Among controls, 4 (14.3%) had a grade 1 reaction, 24 (85.7%) had a grade 2 or 3 reaction. One LED-treated patient (5.3%) and 19 controls (67.9%) had to interrupt treatment." Note: Results are very interesting, but parameters are poorly reported.	PubMed
	Dermatology	Telangiectasia	Tierney & Hanke	USA (Carmel, IN)	2009	Lasers Surg Med	**Randomized controlled trial: Comparative efficacy for the treatment of facial telangiectasias with 532 nm versus 940 nm diode laser.**	Human RCT/SB (?) Split-face	Green light vs LLLT	"Pain associated with the laser treatment was rated as significantly less for the 940 nm wavelength relative to the 532 nm wavelength. Erythema post-treatment was significantly less with 940 nm relative to 532 nm. Significant crusting and swelling were only reported with the 532 nm wavelength. The mean percentage improvement with the 940 nm wavelength (63.0%) was greater than that achieved with the 532 nm wavelength (47.8%) (P<0.05). On photographic evaluation, 940 nm was significantly more efficacious for larger caliber vessels than 532 nm. Both wavelengths were equally efficacious for smaller caliber	PubMed
	Development	Embryogenesis	Lim	USA (Bloomington, IN)	2008	J Biochem Mol Toxicol	**Attenuation of TCDD-induced oxidative stress by 670 nm photobiomodulation in developmental chicken kidney.**	Chicken		"The biochemical indicators of oxidative and energy stress in the kidney were reversed by daily phototherapy, restoring ATP and glutathione contents and increasing antioxidant enzyme activities to control levels. Photobiomodulation also normalized the level of lipid peroxidation increased by TCDD exposure. The results of this study suggest that 670 nm photobiomodulation may be useful as a noninvasive treatment for renal injury resulting from chemically induced cellular oxidative and energy stress."	PubMed
	Development	Embryogenesis	Yeager	USA (Bloomington, IN)	2006	Photomed Laser Surg	**Brief report: embryonic growth and hatching implications of developmental 670-nm phototherapy and dioxin co-exposure.**	Chicken	LED phototherapy Dioxin	"Size and hatching times suggest that the hatching success and preparedness of chicks developmentally exposed to dioxin concentrations above the lethality threshold is improved by 670-nm LED treatment administered throughout the gestation period, but the relationship may be complicated by an LED-oil interaction."	PubMed

	Development	Embryogenesis	Yeager	USA (Bloomington, IN)	2006	J Biochem Mol Toxicol	**670 nanometer light treatment attenuates dioxin toxicity in the developing chick embryo.**			"Our study demonstrates that 670 nm phototherapy can mitigate the oxidative stress and energy deficit resulting from developmental exposure to TCDD while reducing TCDD-induced embryo mortality. Moreover, LED treatment restores hepatic enzyme activities to control levels in TCDD-exposed embryos. The effective attenuation of TCDD-induced embryo toxicity by LED treatment could extend to mitigating the effects of other teratogens that induce oxidative and energy stress." Comment: According to the figure, LLLT seemed to increase mortality at some dioxin dosages... I wonder why this isn't mentioned in the abstract.	PubMed
	Development	Embryogenesis	Yeager	USA (Bloomington, IN)	2006	Photomed Laser Surg	**Survivorship and mortality implications of developmental 670-nm phototherapy: dioxin co-exposure.**	Chicken		"LED therapy decreased the embryonic mortality rate by 41%, resulting in increased embryonic survival and improved hatching success in eggs exposed to 200 ppt dioxin. However, at sub-lethal dioxin concentrations and in oil-treated controls, LED therapy slightly increased mortality."	PubMed
	Development	Embryogenesis	Yeager	USA (Bloomington, IN)	2005	Photomed Laser Surg	**Effects of 670-nm phototherapy on development.**	Chicken	LED phototherapy	"These results indicate that 670-nm phototherapy by itself does not adversely affect developing embryos and may improve the hatching survival rate."	PubMed
	Diabetes mellitus	Glycation	Peplow & Baxter	New Zealand (Dunedin)	2014	Lasers Surg Med	**Defining a therapeutic window for laser irradiation (810 nm) applied to the inguinal region to ameliorate diabetes in diabetic mice.**	Mouse		"The blood plasma fructosamine level of diabetic mice irradiated with 20.4 J/cm(2) was significantly lower than for nonirradiated controls, whereas that for diabetic mice irradiated with 40.8 J/cm(2) was not significantly different than for nonirradiated controls."	PubMed
	Diabetes mellitus	Glycation	Peplow & Baxter	New Zealand (Dunedin)	2013	Lasers Surg Med	**Testing infrared laser phototherapy (810 nm) to ameliorate diabetes: irradiation on body parts of diabetic mice.**	Mouse		"Irradiation of left inguinal region in diabetic mice with 810 nm laser has potential to ameliorate diabetes as shown by decreased blood plasma fructosamine." Comment: Irradiation of other parts wasn't helpful. The total effect is probably quite negligible.	PubMed
	Diabetes mellitus	Glycemia	Fukuoka	Brazil (São Paulo)	2016	J Biophotonics	**Low-power laser irradiation in salivary glands reduces glycemia in streptozotocin-induced diabetic female rats.**	Rat	Irradiation of salivary glands	"LPLI probably reduced the hyperglycemia in diabetes by improving the insulin resistance in these animals" Comment: A surprising results. I think it should be repeated.	PubMed
	Diabetes mellitus	Ulcers and wounds	Tchanque-Fossuo	USA (Mather, CA)	2016	J Drugs Dermatol	**Low-level Light Therapy for Treatment of Diabetic Foot Ulcer: A Review of Clinical Experiences.**	Review			PubMed
	Diabetes mellitus	Ulcers and wounds	Tchanque-Fossuo	USA (Mather, CA)	2016	Wound Repair Regen	**A systematic review of low-level light therapy for treatment of diabetic foot ulcer.**	Systematic review			PubMed
	Diabetes mellitus	Ulcers and wounds	Carvalho	Brazil (Teresina)	2016	Rev Esc Enferm USP	**Low-level laser therapy and Calendula officinalis in repairing diabetic foot ulcers.**	Human RCT		"We conclude that LLLT isolated or in combination with Calendula officinalis oil is effective in relieving pain due to its anti-inflammatory action, and in reducing the total area of ulcers by stimulating neovascularization and accelerating cell proliferation, thereby contributing to improving possible morbidities that may occur as consequence of Diabetes Mellitus."	PubMed
☎	Diabetes mellitus	Ulcers and wounds	Mathur	India (Indore)	2016	Lasers Med Sci	**Low-level laser therapy as an adjunct to conventional therapy in the treatment of diabetic foot ulcers.**	Human RCT		"Percentage ulcer area reduction was 37 ± 9% in the LLLT group and 15 ± 5.4% in the control group ($p < 0.001$)."	PubMed
☹	Diabetes mellitus	Ulcers and wounds	Maltese	UK (London)	2015	Diabetes Care	**A pilot study to evaluate the efficacy of class IV lasers on nonhealing neuroischemic diabetic foot ulcers in patients with type 2 diabetes.**	Letter Human	Nonhealing foot ulcer	"Within the 12-week follow-up, four of five laser-treated patients (80%) had a complete ulcer resolution (most ulcers healed after 4.6 weeks). In the control group, no ulcer healing occurred by week 12." Comment: Parameters were not reported.	PubMed
	Diabetes mellitus	Ulcers and wounds	Houreld NN	South Africa (Johannesburg)	2015	Photomed Laser Surg	**Healing of diabetic ulcers using photobiomodulation.**	Editorial			PubMed
	Diabetes mellitus	Ulcers and wounds	Feitosa	Brazil (São Paulo)	2015	Acta Cir Bras	**Effects of the Low-Level Laser Therapy (LLLT) in the process of healing diabetic foot ulcers.**	Human		"There was a significant decrease in the size of the wound when compared to the control group ($p<0.05$). The pain was also reported as having an intense improvement in the treated group." "The low-level laser treatment seems to be an efficient method, viable, painless and of low costs concerning the tissue repair ulcers in a diabetic foot."	PubMed
	Diabetes mellitus	Ulcers and wounds	Minatel	Brazil (Ribeirão Preto)	2009	Lasers Surg Med	**Phototherapy promotes healing of chronic diabetic leg ulcers that failed to respond to other therapies.**	Human RCT/DB	LED phototherapy	"By day 90, 58.3% of group two ulcers had healed fully and 75% had achieved 90-100% healing. In contrast, only one "placebo" treated ulcer healed fully by day 90; no other ulcer attained > or =90% healing." [Also see additional info]	PubMed
★	Diabetes mellitus	Ulcers and wounds	Al-Watban FA	Saudi Arabia (Riyadh)	2009	Photomed Laser Surg	**Laser therapy converts diabetic wound healing to normal healing.**	Rat	Wavelength comparison Green light therapy	"In this induced-diabetes model, wound and burn healing were improved by 40.3% and 45%, respectively, in 633-nm laser dosimetry experiments, and diabetic wound and burn healing was accelerated by phototherapy. This indicates that the healing rate was normalized in the phototherapy-treated diabetic rats." Star: A remarkably huge study with 893 rats!	PubMed
	Diabetes mellitus	Ulcers and wounds	Schindl	Austria (Vienna)	1998	Diabetes Care	**Low-intensity laser irradiation improves skin circulation in patients with diabetic microangiopathy.**	Human RCT/DB	Diabetic microangiopathy	"After a single transcutaneous low-intensity laser irradiation, a statistically significant rise in skin temperature was noted ($P < 0.001$ by ANOVA for repeated measurements), whereas in the sham-irradiated control group, a slight but significant drop in temperature ($P < 0.001$) was found."	PubMed
	Diabetes mellitus		Kazemikhoo	Iran (Tehran)	2016	Lasers Med Sci	**Modifying effect of intravenous laser therapy on the protein expression of arginase and epidermal growth factor receptor in type 2 diabetic patients.**	Human	Intravenous laser therapy	"In conclusion, laser therapy may have a beneficial effect for diabetic patients via decreasing arginase expression and activation of the NOS/NO pathway which increases NO production and vasodilation, and decreasing EGFR expression which may reduce neuroinflammation and its secondary damages."	PubMed
	Diabetes mellitus		Góralczyk	Poland (Bydgoszcz)	2016	Lasers Med Sci	**Low-level laser irradiation effect on endothelial cells under conditions of hyperglycemia.**	In vitro		"It is considered that adverse effects of hyperglycemia on vascular endothelial cells may be corrected by the action of LLLT, especially with the wavelength of 830 nm. It leads to the reduction of TNF-α concentration in the supernatant and enhancement of cell proliferation."	PubMed
☹	Dose response	Insufficient dosage	Lundeberg	Sweden	1991	Ann Plast Surg	**Low-power HeNe laser treatment of venous leg ulcers.**	Human	Venous leg ulcers	"There were no significant differences in the proportion of healed ulcers or ulcer area in the HeNe group compared with the placebo group." Tuner: "In this study, a 6 mW HeNe laser or a placebo HeNe laser was used to treat leg ulcers twice weekly for 12 weeks. The stated dose was 4 J/cm2. The area of the ulcers varied from 3 cm2 to 32 cm2. To achieve the stated dose, the treatment time of each session of therapy would thus have had to vary from 33 minutes to 6 hours. It is questioned that the patients really would have been treated for 6 hours."	PubMed

	Edema	Paw	Chagas	Brazil (São José dos Campos)	2015	Lasers Med Sci	**Expression of mPGES-1 and IP mRNA is reduced by LLLT in both subplantar and brain tissues in the model of peripheral inflammation induced by carrageenan.**	Rat	Inflammatory paw edema by carrageenan Hyperalgesia	"LLLT was able to reduce both mPGES-1 and IP mRNA expression in subplantar and brain tissues."	PubMed
	Edema	Paw	Prianti	Brazil (São José dos Campos)	2014	Lasers Med Sci	**Low-level laser therapy (LLLT) reduces the COX-2 mRNA expression in both subplantar and total brain tissues in the model of peripheral inflammation induced by administration of carrageenan.**	Rat	Carrageenan-induced paw edema	"LLLT (7.5 J/cm(2)) reduced significantly the COX-2 mRNA expression both in the subplantar (~2.5-fold) and brain (4.84-9.67-fold) tissues. The results show that LLLT is able to reduce COX-2 mRNA expression. It is possible that the mechanism of LLLT decreasing hyperalgesia is also related to its effect in reducing the COX-2 expression in the CNS."	PubMed
	Edema	Paw	Meneguzzo	Brazil (São Paulo)	2013	Lasers Med Sci	**Prevention and treatment of mice paw edema by near-infrared low-level laser therapy on lymph nodes.**	Mouse	Inflammatory paw edema PBM vs diclofenac LLLT on lymph nodes	"Our results suggest that LLLT was able to produce both anti-inflammatory and pro-inflammatory effects depending on to the site and moment of irradiation."	PubMed
★	Edema	Paw	Albertini	Brazil (São José dos Campos)	2008	Photomed Laser Surg	**Cytokine mRNA expression is decreased in the subplantar muscle of rat paw subjected to carrageenan-induced inflammation after low-level laser therapy.**	Rat	Inflammatory paw edema by carrageenan	"A pronounced swelling of the rat paw was observed 4 h after treatment with carrageenan in comparison to the control group. Edema formation was decreased by LLLT with wavelengths of both 660 and 684 nm (Fig. 1)." "Both the 660 nm and 684 nm laser groups had 30%-40% lower mRNA expression for cytokines TNF-alpha, IL-1beta, and IL-6 in the paw muscle tissue than the carrageenan-only control group. Cytokine measurements were made 3 h after laser irradiation of the paw muscle, and all cytokine differences between the carrageenan-only control group and the LLLT groups were statistically significant ($p < 0.001$)."	PubMed
	Edema	Paw	Albertini	Brazil (São José dos Campos)	2007	Inflamm Res	**COX-2 mRNA expression decreases in the subplantar muscle of rat paw subjected to carrageenan-induced inflammation after low level laser therapy.**	Rat	Inflammatory paw edema by carrageenan	↓Edema ↓COX-2 mRNA "Taken together, these results suggest that LLLT may be a new alternative therapy in the treatment of inflammatory disorders, probably activated by a mechanism involving the reduction of COX-2 expression."	PubMed
★	Edema	Paw	Albertini	Brazil (São José dos Campos)	2007	J Photochem Photobiol B	**Anti-inflammatory effects of low-level laser therapy (LLLT) with two different red wavelengths (660 nm and 684 nm) in carrageenan-induced rat paw edema.**	Rat	Inflammatory paw edema by carrageenan	"The 660 nm and 684 nm laser groups developed significantly ($p<0.01$) less edema (0.58 ml [SE+/-0.17] ml and 0.76 ml [SE+/-0.10] respectively) than the control group (1.67 ml [SE+/-0.19]) at 4h after injections. Similarly, both laser groups showed a significantly lower number of inflammatory cells in the muscular and conjunctive sub-plantar tissues than the control group. We conclude that both 660 nm and 684 nm red wavelengths of LLLT are effective in reducing edema formation and inflammatory cell migration when a dose of 7.5 J/cm(2) is used."	PubMed
	Edema	Paw	Albertini	Brazil (São Paulo)	2004	J Photochem Photobiol B	**Effects of different protocol doses of low power gallium-aluminum-arsenate (Ga-Al-As) laser radiation (650 nm) on carrageenan induced rat paw ooedema.**	Rat	Inflammatory paw edema PBM vs diclofenac	"The ED that produced an anti-inflammatory effect were 1 and 2.5 J/cm(2), reducing the oedema by 27% ($P<0.05$) and 45.4% ($P<0.01$), respectively. The ED of 2.5 J/cm(2) produced anti-inflammatory effects similar to those produced by the cyclooxigenase inhibitor sodium diclofenac at a dose of 1 mg/kg. In adrenalectomized animals, the laser irradiation failed to inhibit the oedema."	PubMed
★	Eyes		Merry	Canada (Toronto)	2016	Acta Ophthalmol	**Photobiomodulation reduces drusen volume and improves visual acuity and contrast sensitivity in dry age-related macular degeneration.**	Human Case series (n=42)	Dry age-related macular degeneration LED phototherapy (Warp10 + Gentlewaves)	"Significant improvement in mean BCVA of 5.90 letters ($p < 0.001$) was seen on completion of the 3-week treatment and 5.14 letters ($p < 0.001$) after 3 months. Contrast sensitivity improved significantly (log unit improvement of 0.11 ($p = 0.02$) at 3 weeks and 3 months (log unit improvement of 0.16 ($p = 0.02$) at three cycles per degree. Drusen volume decreased by 0.024 mm3 ($p < 0.001$) and central drusen thickness was significantly reduced by a mean of 3.78 µm ($p < 0.001$), while overall central retinal thickness and retinal volume remained stable." "This is the first study demonstrating improvements in functional and anatomical outcomes in dry AMD subjects with PBM therapy. These findings corroborate an earlier pilot study that looked at functional outcome measures. The addition of anatomical evidence contributes to the basis for further development of a non-invasive PBM treatment for dry AMD."	PubMed
	Eyes		Gueven	Australia (Hobart)	2016	Mitochondrion	**Targeting mitochondrial function to treat optic neuropathy.**	Review			PubMed
	Eyes		Roy	USA (Boston, MA)	2016	Am J Pathol	**Mechanistic Insights into Pathological Changes in the Diabetic Retina : Implications for Targeting Diabetic Retinopathy**	Review			PubMed
	Eyes		Osborne	Spain (Oviedo)	2016	Mitochondrion	**Visual light effects on mitochondria: The potential implications in relation to glaucoma.**	Review			PubMed
	Eyes		Kaynezhad	UK (London)	2016	Exp Eye Res	**Optical monitoring of retinal respiration in real time: 670 nm light increases the redox state of mitochondria.**	Rat		"Retinae of aged rats exposed to 670 nm for 5 mins showed consistent progressive increases in oxidation of COX 5 mins post exposure."	PubMed
	Eyes		Rezaei Kanavi	Iran (Tehran)	2016	Exp Eye Res	**Short-term effects of extremely low-frequency pulsed electromagnetic field and pulsed low-level laser therapy on rabbit model of corneal alkali burn.**	Rabbit		"he defect area was significantly less in the ELF, LLLT, and ELF + LLLT groups than in the control group ($P < 0.005$), and was comparable with that of the [medical therapy] group." "However, the histopathological results showed that LLLT was superior to magnetic therapy in terms of lower intensity of corneal inflammation, and LLLT had a lower rate of keratocyte loss than medical treatment." "Short-term LLLT is a noninvasive and safe treatment method that effectively improves the healing of corneas with alkali burns."	PubMed
★	Eyes		Geneva (Ivayla)	USA (Syracuse, NY)	2016	Int J Ophthalmol	**Photobiomodulation for the treatment of retinal diseases: a review.**	Review			PubMed
	Eyes		Eells	USA & Australia	2016	Adv Exp Med Biol	**Near-Infrared Photobiomodulation in Retinal Injury and Disease.**	Review	Retinal injury		PubMed

Eyes	Del Olmo-Aguado	Spain (Oviedo)	2016	Acta Ophthalmol	**Red light of the visual spectrum attenuates cell death in culture and retinal ganglion cell death in situ.**	Rat		"Low, non-toxic levels of red light focussed on the retina for a short period of time are sufficient to attenuate an insult of raised IOP to the rat retina. Since mitochondrial dysfunctions are thought to play a major role in ganglion cell death in glaucoma, we propose the potential use of red light therapy for the treatment of the disease."	PubMed
Eyes	Chu-Tan	Australia (Canberra)	2016	Int J Photoenergy	**Efficacy of 670 nm Light Therapy to Protect against Photoreceptor Cell Death Is Dependent on the Severity of Damage**	Rat	Light-induced damage	"670 nm light exhibited a biphasic response in its amelioration of cell death in light-induced degeneration in vivo. Lower light damage intensities required lower doses of 670 nm light to reduce TUNEL cell death. At higher damage intensities, the highest dose of 670 nm light showed protection. In vitro, the Seahorse XFe96 Extracellular Flux Analyzer revealed that 670 nm light directly influences mitochondrial metabolism by increasing the spare respiratory capacity of mitochondria in 661 W photoreceptor-like cells in light damaged conditions. Our findings further support the use of 670 nm light as an effective treatment against retinal degeneration as well as shedding light on the mechanism of protection through the increase of the mitochondrial spare respiratory capacity."	Hindawi
Eyes	Beirne	UK (Cardiff)	2016	Photochem Photobiol	**Red Light Treatment in an Axotomy Model of Neurodegeneration.**	Ex vivo (mouse)	Optic nerve injury (axotomy)	"The results demonstrate the ability of 670 nm light to partially prevent ex vivo dendropathy in the mouse retina, suggesting that it is worth exploring as a treatment option for dendropathy-associated neurodegenerative diseases, including glaucoma and Alzheimer's disease."	PubMed
Eyes	Ivandic & Ivandic	Germany (Heidelberg)	2015	Photomed Laser Surg	**Effects of Photobiomodulation Therapy on Patients with Primary Open Angle Glaucoma: A Pilot Study. [RETRACTED ARTICLE]**	Human	LED phototherapy	"Poor visual acuity (≤ 20/25), initially found in 24 of 63 eyes (38.1%), improved in 17 (70.8%) eyes and did not change in 7 eyes (29.2%)." "Mean IOP dropped from 24.9 ± 14.9 to 15.0 ± 6.5 mm Hg (-39.7%, p < 0.001)." "Visual fields were either fully restored, improved by at least 10 degrees, or remained unchanged in 32, 29, and 2 of 63 eyes (51%, 46%, and 3%), respectively." "Mean M-VEP latency was reduced by 13.5 msec (-8%, p < 0.001); mean amplitude increased by +677 nV (+14%, p < 0.001). Adverse effects were not observed. No changes were noted in control eyes." "This first small series of cases indicated that photobiomodulation might be a safe approach to lower IOP and to improve visual acuity and fields in eyes with POAG." RETRACTION NOTICE: "The second author of the article, Dr. Tomislav Ivandic, notified the Journal that inaccuracies in the reported parameters were discovered after publication of the article as a consequence of the information being translated from German (the authors' native language) into English. As a very serious repercussion of this error, Dr. Ivandic states that, 'Further studies or application based on these false doses would probably harm the eye.' The first-named author of the article, Dr. Boris Ivandic, disagrees with this declaration and states that, 'there is no mistake in the dose calculations using the parameters 10 mW power, 3 mm2 beam spot area as well as 30 or 90 sec time of irradiation, respectively.' Photomedicine and Laser Surgery is dedicated to upholding the integrity of the science it publishes. As a result of this irreconcilable dispute between the authors, the editorial leadership of the Journal is officially retracting this article from the literature in an effort to reduce any potential for iatrogenic injury in the event that the erroneous information was used to study or treat other patients. The authors regret this very unfortunate circumstance."	PubMed
Eyes	Sun	China (Shanghai)	2015	Lasers Med Sci	**Pre-exposure to low-power diode laser irradiation promotes cytoprotection in the rat retina.**	Rat	(Preconditioning)	"Pre-exposure to a 60-mW (34.27 J/cm(2) on the retina) power laser irradiation stimulates a hyperexpression of Hsp70 together with a hypoexpression of cleaved caspase 3 in rat retina, which may suggest a cellular protective effect." Higher-power laser induced some apoptosis but no other injury: "No retinal hemorrhage, necrosis, atrophy, or detachment was observed microscopically with HES staining 20 h after irradiation of 80 mW (44.88 J/cm2 on the retina)."	PubMed
Eyes	Saliba	USA (Ohio & Michigan)	2015	PLoS One	**Photobiomodulation Mitigates Diabetes-Induced Retinopathy by Direct and Indirect Mechanisms: Evidence from Intervention Studies in Pigmented Mice.**	Mouse	Diabetic eye	670nm light protected against retinopathy (in streptozotocin-induced diabetes).	PubMed
Eyes	Fuma	Japan	2015	Mol Vis	**Photobiomodulation with 670 nm light increased phagocytosis in human retinal pigment epithelial cells.**	In vitro (human)			PubMed
Eyes	Calaza	UK (London)	2015	Neurobiol Aging	**Mitochondrial decline precedes phenotype development in the complement factor H mouse model of retinal degeneration but can be corrected by near infrared light.**	Mouse	Age-related macular degeneration	"Near infrared (NIR) increases ATP and reduces inflammation. [...] In summary, we provide evidence for a mitochondrial basis for this disease in mice and correct this with simple light exposure known to improve mitochondrial function."	PubMed
Eyes	Koev K	Bulgaria (Sofia)	2015	Acta Ophthalmologica	**Aplication of low-level Laser therapy (LLLT) in patients with Retinitis Pigmentosa (RP) [Abstract]**	Human Case series		"There was a statistically significant increase in visual acuity ($p < 0.001$, end of study versus baseline) for RP patients for the period of 3 years after the LLLT. The mid-peripheral absolute concentric scotoma in RP was reduced after LLLT. No side effects were observed during the therapy." "This study shows that LLLT may be a novel long-lasting therapeutic option for RP. This is highly effective treatment that improves visual acuity for a long time."	Wiley
Eyes	Gkotsi	UK (London)	2014	Exp Eye Res	**Recharging mitochondrial batteries in old eyes. Near infra-red increases ATP.**	Mouse	Age-related macular degeneration	"When 12 month old mice were exposed to 670 nm for 90 s 7 times spaced over 84 h at an energy level of 40 mW/cm2 there was significant increase in retinal ATP of just under 20% from around 14,000 to 17,000 pm/mg ($P < 0.05$. Fig. 1B)." "In light of all these factors, it is likely that this treatment will benefit retinal disease. But this need not be confined to the eye, as declining ATP is a feature of all ageing tissues."	PubMed
Eyes	Giacci	Australia (Adelaide & Crawley)	2014	PLoS One	**Differential effects of 670 and 830 nm red near infrared irradiation therapy: a comparative study of optic nerve injury, retinal degeneration, traumatic brain and spinal cord injury.**	Rat	Light-induced damage Preconditioning	670nm (red light) had better effect on retina than 830nm (near-infrared).	PubMed

	Eyes	Di Marco	Italy (L'Aquila)	2014	PLoS One	**Combining neuroprotectants in a model of retinal degeneration: no additive benefit.**	Rat	Light-induced damage	[PBM protected eyes from light-induced retinal damage.]	PubMed
☎	Eyes	Tang	USA (Cleveland, OH)	2014	Br J Ophthalmol	**Photobiomodulation in the treatment of patients with non-center-involving diabetic macular oedema.**	Human Case series	Diabetic macular edema	"Daily PBM treatment for only 80 s per treatment twice daily caused a significant reduction in focal retinal thickening in all 4 treated eyes. No adverse effects attributable to therapy were noted by the patients or study investigators during the study period."	PubMed
	Eyes	Ahamed Basha	India (Chennai)	2014	Ann Anat	**Protective effect of light emitting diode phototherapy on fluorescent light induced retinal damage in Wistar strain albino rats.**	Rat	Light-induced damage LED phototherapy	"Animals of the FL group showed a significant reduction in the outer nuclear layer thickness and cell count in addition to the total thickness of the retina. LL group which were exposed to 670 nm LED prior to exposure to fluorescent light showed a significant decrease in the degree of damage."	PubMed
	Eyes	Marco	Italy (L'Aquila)	2013	Am J Neurodegener Dis	**The time course of action of two neuroprotectants, dietary saffron and photobiomodulation, assessed in the rat retina.**	Rat	Light-induced damage Preconditioning	"Preconditioning the retina with saffron or PBM reduced photoreceptor death, preserved the population of surviving photoreceptors and reduced the upregulation of GFAP in Müller cells. At the daily dose of saffron used (1 mg/kg), protection was detectable at 2 d, increasing to 10 d. At the daily dose of PBM used (5 J/cm(2) at 670 nm) protection was detectable at 5 d, increasing to 7-10 d."	PubMed
★	Eyes	Tang	USA (Ohio)	2013	Invest Ophthalmol Vis Sci	**Low-intensity far-red light inhibits early lesions that contribute to diabetic retinopathy: in vivo and in vitro.**	Rat + In vitro	Diabetic eye	Red light ameliorated lesions of diabetic retinopathy in vivo and reduced oxidative stress and cell death in vitro.	PubMed
	Eyes	Rodríguez-Santana & Santana-Blank	Venezuela (Caracas)	2013	Photomed Laser Surg	**Laser photobiomodulation as a potential multi-hallmark therapy for age-related macular degeneration.**	Guest Editorial			PubMed
	Eyes	Natoli	Australia (Canberra)	2013	PLoS One	**670nm photobiomodulation as a novel protection against retinopathy of prematurity: evidence from oxygen induced retinopathy models.**	Mouse & Rat	Oxygen-induced damage & Lung damage	"670 nm light reduced neovascularisation, vaso-obliteration and abnormal peripheral branching patterns of retinal vessels in OIR. The neural retina was also protected against OIR by 670 nm light exposure. OIR-exposed animals had severe lung pathology, including haemorrhage and oedema, that was significantly reduced in 670 nm+OIR light-exposed animals."	PubMed
	Eyes	Kokkinopoulos I	UK (London)	2013	J Photochem Photobiol B	**670 nm LED ameliorates inflammation in the CFH−/− mouse neural retina**	Mouse	Retinal inflammation (complement factor H deficiency)	"These regimes significantly reduced activated macrophage number, TNF-alpha and MIF protein expression levels. Immuno-reactivity to C3, C3b and calcitonin, all markers of inflammatory status were also altered. Finally, innate immune proteins, TLR 2 and 4, showed a marked decrease in protein expression."	PubMed
	Eyes	Kokkinopoulos	UK (London)	2013	Neurobiol Aging	**Age-related retinal inflammation is reduced by 670 nm light via increased mitochondrial membrane potential.**	Mouse	Age-related macular degeneration	"Aged mice were exposed to only five 90-second exposures over 35 hours. This significantly increased mitochondrial membrane polarization and significantly reduced macrophage numbers and tumor necrosis factor (TNF)-alpha levels, a key proinflammatory cytokine. Three additional inflammatory markers were assessed; complement component 3d (C3d), a marker of chronic inflammation and calcitonin, and a systemic inflammatory biomarker were significantly reduced. Complement component 3b (C3b), a marker of acute inflammation, was not significantly altered." "These results provide a simple route to combating inflammation in an aging population with declining visual function and may be applicable to clinical conditions where retinal inflammation is a key feature."	PubMed
★	Eyes	Begum	UK	2013	PLoS One	**Treatment with 670 nm light up regulates cytochrome C oxidase expression and reduces inflammation in an age-related macular degeneration model.**	Mouse	Age-related macular degeneration	"Exposed animals had significant increase in cytochrome c oxidase (COX), which is a mitochondrial enzyme regulating oxidative phosphorylation. There was a significant reduction in complement component C3, an inflammatory marker in the outer retina. Vimetin and glial fibrillary acidic protein (GFAP) expression, which reflect retinal stress in Muller glia, were also significantly down regulated. There were also significant changes in outer retinal macrophage morphology."	PubMed
	Eyes	Albarracin	Australia (Canberra)	2013	BMC Neurosci	**670 nm light mitigates oxygen-induced degeneration in C57BL/6J mouse retina.**	Mouse	Oxygen-induced damage	"Pretreatment with 670 nm red light reduced expression of markers of oxidative stress and C3, and slowed, but did not prevent, photoreceptor loss over the time course of hyperoxia exposure."	PubMed
	Eyes	Rutar	Australia (Canberra)	2012	J Neuroinflammation	**670-nm light treatment reduces complement propagation following retinal degeneration.**	Rat		"Our data indicate that 670-nm light pretreatment reduces lipid peroxidation and complement propagation in the degenerating retina. These findings have relevance to the cellular events of complement activation underling the pathogenesis of AMD, and highlight the potential of 670-nm light as a non-invasive anti-inflammatory therapy."	PubMed
★ ☎	Eyes	Gopalakrishnan S	USA (Milwaukee, WI)	2012	DISSERTATION (University of Wisconsin-Milwaukee)	**Photobiomodulation in Inherited Retinal Degeneration**	Rat	P23H transgenic	830 nm PBM exerted a robust retinoprotective effect compared to 670 nm PBM in the P23H transgenic rat model. Star: The dissertation contains a lot of details and photographs. Worth a read.	UWM
	Eyes	Albarracin & Valter	Australia (Canberra)	2012	Photochem Photobiol	**670 nm red light preconditioning supports Müller cell function: evidence from the white light-induced damage model in the rat retina.**	Rat		Red light pretreatment ameliorated the light-induced alterations in the expression of Müller-cell specific markers for structure, stress, metabolism and inflammation.	PubMed
	Eyes	Albarracin & Valter	Australia (Canberra)	2012	Adv Exp Med Biol	**Treatment with 670-nm light protects the cone photoreceptors from white light-induced degeneration.**	Rat	Light-induced damage	Damaging effects of white light on the photoreceptor population, function and structure were ameliorated by red light.	PubMed
☹	Eyes	Koev	Bulgaria (Sofia)	2012	Acta Ophthalmol	**Two year follow-up of low-level laser therapy (LLLT) in patients with age-related macular degeneration (AMD) [ABSTRACT]**	Human Abstract only	AMD	"Visual acuity remained unchanged in all patients in the control group. There was a statistically significant increase in visual acuity (p<0.001, end of study versus baseline) for AMD patients for the period of 2 years after the treatment. The edema and hemorrhage in the patients with progressive, exudative AMD significantly decreased. No side effects were observed during the therapy. The prevalence of metamorphopsia, scotoma in AMD group was reduced." Comment: The results are quite similar to Ivandic's. The dose seems very low. Parameters are incompletely reported.	Wiley
	Eyes	Ivandic & Ivandic	Germany (Heidelberg)	2012	Photomed Laser Surg	**Low-level laser therapy improves visual acuity in adolescent and adult patients with amblyopia.**	Human	Amblyopia	"Visual acuity improved in ~90% of the eyes treated with LLLT (p<0.001), increasing by three or more lines in 56.2% and 53.6% of the eyes with amblyopia caused by ametropia and strabismus, respectively. The treatment effect was maintained for at least 6 months. The mean M-VEP amplitude increased by 1207 nV (p<0.001) and mean latency was reduced by 7 msec (p=0.14). No changes were noted in the control group." "LLLT led to a significant improvement in visual acuity in adolescent and adult patients with amblyopia caused by ametropia or strabismus."	PubMed

	Eyes	Koev	Bulgaria (Sofia)	2011	Proc SPIE	**He-Ne low level laser therapeutic applications for treatment of corneal trauma [Proceedings article]**	Human	Foreign body in the cornea (corneal trauma)	"For irradiated eyes by LLLT, we have found that the healing period is shortened significantly by 42 % (p<0,001). Our results revealed that LLLT application is appropriate and perspective for recovery therapy after corpus alienum corneae extraction."	SPIE
	Eyes	Albarracin	Australia (Canberra)	2011	Invest Ophthalmol Vis Sci	**Photobiomodulation protects the retina from light-induced photoreceptor degeneration.**	Rat	Light-induced damage	Red light attenuated histopathological alterations and abolished microglial invasion of the retina.	PubMed
	Eyes	Qu	China (Sichuan)	2010	Adv Exp Med Biol	**Near-infrared light protect the photoreceptor from light-induced damage in rats.**	Rat	Light-induced damage	A red LED was protective against light-induced retinal damage.	PubMed
	Eyes	Natoli	Australia	2010	Mol Vis	**Gene and noncoding RNA regulation underlying photoreceptor protection: microarray study of dietary antioxidant saffron and photobiomodulation in rat retina.**	Rat		In this study, they also investigated the effects of LLLT on gene expression.	PubMed
☹	Eyes	Koev	Bulgaria (Sofia)	2010	Acta Medica Bulgarica	**He-Ne low level laser therapeutic applications for treatment of acute iridocyclitis**	Human	Device: Mediray 04	"For irradiated eyes by LLLT, we have found that the healing period is shortened signi¿ cantly by 40 % (p<0,001)" Comment: The parameters were very poorly reported. Even treatment time is unknown.	PDF
	Eyes	Ivandic	Germany (Heidelberg)	2009	Photomed Laser Surg	**Early diagnosis of ocular hypertension using a low-intensity laser irradiation test.**			"In this study of a case series we examined the potential use of LILI as a tool to determine the individual physiological IOP. The aim was to differentiate between normoand hypertensive eyes by classifying changes in IOP after irradiation of the limbus area of the eye with a weak laser." "We report here for the first time that LILI of the limbus area of the eye may lower the IOP. The laser power used here does not cause thermal damage and may well reach the ciliary body and the trabecular meshwork as previously shown." "A study limitation is the lack of long-term observations after LILI. It is currently unknown, how long the effects of a single LILI treatment last." "The largest decrease in IOP (26%) was observed in eyes with a pathological baseline IOP of >21 mm Hg which exhibited ocular hypertension without damage. However, LILI also decreased IOP in most eyes (73%) with a 'normotensive' baseline IOP reaching a mean level of 14.1 mm Hg in this group, which is in agreement with the accepted population-based normative IOP." "The diagnostic 'LILI test' introduced here, may be particularly useful to detect latent ocular hypertension in eyes with apparently ‘‘normotensive’’ but potentially nonphysiological IOP, if ocular hypertension is associated with an open angle. Eyes with ocular hypertension may be at risk of developing glaucoma later on. Untreated ocular hypertension leads to glaucoma in 9.5% of cases."	PubMed
	Eyes	Rojas	USA (Austin, TX)	2008	J Neurosci	**Neuroprotective effects of near-infrared light in an in vivo model of mitochondrial optic neuropathy.**	Rat	Optic neuropathy (rotenone) LED phototherapy	"Rotenone induced a decrease in visual function, as determined by changes in the dark-adapted illuminance sensitivity threshold, escape latency and rate of successful trials in a two-choice visual task, compared with vehicle-treated controls. Behavioral impairment correlated with a decrease in retinal and visual pathway metabolic activity, retinal nerve fiber layer thickness and ganglion cell layer cell density. These changes were prevented by NIL treatments in a dose-dependent manner. Whole-brain cytochrome oxidase and superoxide dismutase activities were also increased in NIL-treated subjects in a dose-dependent manner, suggesting an in vivo transcranial effect of NIL. In whole-brain membrane isolates, NIL prevented the rotenone-induced decrease in cell respiration. The results show that NIL treatment can effectively prevent the neurotoxic effects of rotenone and that it might be used in the treatment of neurodegenerative disorders associated with mitochondrial dysfunction."	PubMed
	Eyes	Ivandic & Ivandic	Germany	2008	Photomed Laser Surg	**Low-level laser therapy improves vision in patients with age-related macular degeneration.**	Human Retrospective data	Age-related macular degeneration	LLLT improved visual acuity in 162/182 (95%) of eyes with cataracts and 142/146 (97%) of eyes without cataracts. The prevalence of metamorphopsia, scotoma, and dyschromatopsia was reduced. In patients with wet AMD, edema and bleeding improved. The improved vision was maintained for 3-36 mo after treatment. No adverse effects were observed.	PubMed
★	Eyes	Eells	USA (Milwaukee, WI)	2003	Proc Natl Acad Sci U S A	**Therapeutic photobiomodulation for methanol-induced retinal toxicity.**	Rat	Methanol toxicity LED phototherapy	"Our studies document a significant recovery of rod- and cone-mediated function in LED-treated, methanol-intoxicated rats. We further show that LED treatment protected the retina from the histopathologic changes induced by methanol-derived formate. These findings provide a link between the actions of monochromatic red to near-IR light on mitochondrial oxidative metabolism in vitro and retinoprotection in vivo."	PubMed
	Eyes	Prokof'eva	Russia	1996	Vestn Oftalmol	**[Effects of low-intensity infrared laser irradiation on the eye (an experimental study)]. [Article in Russian]**	Rabbit		"An increase of intraocular pressure was recorded at a dose of 0.1 J/cm2 (4.5 min) and higher; morphological study showed dilated, well-filled and newly formed vessels in the ciliary body and iris, as well as edema and destruction of the external layers of the retina. Exposure to a dose of 0.05 J/cm2 and lower did not lead to destruction of ocular structures and increase of intraocular pressure." Comment: They reported harmful effects with a suspiciously low dose...	PubMed
	Eyes	Belkin & Schwartz	Israel (Ramat Gan)	1994	Surv Ophthalmol	**Ophthalmic effects of low-energy laser irradiation.**	Review			PubMed
	Eyes	Sokolovskii	Russia	1990	Oftalmol Zh	**[The stimulating effect of helium-neon laser radiation on rabbit eyes]. [Article in Russian]**	Rabbit		Comment: Very low dose was used... Is it even possible to see such a low-power laser ray?	PubMed

Eyes		Shmyreva	Russia	1989	Oftalmol Zh	**[The mechanism of action of laser stimulation of the eye]. [Article in Russian]**	Human		"The mechanism of action of helium-neon laser stimulation has been studied in 26 eyes of 15 patients with dystrophic diseases of the eye and on the ground of 63 lymphangiographic investigations of the same patients. It was found that low-energy helium-neon laser stimulation (0.05-0.5 mWt/cm2) has a positive effect on restoration of visual functions. Lymphangiographic investigations have revealed a new biological phenomenon--activation of disturbed lymphatic flow under the action of a specially organized laser radiation. The results obtained confirm the earlier hypothesis (M. M. Krasnov et al., 1982) that under the action of laser radiation a normal physiologic system purifying the retina from disintegrated products is engaged ..."	PubMed
Fertility and genitals	Dyssmenorrhea	Shin	Korea (Yangsan)	2012	Arch Gynecol Obstet	**Skin adhesive low-level light therapy for dysmenorrhoea: a randomized, double-blind, placebo-controlled, pilot trial.**	Human RCT/DB		"The pain reduction rate was 83 % in the active LLLT group, whereas there was only a slight and temporary reduction in pain in the placebo LLLT group. Changes of VAS within 6 months of LLLT showed statistical significance (p = 0.001) over placebo control." "In conclusion, this study supported our hypothesis that the direct cause of dysmenorrhoea might not be changes in bioactive substances, such as hormone imbalance, a decrease in serotonin levels or excessive prostaglandin production, but the abnormal function of parts of smooth muscles in the uterus secondary to long-term deficient blood supply into smooth muscle tissue caused by disease or stress. This study also suggests that skin adhesive LLLT administered to acupuncture points might be an effective, simple, safe non-pharmacological method for the treatment of dysmenorrhoea. This study also shows the possibility that even low-level light stimulation on acupuncture points can relax smooth muscles of internal organs through meridians. To the best of our knowledge, this is the first study on the treatment of dysmenorrhoea	PubMed
Fertility and genitals	Infertility	Karu TI	Russia	2012	Photomed Laser Surg	**Lasers in infertility treatment: irradiation of oocytes and spermatozoa.**	Guest Editorial			PubMed
Fertility and genitals	Sperm motility	Siqueira	Brazil (São Paulo)	2016	Lasers Med Sci	**Effects of photobiomodulation therapy (PBMT) on bovine sperm function.**	In vitro	Bovine sperm	"Results showed significant effects depending on power while using 10 min of irradiation on motility parameters and mitochondrial potential. However, no effect was observed using 5 min of irradiation, regardless of power applied." "In conclusion, PBMT is effective to modulate bovine sperm function. The effectiveness is dependent on the interaction between power applied and duration of irradiation, showing that these two parameters simultaneously influence sperm function. In this context, when using the same fluency and energy with different combinations of power and time of exposure, we observed distinct effects, revealing that biological effects should be also based on simple parameters rather than only composite parameters such as fluency, irradiance and energy. Laser irradiation of frozen/thawed bovine semen led to an increase on mitochondrial function and motility parameters that could potentially improve fertility rates."	PubMed
Fertility and genitals	Sperm motility	Ban Frangez	Slovenia (Ljubljana)	2015	Lasers Med Sci	**Photobiomodulation with light-emitting diodes improves sperm motility in men with asthenozoospermia.**	In vitro	Human sperm LED phototherapy	"This finding confirmed that photobiomodulation using LED improved the sperm motility in asthenozoospermia regardless of the wavelength." Comment: Interesting result, since blue light was effective too.	PubMed
Fertility and genitals	Sperm motility	Fernandes	Brazil (São Paulo)	2015	PLoS One	**The effect of low-level laser irradiation on sperm motility, and integrity of the plasma membrane and acrosome in cryopreserved bovine sperm.**	In vitro	Bovine spern Biphasic dose response	"We conclude that LLLI may exert beneficial effects in the preservation of live sperm. A dose of 4 joules prior to cryopreservation was more effective than a dose of 6 joules in preserving sperm motility."	PubMed
Fertility and genitals	Sperm motility	Salman Yazdi	Iran (Tehran)	2014	Lasers Med Sci	**Effect of 830-nm diode laser irradiation on human sperm motility.**	In vitro	Human sperm	"Sperm motility of the control groups significantly decreased after 30, 45 and 60 min of irradiation, while those of irradiated groups remained constant or slightly increased by passing of time. Significant increases have been observed in doses of 4 and 6 J/cm(2) at the times of 60 and 45 min, respectively. SCD test also revealed a non-significant difference."	PubMed
Fertility and genitals	Sperm motility	Drozdov	Russia (Vladivostok)	2014	Dokl Biochem Biophys	**Influence of low-intensity red diode and laser radiation on the locomotor activity of sea urchin sperm.**	In vitro	Sea urchin sperm	"In this study, we showed that lowintensity red light diode and laser radiation affect the locomotor activity of sea urchin sperms, 2–5 times increasing the per centage of active cells depending on the time elapsed after exposure."	PubMed
Fertility and genitals	Sperm motility	Corral-Baqués	Spain	2009	Lasers Med Sci	**The effect of low-level laser irradiation on dog spermatozoa motility is dependent on laser output power.**	In vitro	Dog sperm	"The results showed that different output powers affected dog semen motility parameters differently. The highest output power showed the most intense effects. Significant changes in the structure of the motile sperm subpopulation were linked to the different output powers used."	PubMed
Fertility and genitals	Sperm motility	Corral-Baqués	Spain (Reus)	2005	Lasers Med Sci	**Effect of 655-nm diode laser on dog sperm motility.**	In vitro	Dog sperm	"Average path velocity (VAP), linear coefficient (Lin) and beat cross frequency (BCF) were statistically and significantly different when compared to the control. The functional tests also showed a significant difference. At these parameters, the 655-nm continuous-wave diode laser improves the speed and linear coefficient of the sperm."	PubMed
Fertility and genitals	Testicle	Alves	Brazil (Pirassununga)	2016	Lasers Med Sci	**Low-level laser therapy to recovery testicular degeneration in rams: effects on seminal characteristics, scrotal temperature, plasma testosterone concentration, and testes histopathology.**	Ram	Biphasic dose response	"Thus, in concern to the results, it is possible to conclude that LLLT at energy of 28 J/cm2 , 808 nm of wavelength, and 30 mW of power output can induce semen injuries and increase the quantities of cells in seminiferous tubule when detected 32 days after LLLT treatment. However, this increase did not occur in a long time after the therapy and in animals that did not present testicular degeneration. LLLT in this condition is not efficient to increase serum testosterone concentration, and consequently, it is not efficient to stimulate Leydig cells. It is an evident need for further studies investigating the effect of LLLT in testicular degeneration with other protocols and other methods to measure its biostimulatory effects."	PubMed
Fertility and genitals	Testicle	Al-Ebady	Iraq	2014	Int J Adv Res	**The effect of expose the rat testis to low level laser light on changing serum LH and testosterone levels**	Rat	Biphasic dose response Toxicity	"The results showed that there was significant (P<0.05) decrease in serum LH level in group II when compared with group I and control, while serum T levels were not significantly higher between groups, and there was clear histopathological changes in right testes seminiferous tubules of group II which exposed to 12 joules of laser light."	IJAR

	Fertility and genitals	Testicle	Ahn	Korea (Cheonan)	2013	Biomed Res	**The effects of low level laser therapy (LLLT) on the testis in elevating serum testosterone level in rats.**	Rat		"Our results showed that the rate of tissue penetration was significantly higher in the 808 nm wavelength group as compared with the 670 nm wavelength group (P<0.05); serum T level was not significantly higher in the experimental groups as compared with the control group; but serum T level was significantly elevated in the 670 nm wavelength group on day 4. Thus the LLLT using a 670-nm diode laser was effective in increasing serum T level without causing any visible histopathological side effects. In conclusion, the LLLT might be an alternative treatment modality to the conventional types of testosterone replacement therapy." Comment: This finding was published in a very-low impact journal, not indexed by PubMed.	PDF
	Fertility and genitals	Testicle	Taha & Valojerdi	Iran (Tehran)	2004	Lasers Surg Med	**Quantitative and qualitative changes of the seminiferous epithelium induced by Ga. Al. As. (830 nm) laser radiation.**	Rat	Toxicity (with high dose) Biphasic dose response	"The number of germ cells specially the pachytene spermatocytes and elongated spermatids increased after 28.05 J/cm(2) laser radiation. Ultrastructural features of germ and Sertoli cells in this group were similar to that of control; while laser irradiation at 46.80 J/cm(2) had a destructive effect on the seminiferous epithelium such as dissociation of immature spermatids and evident ultrastructural changes in them." "Moreover, it was revealed that low doses of laser light have a biostimulatory effect on the spermatogenesis and may provide benefits to the patients with oligospermia and azoospermia."	PubMed
	Fibromyalgia		da Silva	Brazil (São Paulo)	2015	Trials	**Effects of exercise training and photobiomodulation therapy (EXTRAPHOTO) on pain in women with fibromyalgia and temporomandibular disorder: study protocol for a randomized controlled trial.**	Study protocol			PubMed
	Fibromyalgia		Ruaro	Brazil (Guarapuava)	2014	Lasers Med Sci	**Low-level laser therapy to treat fibromyalgia.**	Human RCT		"LLLT provided relief from fibromyalgia symptoms in patients and should be further investigated as a therapeutic tool for management in fibromyalgia."	PubMed
☹	Fibromyalgia		Fernández García	Spain (Almería)	2011	Reumatol Clin	**Using a laser based program in patients diagnosed with fibromyalgia**	Human RCT		Comment: This paper reported very slightly positive results. Parameters were reported very poorly and there is a formatting error in the table showing treatment results.	PubMed
	Fibromyalgia		Armagan	Turkey (Eskisehir)	2006	J Back Musculoskelet Rehabil	**Long-term efficacy of low level laser therapy in women with fibromyalgia: A placebo-controlled study**	Human RCT		"Our results suggest that LLLT has both short- and long-term effectiveness in the treatment of fibromyalgia."	IOS Press
	Fibromyalgia		Gür	Turkey (Diyarbakir)	2002	Rheumatol Int	**Effects of low power laser and low dose amitriptyline therapy on clinical symptoms and quality of life in fibromyalgia: a single-blind, placebo-controlled trial.**	Human RCT/SB		"Our study suggests that both amitriptyline and laser therapies are effective on clinical symptoms and QOL in fibromyalgia and that Ga-As laser therapy is a safe and effective treatment in cases with FM. Additionally, the present study suggests that the Ga-As laser therapy can be used as a monotherapy or as a supplementary treatment to other therapeutic procedures in FM."	PubMed
	Fibromyalgia		Gür	Turkey (Diyarbakir)	2002	Lasers Med Sci	**Efficacy of low power laser therapy in fibromyalgia: a single-blind, placebo-controlled trial.**	Human RCT/SB		"Our study suggests that laser therapy is e#ective on pain, muscle spasm, morning sti#ness, and total tender point number in fibromyalgia and suggests that this therapy method is a safe and e#ective way of treatment in the cases with fibromyalgia."	PubMed
	Flatworms	Dugesia tigrina	Wu & Persinger	Canada (Ontario)	2011	J Photochem Photobiol B	**Increased mobility and stem-cell proliferation rate in Dugesia tigrina induced by 880nm light emitting diode.**	Dugesia tigrina		"These findings suggest that non-coherent light sources with power-densities about 1000 times lower than contemporary low-power laser settings remain effective in generating photobiostimulation effects and warrants further investigation on stem-cell proliferation induced by near-infrared light emitting diodes."	PubMed
	Flatworms	Dugesia tigrina	Lopes	Brazil (São José dos Campos)	2009	Braz J Biol	**A study of low power laser on the regenerative process of Girardia tigrina (Girard,1850) (Turbellaria; Tricladida; Dugesiidae).**	Dugesia tigrina		"The head fragment after 1 minute of irradiation presented a better organized tissue scheme, when compared with the other treatments. Aspects of the body fragments submitted to 3 minutes of light treatment were very similar to fragments that had not been injured. It can be concluded that there are changes in the quality of regeneration when treated with low power laser under the conditions mentioned above."	PubMed
	Flatworms	Dugesia tigrina	de Souza	Brazil (São José dos Campos)	2005	J Photochem Photobiol B	**Low power laser radiation at 685 nm stimulates stem-cell proliferation rate in Dugesia tigrina during regeneration.**	Dugesia tigrina		"A remarkable increase in stem cells counts for the fourth day of regeneration was observed when the regenerating worms was stimulated by the laser radiation. Our findings encourage further research works on the influence of optical radiation onto stem cells and tissue regeneration."	PubMed
	Fluorescent lamps		Ahamed	India	2016	Lasers Med Sci	**Effect of LED photobiomodulation on fluorescent light induced changes in cellular ATPases and Cytochrome c oxidase activity in Wistar rat.**	Rat		"This study demonstrates the protective effect of 670 nm LED pre exposure on cellular enzymes against fluorescent light induced change." Note: See also the another paper from this group, in the Eyes-category.	PubMed
	Gastroenterology	Atrophic gastritis	Yang	China (Zhangjiakou)	2005	Sheng Wu Yi Xue Gong Cheng Xue Za Zhi	**[Effects of He-Ne laser on gastric mucosa in rat with chronic atrophic gastritis].** **[Article in Chinese]**	Rat	Biphasic dose response	"Compared with untreated group, the gastric mucosa of 3.36J x cm(-2) He-Ne laser group was significantly thicker (P < 0.01), the inflammatory cells of gastric mucosa were decreased (P < 0.05), the morphology, structure and volume of the cells were restored or nearly normal and the expressions of cyclinD1 were higher (P < 0.05). In a word, small dose He-Ne laser (3.36 J x cm(-2)) has a good adjuvant therapeutic effect on rat's GAG."	PubMed
	Gastroenterology	Atrophic gastritis	Shao	China (Zhangjiakou)	2005	World J Gastroenterol	**Effects of He-Ne laser irradiation on chronic atrophic gastritis in rats.**	Rat	Biphasic dose response	"After 3.36 J/cm(2) dose of He-Ne laser treatment for 20 d, the secretion of gastric acid was increased (P<0.05), the thickness of gastric mucosa was significantly thicker than that in model control group (P<0.01), the gastric mucosal inflammation cells were decreased (P<0.05). Morphology, structure and volume of the parietal cells all recuperated or were closed to normal." Comment: In higher dose groups, no benefit was noted.	PubMed
	Gastroenterology	Colitis	Zigmond	Israel (Tel Aviv)	2014	Photomed Laser Surg	**Low-level light therapy induces mucosal healing in a murine model of dextran-sodium-sulfate induced colitis.**	Mouse	Biphasic dose response	"The three wavelengths used demonstrated efficacy, and a clear dose-response curve was observed for one of the wavelengths (850 nm). On day 11, colonoscopic scoring in the sham-treated mice increased from 7.9±1.3 to 12.2±2.2, while activity in all treated groups remained stable." Note: In another study (J Gastroenterol Hepatol 2014 Apr;29(4):749-56), bright light therapy with 1000lux alleviated colitis compared to 200lux light, while 2500lux didn't have a beneficial effect.	PubMed
	Gastroenterology	Ulcerative colitis	Dubinkin & Mimrikova	Russia	1999	-	**Complex treatment of non-specific ulcerative colitis with low-level HeNe laser used transanally**	Human		["81 patients (average age 42) with non-specific ulcerous colitis were treated with trans-anal HeNe laser. After 10-12 sessions 72% of the patients noted a reduction of pain and the stool became rare. Coloscopy showed that the mucous membrane regenerated rapidly with an increased vascular picture."]	
	Gene expression		Tim	Brazil	2016	J Photochem Photobiol B	**Effects of low level laser therapy on inflammatory and angiogenic gene expression during the process of bone healing: A microarray analysis.**	Rat		"Our findings indicate that LLLT was efficient on accelerating the development of newly formed bone probably by modulating the inflammatory and angiogenic gene expression as well as COX2 and VEGF immunoexpression during the initial phase of bone healing."	PubMed

	Gene expression		Houreld	South Africa (Johannesburg)	2014	J Photochem Photobiol B	**Expression of genes in normal fibroblast cells (WS1) in response to irradiation at 660nm.**	In vitro		"This study aimed to profile 84 genes in response to irradiation at 660nm." "A total of 76 genes were regulated by laser irradiation, 43 genes were up-regulated while 33 genes were down-regulated. Irradiation of WS1 cells at 660nm modulates the expression of genes involved in collagen production, cellular adhesion, remodelling and spreading, the cytoskeleton, inflammatory cytokines and chemokines, growth factors and molecules involved in signal transduction."	PubMed
	Gene expression		Masha	South Africa (Johannesburg)	2013	Photomed Laser Surg	**Low-intensity laser irradiation at 660 nm stimulates transcription of genes involved in the electron transport chain.**			"LILI upregulated cytochrome c oxidase subunit VIb polypeptide 2 (COX6B2), cytochrome c oxidase subunit VIc (COX6C), and pyrophosphatase (inorganic) 1 (PPA1) in diabetic wounded cells; COX6C, ATP synthase, H+transporting, mitochondrial Fo complex, subunit B1 (ATP5F1), nicotinamide adenine dinucleotide (NADH) dehydrogenase (ubiquinone) 1 alpha subcomplex, 11 (NDUFA11), and NADH dehydrogenase (ubiquinone) Fe-S protein 7 (NDUFS7) in wounded cells; and ATPase, H+/K+ exchanging, beta polypeptide (ATP4B), and ATP synthase, H+ transporting, mitochondrial Fo complex, subunit C2 (subunit 9) (ATP5G2) in ischemic cells." "LILI at 660 nm stimulates the upregulation of genes coding for subunits of enzymes	PubMed
	Gene expression		Peplow	New Zealand (Dunedin)	2011	Photomed Laser Surg	**Laser photobiomodulation of gene expression and release of growth factors and cytokines from cells in culture: a review of human and animal studies.**	Systematic review			PubMed
	Gene expression		Safavi	Iran	2008	Lasers Med Sci	**Effects of low-level He-Ne laser irradiation on the gene expression of IL-1beta, TNF-alpha, IFN-gamma, TGF-beta, bFGF, and PDGF in rat's gingiva.**	Rat		"The case and control groups did not have a significant difference in the gene expression of TNF-alpha and bFGF (P > 0.05)." "These findings suggest that low-level He-Ne laser irradiation decreases the amount of inflammation and accelerates the wound healing process by changing the expression of genes responsible for the production of inflammatory cytokines."	PubMed
	General	Laser	Rola	Poland (Wroclaw)	2014	Adv Clin Exp Med	**The Use of Low-Level Energy Laser Radiation in Basic and Clinical Research.**	Review			PubMed
	General	LED	Lim S	Korea (Cheonan)	2011	J Soc Inf Disp	**Phototherapy and the benefits of LEDs**				Wiley
	General	LED	Desmet	USA (Milwaukee, WI)	2006	Photomed Laser Surg	**Clinical and experimental applications of NIR-LED photobiomodulation.**	Review	LED phototherapy		PubMed
	Hair		Keene	USA (Tucson, AZ)	2016	Exp Dermatol	**Illuminating current pitfalls in optimal photobiomodulation device development and assessment for treating hair loss.**	Commentary			PubMed
	Hair		Mignon	UK & Netherlands	2016	Exp Dermatol	**Photobiomodulation devices for hair regrowth and wound healing: a therapy full of promise but a literature full of confusion.**	Review	Parameters		PubMed
	Hair		Gupta & Foley	Canada (Toronto & London, Ontario)	2016	Dermatol Surg	**A Critical Assessment of the Evidence for Low-Level Laser Therapy in the Treatment of Hair Loss.**	Systematic review	Hair loss treatment		PubMed
	Hair		Afifi	USA (Miami, FL)	2016	Lasers Surg Med	**Low-level laser therapy as a treatment for androgenetic alopecia.**	Systematic review	Androgenetic alopecia		PubMed
	Hair		Sheen	Taiwan (Taipei)	2015	Lasers Surg Med	**Visible red light enhances physiological anagen entry in vivo and has direct and indirect stimulative effects in vitro.**	In vitro	Anagen entry	"These results suggest that hair follicles respond to visible light in vivo. Red light may promote physiological telogen to anagen transition by directly stimulating outer root sheath keratinocytes and indirectly by enhancing epithelial-mesenchymal interaction in vitro."	PubMed
	Hair		Olivieri	Italy (Spilamberto)	2015	Vet Dermatol	**Efficacy of low-level laser therapy on hair regrowth in dogs with noninflammatory alopecia: a pilot study.**	Dog	Alopecia, non-inflammatory	"By morphometry, the area occupied by hair follicles was 18% in the treated sample and 11% in the untreated one (11%)" "Haired follicles were (per area) 93% in the treated sample and only 9% in the control sample." Comment: Article has some nice photographs of the LLLT device/treatment and the effects	PubMed
	Hair		Munck	Brazil & Switzerland	2014	Int J Trichology	**Use of low-level laser therapy as monotherapy or concomitant therapy for male and female androgenetic alopecia.**	Human Retrospective data	Androgenetic alopecia HairMax Laser Comb(®)	"LLLT represents a potentially effective treatment for both male and female AGA, either as monotherapy or concomitant therapy."	PubMed
	Hair		Lanzafame	USA (Rochester, NY)	2014	Lasers Surg Med	**The growth of human scalp hair in females using visible red light laser and LED sources.**	Human (♀) RCT/DB	Androgenetic alopecia TOPHAT655 device	"LLLT of the scalp at 655 nm significantly improved hair counts in women with androgenetic alopecia at a rate similar to that observed in males using the same parameters."	PubMed
	Hair		Gupta & Daigle	Canada (Toronto)	2014	J Dermatolog Treat	**The use of low-level light therapy in the treatment of androgenetic alopecia and female pattern hair loss.**	Review	Androgenetic alopecia		PubMed
	Hair		Avci	USA (Boston, MA)	2014	Lasers Surg Med	**Low-level laser (light) therapy (LLLT) for treatment of hair loss.**	Review	Hair loss		PubMed
☹	Hair		Wikramanayake	USA (Miami, FL)	2013	Lasers Med Sci	**Low-level laser treatment accelerated hair regrowth in a rat model of chemotherapy-induced alopecia (CIA).**	Mouse	Chemotherapy-induced alopecia	"Taken together, our results demonstrated that LLL treatment significantly accelerated hair regrowth after CIA without compromising the efficacy of chemotherapy in our rat model." Star: Results are very interesting, and a photograph is supplied. Comment: Parameters were poorly reported	PubMed
	Hair		Lanzafame	USA (Rochester, NY)	2013	Lasers Surg Med	**The growth of human scalp hair mediated by visible red light laser and LED sources in males.**	Human (♂) RCT/DB	Androgenetic alopecia TOPHAT655 device	"LLLT of the scalp at 655 nm significantly improved hair counts in males with androgenetic alopecia."	PubMed

	Hair		Kim	Korea (Seongnam)	2013	Dermatol Surg	**Low-level light therapy for androgenetic alopecia: a 24-week, randomized, double-blind, sham device-controlled multicenter trial.**	Human RCT/DB	Androgenetic alopecia	"After 24 weeks of treatment, the LLLT group showed significantly greater hair density than the sham device group. Mean hair diameter improved statistically significantly more in the LLLT group than in the sham device group. Investigator global assessment showed a significant difference between the two groups, but that of the subject did not."	PubMed
	Hair		Ghanaat M	USA (Brooklyn, NY)	2010	South Med J	**Types of hair loss and treatment options, including the novel low-level light therapy and its proposed mechanism.**	Review	Hair loss		PubMed
	Hair		Avram	USA (New York, NY)	2007	J Cosmet Laser Ther	**The current role of laser/light sources in the treatment of male and female pattern hair loss.**	Review	Hair loss		PubMed
	Hair		Yamazaki	Japan (Tokyo)	2003	Int J Dermatol	**Linear polarized infrared irradiation using Super Lizer is an effective treatment for multiple-type alopecia areata.**	Human	Alopecia areata Super Lizer™	For irratiated lesions, the success was 7/15. For non-irratiated, 0/15. [See additional info for details about Super Lizer]	
★ ☎	Hearing	Auditory neuropathy	Lee	Korea (Cheonan)	2016	Neurosci Lett	**Photobiomodulation by laser therapy rescued auditory neuropathy induced by ouabain.**	Gerbil	Ouabain-induced auditory neuropathy	"Ouabain application increased the ABR thresholds increase, while the use of ouabain plus laser produced lower threshold compared to the ouabain group. Hematoxylin and Eosin staining of cochlea mid-modiolar sections in animals treated with ouabain showed damaged spiral ganglion cells, neurofilaments, and post synaptic puncta. Ouabain plus laser group showed higher number of spiral ganglion cells, higher density of neurofilaments, and higher number post synaptic puncta counts compared with ouabain application group." Star: Parameters were well reported, and a good-quality photograph was supplied.	PubMed
	Hearing	Hearing loss	Tamura	Japan (Saitama)	2016	Brain Res	**Photobiomodulation rescues the cochlea from noise-induced hearing loss via upregulating nuclear factor κB expression in rats.**	Rat	Noise-induced hearing loss	"These data suggest that PBM activates NF-κB to induce protection against inducible nitric oxide synthase-triggered oxidative stress and caspase-3-mediated apoptosis that occur following noise-induced hearing loss."	PubMed
★	Hearing	Hearing loss	Lee	Korea (Cheonan)	2016	PeerJ	**Simultaneous bilateral laser therapy accelerates recovery after noise-induced hearing loss in a rat model.**	Rat	Noise-induced hearing loss	"Both bilateral and unilateral laser therapy decreased the hearing threshold after noise overstimulation in the rat model. The bilateral laser therapy group showed faster functional recovery at all tested frequencies compared with the unilateral laser therapy group." Star: Parameters were well reported in a table	PubMed
	Hearing	Hearing loss	Tamura	Japan (Saitama)	2015	Neurosci Lett	**Low-level laser therapy for prevention of noise-induced hearing loss in rats.**	Rat	Noise-induced hearing loss	"Our findings suggest that LLLT has cytoprotective effects against NIHL via the inhibition of iNOS expression and apoptosis."	PubMed
★	Hearing	Hearing loss	Rhee	Korea (Cheonan)	2013	J Biomed Opt	**Effect of low-level laser treatment on cochlea hair-cell recovery after ototoxic hearing loss.**	Rat	Gentamicin-induced hearing loss	"Hearing was significantly improved by laser irradiation. After LLLT treatment, both the hearing threshold and hair-cell count significantly improved." Star: Parameters were well reported, and some photographic material was supplied.	PubMed
☹	Hearing	Hearing loss	Goodman	USA (Iowa city, IA)	2013	ISRN Otolaryngol	**The effect of low-level laser therapy on hearing.**	Human RCT/DB		"No statistically significant differences were found between groups for any of the auditory tests. Additionally, no clinically significant differences were found in any individual subjects." Comment: Parameters were poorly reported	PubMed
	Hearing	Hearing loss	Rhee	Korea (Cheonan)	2012	J Biomed Opt	**Effect of low-level laser treatment on cochlea hair-cell recovery after acute acoustic trauma.**	Rat	Noise-induced hearing loss	"Our findings suggest that low-level laser irradiation promotes recovery of hearing thresholds after acute acoustic trauma." Comment: Parameters were insufficiently reported.	PubMed
	Hearing	Meniere's disease	Teggi	Italy (Milan)	2008	Photomed Laser Surg	**Efficacy of low-level laser therapy in Ménière's disease: a pilot study of 10 patients.**	Human Pilot study		"In our experience, LLLT seems to prevent vertigo spells in MD, although results indicate that it has a slower action than betahistine. Dose-dependent therapeutic effects could explain the last result. In our opinion, increased blood flow in the inner ear is the main mechanism leading to the therapeutic results."	PubMed
☹	Hearing	Tinnitus	Park	Korea (Cheonan)	2013	Neurosci Lett	**Trans-canal laser irradiation reduces tinnitus perception of salicylate treated rat.**	Rat	High dose LLLT	"Therapeutic effect of LLLT is demonstrated in animal tinnitus model by means of GPIAS. Further experimental studies are needed to find possible mechanisms and better methods to improve LLLT efficacy." Comment: Parameters were poorly reported.	PubMed
	Hearing	Tinnitus	Dehkordi	Iran (Mashhad)	2015	Ear Nose Throat J	**Effect of low-level laser therapy in the treatment of cochlear tinnitus: a double-blind, placebo-controlled study.**	Human RCT/DB		"We conclude that 5-mV laser therapy with a wavelength of 650 nm is no better than placebo for improving hearing thresholds overall or for treating tinnitus with regard to age, sex, environmental noise level, and the duration of tinnitus." Jan Tunér: "Not arguing against the results of this paper, but a problem with most studies trying to treat tinnitus with laser light is the lack of proper diagnosis of the patients. Quite a few of these have a somatosensory background (the problem is basicly muscluar). Irradiation into the ear will then have no effect." [See additional info for Tunér's references]	PubMed
	Hearing	Tinnitus	Salahaldin	Qatar (Doha)	2012	ISRN Otolaryngol	**Low-level laser therapy in patients with complaints of tinnitus: a clinical study.**	Human		"Over half of the patients (56.9%) had some form of improvement in their tinnitus symptoms. Mild improvement was reported in 33.8% of patients, moderate improvement was reported in 16.9%, and full improvement was reported in 6.15%."	PubMed
	Hearing	Tinnitus	Teggi	Italy (Milan)	2009	Audiol Neurootol	**Transmeatal low-level laser therapy for chronic tinnitus with cochlear dysfunction.**	Human RCT/DB		"Soft laser therapy demonstrated no efficacy as a therapeutic measure for tinnitus."	PubMed
	Hearing	Tinnitus	Hahn	Czech Republic (Prague)	2008	Int Tinnitus J	**Multimodal therapy for chronic tinnitus.**	Human		"None of the treatment modalities had an objective correlate of improvement, though improvement was reported by a visual analog scale."	PubMed
	Hearing	Tinnitus	Cuda & De Caria	Italy (Piacenza)	2008	Int Tinnitus J	**Effectiveness of combined counseling and low-level laser stimulation in the treatment of disturbing chronic tinnitus.**	Human RCT		"The THI scores improved in the entire sample after treatment but more significantly in the group receiving low-level laser stimulation. From the point of view of clinical classification, approximately 61% of irradiated patients had tinnitus severity decreased by one class, in comparison to 35% of the placebo group."	PubMed
	Hearing	Tinnitus	Gungor	Turkey (Istanbul)	2008	J Laryngol Otol	**Effectiveness of transmeatal low power laser irradiation for chronic tinnitus.**	Human RCT/DB		"The loudness, duration and degree of annoyance of tinnitus were improved, respectively, in up to 48.8, 57.7 and 55.5 per cent of the patients in the active laser group. No significant improvement was observed in the placebo laser group." Jan Tunér: "A problem with most studies trying to treat tinnitus with laser light is the lack of proper diagnosis of the patients. Quite a few of these have a somatosensory background (the problem is basicly muscluar). Irradiation into the ear will then have no effect."	PubMed

	Hearing	Tinnitus	Tauber	Germany (Munich)	2003	Lasers Med Sci	**Transmeatal cochlear laser (TCL) treatment of cochlear dysfunction: a feasibility study for chronic tinnitus.**	Human Pilot study		"After a follow-up period of six months tinnitus loudness was attenuated in 13 of 35 irradiated patients, while two of 35 patients reported their tinnitus as totally absent. Hearing threshold levels and middle ear function remained unchanged."	PubMed
	Hearing	Tympanic membrane	Maleki	Iran (Tehran)	2013	J Laryngol Otol	**Effect of local irradiation with 630 and 860 nm low-level lasers on tympanic membrane perforation repair in guinea pigs.**	Guinea pig		"The results show that the combined application of 630 and 860 nm lasers had a significant effect on the healing of tympanic membrane perforation, and on the prevention of thick fibrotic or atelectatic neomembrane formation."	PubMed
	Hearing		Bartos	USA (Boston, MA)	2016	J Biophotonics	**Pre-conditioning with near infrared photobiomodulation reduces inflammatory cytokines and markers of oxidative stress in cochlear hair cells.**	In vitro	Cochlear hair cells treated with gentamicin or LPS	"We report a decrease of inflammatory cytokines and stress levels resulting from NIR applied to HEI-OC1 auditory cells before treatment with gentamicin or lipopolysaccharide."	PubMed
☹	Hearing		Rhee	Korea (Cheonan)	2012	Lasers Med Sci	**Effect of low-level laser therapy on cochlear hair cell recovery after gentamicin-induced ototoxicity.**	In vitro	LED phototherapy Cochlear hair cells treated with gentamicin	"These results suggest that LLLT may promote hair cell survival following gentamicin damage in the cochlea." Comment: Parameters are contradictory. I guess that fluence is actually 48 J/cm2, not 0.48	PubMed
☹	Heart	CABG surgery	Kazemi Khoo	Iran (Tehran)	2014	J Lasers Med Sci	**Application of Low-Level Laser Therapy Following Coronary Artery Bypass Grafting (CABG) Surgery.**	Human		"It is concluded that low-level laser irradiation after CABG surgery could decrease cardiac cellular damage and help accelerate the repair of cardiac tissue post-operatively." Comment: Parameters insufficiently reported	PubMed
	Heart	Cardiomyocytes	Zhang	USA (Milwaukee, WI)	2009	J Mol Cell Cardiol	**Near infrared light protects cardiomyocytes from hypoxia and reoxygenation injury by a nitric oxide dependent mechanism.**	In vitro		"Our results demonstrate that exposure to NIR at the time of reoxygenation protects neonatal rat cardiomyocytes and HL-1 cells from injury, as assessed by lactate dehydrogenase release and MTT assay. Similarly, indices of apoptosis, including caspase 3 activity, annexin binding and the release of cytochrome c from mitochondria into the cytosol, were decreased after NIR treatment. NIR increased NO in cardiomyocytes, and the protective effect of NIR was completely reversed by the NO scavengers carboxy-PTIO and oxyhemoglobin, but only partially blocked by the NO synthase (NOS) inhibitor L-NMMA. Mitochondrial metabolism, measured by ATP synthase activity, was increased by NIR, and NO-induced inhibition of oxygen consumption with substrates for complex I or complex IV was reversed by exposure to NIR. Taken together these data provide evidence for protection against hypoxia and reoxygenation injury in cardiomyocytes by NIR in a manner that is dependent upon NO derived from NOS and non-NOS sources."	PubMed
	Heart	Coronary arteries	Plass	Austria (Vienna)	2012	Ann Thorac Surg	**Light-induced vasodilation of coronary arteries and its possible clinical implication.**	In vitro	LED phototherapy Dose response Biphasic dose response	"Vessels exposed to either light source showed a remarkable as well as comparable photorelaxation at definite energy densities. This effect is mediated by an intracellular nitric oxide-dependent mechanism. As LED sources are of small size, simple, and inexpensive build-up, they may be used during routine coronary artery bypass surgery to ease suturing of anastomosis by target vessel vasodilation."	PubMed
	Heart	Coronary arteries	Plass	Austria (Vienna)	2012	Lasers Surg Med	**Low-level-laser irradiation induces photorelaxation in coronary arteries and overcomes vasospasm of internal thoracic arteries.**	In vitro		"Macroscopic healthy LAD exposed to [low-level laser irradiation] revealed significant photorelaxation. With the administration of [low-level laser irradiation, 73% of the maximal obtainable effect by an endothelium-dependent vasodilator could be reached. Furthermore, [low-level laser irradiation] has the potential to overcome vasospasms of [internal thoracic arteries."	PubMed
	Heart	Gene expression	Khanna	USA (Milwaukee, WI)	1999	Cardiovasc Radiat Med	**Augmentation of the expression of proangiogenic genes in cardiomyocytes with low dose laser irradiation in vitro.**	In vitro	Dose response	"We observed that a dose-dependent increase in cardiomyocytes proliferation can be obtained with [low power red laser light] and that there is a significant increase in VEGF and TGF-beta mRNA expression by cardiomyocytes." "These data may have significant importance leading to the establishment of new methods for myocardial photoangiogenesis and photoregeneration as well as in vitro proliferation of cardiac myocytes."	PubMed
★	Heart	Heart failure	Hentschke	Brazil (Porto Alegre)	2016 epub	Lasers Med Sci	**Maximal oxygen uptake and exercise tolerance are improved in rats with heart failure subjected to low-level laser therapy associated with resistance training.**	Rat		"LLLT associated with [resistance training] improved oxygen uptake and exercise tolerance compared with [resistance training] alone in [heart failure] rats."	PubMed
	Heart	Heart failure	Bublitz	Brazil	2016	Lasers Med Sci	**Acute effects of low-level laser therapy irradiation on blood lactate and muscle fatigue perception in hospitalized patients with heart failure-a pilot study.**	Human RCT	Heart failure	LLLT was associated with decreased perceived exercion, but functional capacity wasn't improved.	PubMed
	Heart	Heart failure	Capalonga	Brazil (Porto Alegre)	2016	Lasers Med Sci	**Light-emitting diode therapy (LEDT) improves functional capacity in rats with heart failure.**	Rat	LED phototherapy	"Sham and LEDT-HF groups showed higher relative values than the Control-HF group, respectively, for distance covered (27.7 and 32.5 %), time of exercise test (17.7 and 20.5 %), and speed (13.6 and 12.2 %)." Note: In this paper, the "sham" group does not refer to sham-therapy, but instead to sham-HF	PubMed
	Heart	Review	Liu & Zhang	China (Beijing)	2016	Photomed Laser Surg	**Low-Level Laser Irradiation Precondition for Cardiac Regenerative Therapy.**	Review			PubMed
	Heart	Heart failure	Biasibetti	Brazil (Porto Alegre)	2014	Lasers Med Sci	**The influence of low-level laser therapy on parameters of oxidative stress and DNA damage on muscle and plasma in rats with heart failure.**	Rat	Heart failure markers	(?)	PubMed
	Heart	Heart failure	Hentschke	Brazil (Porto Alegre)	2013	Lasers Med Sci	**Low-level laser therapy improves the inflammatory profile of rats with heart failure.**	Rat	Heart failure	"LLLT showed systemic and skeletal muscle anti-inflammatory effects in rats with HF."	PubMed
★	Heart	MI	Blatt	Israel	2016	Photomed Laser Surg	**Low-Level Laser Therapy to the Bone Marrow Reduces Scarring and Improves Heart Function Post-Acute Myocardial Infarction in the Pig.**	Pig	MI	"LLLT application to BM in the porcine model for MI caused a significant reduction in scarring, enhanced angiogenesis and functional improvement both in the acute and long term phase post-MI."	PubMed
	Heart	MI	Carlos	Brazil (São Paulo)	2016	Life Sci	**Role of low-level laser therapy on the cardiac remodeling after myocardial infarction: A systematic review of experimental studies.**	Systematic Review	Systemic effect MI		PubMed

	Heart	MI	Quirk	USA (Milwaukee, WI)	2014	Photomed Laser Surg	**Cardioprotection from ischemia-reperfusion injury by near-infrared light in rats.**	Rat	Ischemia-reperfusion LED phototherapy LED cluster	"NIR application had no effect on the function of the nonischemic isolated heart, and had no effect on infarct size when applied during global ischemia. In the in vivo model, NIR commencing immediately before reperfusion decreased infarct size by 40%, 33%, 38%, and 77%, respectively, after regional ischemic periods of 30. 20. 15. and 10 min."	PubMed
	Heart	MI	Keszler	USA (Milwaukee, WI)	2014	Front Physiol	**Far red/near infrared light-induced protection against cardiac ischemia and reperfusion injury remains intact under diabetic conditions and is independent of nitric oxide synthase.**	Mouse	Diabetic mice Dose response LED phototherapy LED array	"Here we tested the hypothesis that NIR elicits protection in a diabetic mouse model where other cardioprotective interventions such as pre- and postconditioning fail, and that the protection is independent of nitric oxide synthase (NOS). NIR reduced infarct size dose dependently. Importantly, NIR-induced protection was preserved in a diabetic mouse model (db/db) and during acute hyperglycemia, as well as in endothelial NOS(-/-) mice and in wild type mice treated with NOS inhibitor L-NAME." "Irradiation at 660 nm yields the highest release of NO, while at longer wavelengths a dramatic decrease of NO release can be observed." "NIR is cardioprotective in the presence of diabetes or hyperglycemia." "In summary, NIR applied during reperfusion protects the myocardium against infarction in an NO-dependent, but NOS-independent mechanisms, whereby mitochondria may be a target of NO released by NIR, leading to reduced reactive oxygen species generation during reperfusion. This unique mechanism preserves protection even during diabetes where other protective strategies fail." Comment: Beam area was not reported. According to the paper, LED array was used, so it's likely the area was large.	PubMed
	Heart	MI	Manchini	Brazil (São Paulo)	2014	PLoS One	**Amelioration of cardiac function and activation of anti-inflammatory vasoactive peptides expression in the rat myocardium by low level laser therapy.**	Rat	MI	"Our data suggest that LLLT diminishes the acute inflammation in the myocardium, reduces infarct size and attenuates left ventricle dysfunction post-MI and increases vasoactive peptides expression and nitric oxide (NO) generation."	PubMed
	Heart	MI	Yang	China (Zhengzhou)	2013	Photomed Laser Surg	**Effect of low-level laser irradiation on oxygen free radicals and ventricular remodeling in the infarcted rat heart.**	Rat	MI	"LLLI could cause OFR accumulation, reduce infarct size, increase ventricular wall thickness, and attenuate the formation of collagen fibers, suggesting the beneficial effects of LLLI on improvement of VR after MI."	PubMed
	Heart	MI	Yang	China (Beijing)	2011	Photomed Laser Surg	**Low-level laser irradiation alters cardiac cytokine expression following acute myocardial infarction: a potential mechanism for laser therapy.**	Rat	MI	"Although LLLI did not improve the damaged heart function, it did reduce the infarct area expansion."	PubMed
★	Heart	MI	Tuby	Israel	2011	Lasers Surg Med	**Induction of autologous mesenchymal stem cells in the bone marrow by low-level laser therapy has profound beneficial effects on the infarcted rat heart.**	Rat	MI Systemic effect	"Infarct size and ventricular dilatation were significantly reduced (76% and 75%, respectively) in the laser-treated rats 20 minutes post-MI as compared to the control-non-treated rats at 3 weeks post-MI. There was also a significant 25-fold increase in cell density of c-kit+ cells in the infarcted area of the laser-treated rats (20 minutes post-MI) as compared to the non-laser-treated controls." [Star: interesting results!]	PubMed
	Heart	MI	Zhang	China (Beijing)	2010	J Cell Mol Med	**Low level laser irradiation precondition to create friendly milieu of infarcted myocardium and enhance early survival of transplanted bone marrow cells.**	Rat	MI	"After LLLI precondition, increased VEGF and GRP78 expression, as well as the enhanced SOD activity and inhibited MDA production, was observed. Compared with BMSC transplantation and culture media injection group, although there was no difference in the improved heart function and myogenic differentiation, LLLI precondition significantly enhanced early cell survival rate by 2-fold, decreased the apoptotic percentage of implanted BMSCs in infarcted myocardium and thus increased the number of newly formed capillaries. Taken together, LLLI precondition could be a novel non-invasive approach for intraoperative cell transplantation to enhance cell early survival and therapeutic potential."	PubMed
	Heart	MI	Lohr	USA (Milwaukee, WI)	2009	J Mol Cell Cardiol	**Enhancement of nitric oxide release from nitrosyl hemoglobin and nitrosyl myoglobin by red/near infrared radiation: potential role in cardioprotection.**	Rabbit		"As shown in Figure 5B, exposure of the rabbit cardiac preparation to 60 mW/cm2 (11 J) of 670 nm light, in the absence of nitrite, at the time of reperfusion resulted in a significant reduction in infarct size whereas a lower power radiation (3 mW/cm2, 0.5J) was ineffective. Interestingly, when low dose radiation (3 mW/cm2) was combined with low-dose nitrite (0.4 mg/kg) a synergistic effect was observed suggesting that R/NIR is able to potentiate the cardioprotective effects of nitrite."	PubMed
	Heart	MI	Tuby	Israel	2009	Photomed Laser Surg	**Implantation of low-level laser irradiated mesenchymal stem cells into the infarcted rat heart is associated with reduction in infarct size and enhanced angiogenesis.**	Rat	MI MSCs	"The findings of the present study provide the first evidence that LLLT can significantly increase survival and/or proliferation of MSCs post-implantation into the ischemic/infarcted heart, followed by a marked reduction of scarring and enhanced angiogenesis. The mechanisms associated with this phenomenon remain to be elucidated in further studies."	PubMed
	Heart	MI	Tuby	Israel	2006	Lasers Surg Med	**Modulations of VEGF and iNOS in the rat heart by low level laser therapy are associated with cardioprotection and enhanced angiogenesis.**	Rat	MI Angiogenesis	"It is concluded that VEGF and iNOS expression in the infarcted rat heart is markedly upregulated by LLLT and is associated with enhanced angiogenesis and cardioprotection."	PubMed
★	Heart	MI	Yaakobi	Israel	2001	Lasers Surg Med	**Long-term effect of low energy laser irradiation on infarction and reperfusion injury in the rat heart.**	Rat	MI	LLLT decreased infarct size and increased HSP70 and angiogenesis. Star: The article was quite extensive, with multiple measurements of infarct sizes at different time points.	PubMed
	Heart	MI	Oron	Israel	2001	Lasers Surg Med	**Attenuation of infarct size in rats and dogs after myocardial infarction by low-energy laser irradiation.**	Rat, Dog	MI	LLLT protected against myocardial infarction. In rats, a bi-phasic dose response was noted. Infarct size decrease according to energy densities (in rats) 2.5 mW/cm2 ---> 14 % 6 mW/cm2 -----> 62 % (significant) 20 mW/cm2 ------> 2.8 (other experiments were also done)	PubMed
	Heart	MI	Oron	Israel	2001	Circulation	**Low-energy laser irradiation reduces formation of scar tissue after myocardial infarction in rats and dogs.**	Rat, Dog	MI	ATP content in the ischemic zone was 7.6-fold higher in LLLT rats. Infarct size was 52% reduced in dogs. NIR (803nm) was used.	PubMed
	Heart	MI	Ad & Oron	Israel	2001	Int J Cardiol	**Impact of low level laser irradiation on infarct size in the rat following myocardial infarction.**	Rat	MI	"The infarct size (expressed as percent of total left ventricle area) of the LI rats was 10.1+/-5.8, which was significantly lower (65%; P<0.01) than the infarct size of NLI rats which was 28.7+/-9.6."	PubMed

Heart	MI	Whittaker & Patterson	USA (LA, California)	2000	Lasers Surg Med	**Ventricular remodeling after acute myocardial infarction: effect of low-intensity laser irradiation.**	Rat	MI	"Laser-treated fibroblasts occupied more area than controls. Hearts receiving the 10 mW treatment had smaller volumes than sham hearts. Laser treatment reduced infarct thinning and preserved arterial lumen area; however, collagen was not increased and inflammation was inhibited."	PubMed
Heart	MI	Whittaker (Peter)	USA (LA, California)	1999	Lasers Surg Med	**Laser-mediated reversal of cardiac expansion after myocardial infarction.**	Rat	MI LLLT? (λ = 1320 nm)	"Cavity volume was reduced by laser treatment (0.72 +/- 0.07 ml vs. 0.54 +/- 0.05 ml; P= 0.044). In addition, treatment resulted in thicker scars, a leftward shift of the heart's electrical axis, and straightening of collagen fibers."	PubMed
Heart	Russian research	Moshkovska & Mayberry	UK (Leicester)	2005	Postgrad Med J	**It is time to test low level laser therapy in Great Britain.**	Review			PubMed
Heart	Transplants	Lukes	Sweden (Göteborg)	2005	Transplant Proc	**Singlet oxygen energy illumination during moderate cold ischemia prolongs the survival of concordant hamster xeno-heart transplants.**	Rat		"The graft survival of SOE-illuminated ischemic hamster xenografts was 2.34 +/- 0.56 versus 1.15 +/- 0.37 days in the control group (P < .05). All hearts displayed immediate graft function versus 70% in the controls (NS)." "SOE illumination at lambda 634 nm during moderate cold ischemia (+4 degrees C) can improve the survival of concordant hamster xeno-heart transplants. The exact mechanism(s) are currently unknown, but the effect might in part be exerted by a combination of reduced production of ROS and increased oxidative phosphorylation."	PubMed
Immunity	Neutrophils	Cerdeira	Brazil&USA	2016	J Biophotonics	**Low-level laser therapy stimulates the oxidative burst in human neutrophils and increases their fungicidal capacity.**	In vitro			PubMed
Immunity	Mast cells	de Carvalho Monteiro	Brazil (Salvador, Bahia)	2011	Photomed Laser Surg	**Effect of LED red and IR Photobiomodulation in tongue mast cells in Wistar rats: histological study.**	Rat		Our results lead us to conclude that both red and IR-LED light caused increased mast cell degranulation and that IR-LED light resulted in a greater number of mast cells.	PubMed
Immunity	Monocytes	Chen	Taiwan (Kaohsiung)	2014	Mediators Inflamm	**Effects of low-level laser therapy on M1-related cytokine expression in monocytes via histone modification.**	In vitro			PubMed
Immunity		Lee	Korea (Seoul)	2011	J Photochem Photobiol B	**Enhancement of cutaneous immune response to bacterial infection after low-level light therapy with 1072 nm infrared light: a preliminary study.**				
Immunity		Vilela	Brazil (Salvador, Bahia)	2012	J Photochem Photobiol B	**Influence of the HPA axis on the inflammatory response in cutaneous wounds with the use of 670-nm laser photobiomodulation.**	Rat		"Decreases in the number of CD45-positive inflammatory cells and in the total numbers of CD8- and CD45-positive cells were observed in histological sections of adrenalectomized animals subjected to laser biomodulation at 24h. Similar results were observed for distribution of total lymphocytes in blood (p<0.05). The action of 670 nm laser does not depend exclusively on HPA axis. It is believed that corticosteroid-promoting enzymes liberated in non-adrenal tissues may influence immune response under the influence of this type of phototherapy."	PubMed
Immunity	Lymphocytes	Al Musawi	Malaysia (Pulau Pinang)	2017 epub	Lasers Med Sci	**Effects of low-level laser irradiation on human blood lymphocytes in vitro.**	In vitro	Whole blood irradiation	"At a wavelength of 589 nm and fluence of 72 J/cm2, irradiation of whole blood samples showed a significant increase in CD45 lymphocytes and natural killer (NK) (CD16, CD56) cells, but no significant changes in CD3 T lymphocytes, T-suppressor (CD3, CD8) cells, T-helper (CD3, CD4) cells, and CD19 B lymphocytes when compared with their non-irradiated counterparts. Our results clearly demonstrate that NK cell count is altered by irradiation, which ultimately affects the whole lymphocyte count significantly."	PubMed
Immunity	Lymphocytes	Stadler	USA (Rochester, NY)	2000	Lasers Surg Med	**In vitro effects of low-level laser irradiation at 660 nm on peripheral blood lymphocytes.**	In vitro	Whole blood irradiation	"Lymphocyte proliferation was significantly higher (P<0.05) as expressed by a Stimulation Index in samples irradiated in the presence of whole blood compared with lymphocytes irradiated after isolation from whole blood. Free radical and lipid peroxide production also increased significantly when samples were irradiated in the presence of red blood cells." "The present study supports the hypothesis that one mechanism for the photobiostimulation effect after irradiation at 660 nm is the reaction of light with hemoglobin, resulting in oxygen radical production."	PubMed
Immunity	Macrophage-like cells	Fernandes	Brazil (São Paulo)	2015	J Photochem Photobiol B	**Photobiomodulation with 660-nm and 780-nm laser on activated J774 macrophage-like cells: Effect on M1 inflammatory markers.**	In vitro		"Both lasers were able to reduce TNF-α and iNOS expression, and TNF-α and COX-2 production, although the parameters used for 780 nm laser provided an additional decrease. 660 nm laser parameters resulted in an up-regulation of IL-6 expression and production. These findings imply a distinct, time-dependent modulation by the two different sets of laser parameters, suggesting that the best modulation may involve more than one combination of parameters."	PubMed
Immunity	Macrophages (alveolar)	Souza	Brazil (São Paulo)	2014	J Photochem Photobiol B	**Low-level laser therapy suppresses the oxidative stress-induced glucocorticoids resistance in U937 cells: relevance to cytokine secretion and histone deacetylase in alveolar macrophages.**	In vitro		"LLLT and dexa inhibited the LPS-stimulated U937 cells cytokines, but dexa effect disappeared with H2O2. With TSA, the LLLT was less effective on H2O2/LPS stimulated- U937 cells cytokines. Dexa failed on H2O2/LPS- induced HDAC, while LLLT restored the HDAC and the dexa effect. LLLT plus prostaglandin E2 (PGE2) increased cyclic adenosine monophosphate (cAMP) and potentiated the laser action on oxidative stress-induced cytokine. LLLT reduced the PI3K and its effects on cytokine and HDAC was suppressed with LY294002. In situations of corticoid resistance, LLLT acts decreasing the cytokines and HDAC through the activation of the protein kinase A via the inhibition of PI3K."	PubMed
Immunity	Macrophages (alveolar)	de Lima	Brazil (São Paulo)	2010	Photomed Laser Surg	**Low-level laser therapy associated to N-acetylcysteine lowers macrophage inflammatory protein-2 (MIP-2) mRNA expression and generation of intracellular reactive oxygen species in alveolar macrophages.**	In vitro		"LLLT attenuated the MIP-2 mRNA expression and intracellular ROS generation after LPS or H(2)O(2). When the AM were pretreated with NAC, the laser effect was potentiated. BMS 205820 suppresses the effect of LLLT on MIP-2 mRNA expression and ROS generation, stimulated by LPS or H(2)O(2). On NF-κB transcription factor, both the LLLT and NAC reduced this protein in the AM exposed to LPS or H(2)O(2). The synergistic effect between LLLT and NAC on the reduction the NF-κB was also evidenced."	PubMed

Immunity	Macrophages	Lu	China (Guangzhou)	2016	Int J Biochem Cell Biol	**Photo-enhancement of macrophage phagocytic activity via Rac1-mediated signaling pathway: Implications for bacterial infection.**	Mouse + in vitro	Listeria infection	"Here, we demonstrated for the first time that LPLI enhanced the phagocytic activity of macrophages by stimulating the activation of Rac1. The overexpression of constitutively activated Rac1 clearly enhanced LPLI-induced phagocytosis, whereas the overexpression of dominant negative Rac1 exerted the opposite effect. The phosphorylation of cofilin was involved in the effects of LPLI on phagocytosis, which was regulated by the membrane translocation and activation of Rac1. Furthermore, the photoactivation of Rac1 was dependent on the Src/PI3K/Vav1 pathway. The inhibition of the Src/PI3K pathway significantly suppressed LPLI-induced actin polymerization and phagocytosis enhancement. Additionally, LPLI-treated mice exhibited increased survival and a decreased organ bacterial load when challenged with Listeria monocytogenes, indicating that LPLI enhanced macrophage phagocytosis in vivo." "These findings highlight the important roles of the Src/PI3K/Vav1/Rac1/cofilin pathway in regulating macrophage phagocytosis and provide a potential strategy for treating phagocytic deficiency via LPLI."	PubMed
Immunity	Macrophages	Gavish	Israel (Jerusalem)	2008	Lasers Surg Med	**Irradiation with 780 nm diode laser attenuates inflammatory cytokines but upregulates nitric oxide in lipopolysaccharide-stimulated macrophages: implications for the prevention of aneurysm progression.**	In vitro		"LLLI reduced gene expression of MCP-1, IL-1alpha, IL-10 (P<0.01), IL-1beta, and IL-6 (P<0.05) when cells were stimulated by 1 microg/ml LPS. LLLI reduced LPS-induced secretion of MCP-1 over non-irradiated cells by 17+/-5% and 13+/-5% at 12 hours (0.1 and 1 microg/ml LPS; P<0.01 and P=0.05, respectively), and reduced IL-1beta by 22+/-5% and 25+/-9% at 24 hours (0.1 and 1 microg/ml LPS, P=0.01 and P=0.06, respectively)." "These properties of LLLI [...] may be of profound therapeutic relevance for arterial diseases such as aneurysm where inflammatory processes and weakening of the matrix structure of the arterial wall are major pathologic components."	PubMed
Immunity	Monocytic cells (U937)	Spoto	Italy (Chieti)	2016	J Biol Regul Homeost Agents	**Effect of low energy light irradiation by light emitting diode on U937 cells.**	In vitro		"We demonstrate that LED exposure, in the presence or absence of lipopolysaccharide (LPS), activates cell degranulation, increased expression of Interleukin-8 (IL-8) and modulation of beta galactosidase activity. Evidence shows that the well-known pro-inflammatory nuclear factor kappa-light-chain-enhancer of activated B cells (NF-kB) and the apoptotic marker (caspase3/cleaved-caspase3 ratio) are up-regulated in response to a proinflammatory biochemical pathway."	PubMed
Immunity	Sepsis	Yu	USA (Rochester, NY)	1997	Lasers Surg Med	**Improvement of host response to sepsis by photobiomodulation.**	Rat		"LI significantly improved ex-vivo lymphocyte proliferation of cells from septic rats (179.7 +/- 17.2 vs. 129.5 +/- 7.8; P < 0.01) and enhanced survival in septic rats (79% vs. 42%; P < 0.001). LI significantly stimulated lymphocyte proliferation in the presence of mitogenic stimuli and enhanced lymphocyte ATP synthesis (P < 0.05)." "LI improves the host immune response and survival rate in sepsis in an animal model. Our studies suggest that LI may be useful as an adjuvant therapy for sepsis."	PubMed
Infections	Bacteria	Silva	Brazil (Petrolina)	2013	An Bras Dermatol	**Low level laser therapy (AlGaInP) applied at 5J/cm2 reduces the proliferation of Staphylococcus aureus MRSA in infected wounds and intact skin of rats.**	Rat		"The laser (AlGaInP), with a dose of 5J/cm2 in both intact skin and in wounds of rats infected with Staphylococcus aureus MRSA, is shown to reduce bacterial proliferation."	PubMed
Infections	Bacteria	Lubart	Israel (Ramat Gan)	2011	Laser Ther	**A possible mechanism for the bactericidal effect of visible light.**	Review			PubMed
Infections	Bacteria	Lipovsky	Israel (Ramat Gan)	2010	Lasers Surg Med	**Visible light-induced killing of bacteria as a function of wavelength: implication for wound healing.**	In vitro	Red light vs blue light	"ROS production following blue (400-500 nm) light illumination was found to be higher than that of red (500-800 nm). Within the blue range, light of 415 nm induced more ROS than 455 nm, which correlated with results obtained for the reduction in colony count of S. aureus and E. coli following illumination using equal intensities of these two wavelengths."	PubMed
Infections	Bacteria	Lipovsky	Israel (Ramat Gan)	2008	Lasers Surg Med	**A possible mechanism for visible light-induced wound healing.**	In vitro		"Illumination with white light, 120 J/cm(2), caused a reduction of 62%, 83%, and 56% in the colony count of E. coli 1313, S. aureus 195 and S. marcescens, respectively, though no reduction in the viability of P. aeruginosa 1316 was demonstrated. The phototoxic effect was found to involve induction of ROS production by the bacteria. It was also found that illumination of S. aureus 195 and E. coli 1313 in the presence of pyocyanin, known to be secreted by P. aeruginosa, had a stronger bactericidal effect compared to illumination alone."	PubMed
Infections	Fungal	Seyedmousavi	Iran (/Netherlands)	2014	Photomed Laser Surg	**Effects of low-level laser irradiation on the pathogenicity of Candida albicans: in vitro and in vivo study.**	In vitro In vivo (mice, n=110)		LLLT improved the survival of infected mice dose-dependently. both 685nm and 830nm were effective.	PubMed
Infections	Staphylococcus	Ma	China (Tianjin)	2012	Lasers Med Sci	**Antiinflammatory effect of low-level laser therapy on Staphylococcus epidermidis endophthalmitis in rabbits.**	Rabbit	Endophthalmitis LLLT vs dexamethasone	"As an adjunct to vancomycin therapy to treat S. epidermidis endophthalmitis, LLLT has an antiinflammatory effect similar to that of dexamethasone."	PubMed
Insect health	Bumblebee	Powner	UK (London)	2016	PLoS One	**Improving Mitochondrial Function Protects Bumblebees from Neonicotinoid Pesticides.**	Bumblebee	Imidaclopride toxicity	"Bees exposed to insecticide and daily to 670nm light showed corrected ATP levels and significantly improved mobility allowing them to feed. Physiological recordings from eyes revealed that light exposure corrected deficits induced by the pesticide. Overall, death rates in bees exposed to insecticide but also given 670nm light were indistinguishable from controls." "Treatment with 670nm on control bees also resulted in a significant improvement in survival over controls (P<0.01), similar to data from fruit flies exposed to this light [15]" "Hence, we show that deep red light exposure that improves mitochondrial function, reverses the sensory and motor deficits induced by Imidacloprid."	PubMed
Insect health	Fruit fly	Begum	UK (London)	2015	Biol Lett	**Near-infrared light increases ATP, extends lifespan and improves mobility in aged Drosophila melanogaster.**	Fruit fly		"Here, we expose fruitflies daily to 670 nm radiation, revealing elevated ATP and reduced inflammation with age. Critically, there was a significant increase in average lifespan: 100-175% more flies survived into old age following 670 nm exposure and these had significantly improved mobility."	PubMed

★	Intravascular LLLT		Huang	Taiwan (Taipei)	2012	Photomed Laser Surg	**Effects of intravascular laser irradiation of blood in mitochondria dysfunction and oxidative stress in adults with chronic spinal cord injury.**	Human RCT/SB	Spinal cord injury patients	"At day 15 of therapy, the study group revealed a significantly higher mitochondrial DNA (mtDNA) copy number, white blood cell adenosine triphosphate (WBC ATP) synthesis, and total antioxidant capacity (TAC) with significantly reduced malondialdehyde (MDA), than did the sham group." Star: The results are quite intriguing. This is interesting work.	PubMed
	Joints	Ankylosing spondylitis	Stasinopoulos	Cyprus (Nicosia)	2016	Lasers Med Sci	**LLLT for the management of patients with ankylosing spondylitis.**	Human RCT/SB		"The results suggested that after an 8-week treatment and after a follow-up, the combination of LLLT and passive stretching exercises decreased pain more effectively than placebo LLLT along with the same passive stretching exercises in patients with Ankylosing spondylitis"	PubMed
	Joints	Arthritis	Pallotta	Brazil (São Paulo)	2012	Lasers Med Sci	**Infrared (810-nm) low-level laser therapy on rat experimental knee inflammation.**	Rat	Acute knee arthritis	"This result was corroborated by cell counting showing the reduction of polymorphonuclear cells at the inflammatory site. Vascular extravasation was significantly inhibited at the higher dose of energy of 10 J. Both COX-1 and 2 gene expression were significantly enhanced by laser irradiation while PGE(2) production was inhibited. Low-level laser therapy operating at 810 nm markedly reduced inflammatory signs of inflammation but increased COX-1 and 2 gene expression."	PubMed
	Joints	Arthritis	Castano	USA (Boston, MA)	2007	Lasers Surg Med	**Low-level laser therapy for zymosan-induced arthritis in rats: Importance of illumination time.**	Rat		LLLT was highly effective in treating inflammatory arthritis in this model. Longer illumination times were more effective than short times regardless of total fluence or irradiance.	PubMed
	Joints	Arthritis	Brosseau	Canada (Ontario)	2000	J Rheumatol	**Low level laser therapy for osteoarthritis and rheumatoid arthritis: a metaanalysis.**	Meta-analysis			PubMed
	Joints	Crystalopathy	Rubio	Argentina (Córdoba)	2009	Photomed Laser Surg	**Inflammatory and oxidative stress markers in experimental crystalopathy: their modification by photostimulation.**	Rat	Arthritis, exp crystalopathy	↓↓ fibrinogen "Inflammatory and oxidative stress markers in experimental crystalopathy are positively modified by photobiostimulation."	
	Joints	Crystal arthropathy	Soriano	Argentina (Rosario)	2006	Photomed Laser Surg	**Photobiomodulation of pain and inflammation in microcrystalline arthropathies: experimental and clinical results.**	Rat Human RCT	Crystal arthropathy Acute gouty arthritis	"Fibrinogen, prostaglandin E(2), and TNF(alpha) concentrations in the rats injected with crystals and treated with laser decreased significantly as compared with the groups injected with crystals without treatment." "Both laser therapy and diclofenac achieved rapid pain relief in patients with acute gouty arthritis without significant differences in efficacy. Laser therapy was more effective than diclofenac in patients with chronic pyrophosphate arthropathy and in patients with chronic apatite deposition disease."	PubMed
	Joints	Haemophilic arthropathy	El-Shamy & Abdelaal	Egypt (Giza)	2016 epub	Disabil Rehabil	**Efficacy of pulsed high-intensity laser therapy on pain, functional capacity, and gait in children with haemophilic arthropathy.**	Human RCT		"Children in the laser group showed significant improvement in pain, functional capacity, and gait parameters compared to those in the placebo group ($p < 0.05$)." Comment 1: Parameters were somewhat poorly reported. Even wavelength was not mentioned. Comment 2: However, results are encouraging. This isn't the first time that Egyptian researchers report very good results for the diseases they are treating with "HILT".	PubMed
★	Joints	Meniscus	Malliaropoulos	Greece (Thessaloniki)	2013	Lasers Med Sci	**Low-level laser therapy in meniscal pathology: a double-blinded placebo-controlled trial.**	Human RCT/DB		"The pain decreased approximately by 65 % 4 weeks after LLLT and by 22 % in the placebo group." "Treatment with LLLT was associated with a significant decrease of symptoms compared to the placebo group: it should be considered in patients with meniscal tears who do not wish to undergo surgery."	PubMed
☹	Joints	Osteoarthritis	Kim	Korea (Daegu)	2016	J Phys Ther Sci	**The effects of high intensity laser therapy on pain and function in patients with knee osteoarthritis.**	Human Controlled		"The comparison of the two groups showed that the high intensity laser therapy group had statistically significant lower scores in both the visual analogue scale and the Korean Western Ontario and McMaster Universities Osteoarthritis Index than the conservative physical therapy group." "High intensity laser therapy is considered an effective non-surgical intervention for reducing pain in patients with knee osteoarthritis and helping them to perform daily activities." Comment: The important parameters were not reported (wavelength, power output,	PubMed
★	Joints	Osteoarthritis	S	Saudi Arabia (Al-Kharj)	2016 epub	Lasers Med Sci	**Radiological and biochemical effects (CTX-II, MMP-3, 8, and 13) of low-level laser therapy (LLLT) in chronic osteoarthritis in Al-Kharj, Saudi Arabia.**			"After 4- and 8-week treatment, active laser group shows more significant difference ($p < 0.001$) in all the parameters than the placebo laser group ($p > 0.05$). Our results show that low-level laser therapy was more efficient in reducing pain and improving cartilage thickness through biochemical changes." Star: In this study, the improvement in LLLT versus placebo is huge. Maybe they found some good parameters for the treatment of knee osteoarthritis?	PubMed
	Joints	Osteoarthritis	Youssef	Saudi Arabia (Dammam)	2016	J Lasers Med Sci	**Effect of Laser Therapy on Chronic Osteoarthritis of the Knee in Older Subjects.**	Human RCT		"It can be concluded that addition of LLLT to exercise training program is more effective than exercise training alone in the treatment of older patients with chronic knee OA and the rate of improvement may be dose dependent, as with 6 J/cm(2) or 3 J/cm(2)."	PubMed
	Joints	Osteoarthritis	Tomazoni	Brazil (São Paulo)	2016	J Biomed Opt	**Isolated and combined effects of photobiomodulation therapy, topical nonsteroidal anti-inflammatory drugs, and physical activity in the treatment of osteoarthritis induced by papain.**	Rat	Osteoarthritis induced by papain	"The results of this study indicate that PBMT is the most effective therapy in stopping disease progression, and improving inflammatory conditions observed in OA."	PubMed
	Joints	Osteoarthritis	Tomazoni	Brazil (São Paulo)	2016	Lasers Med Sci	**Effects of photobiomodulation therapy, pharmacological therapy, and physical exercise as single and/or combined treatment on the inflammatory response induced by experimental osteoarthritis.**	Rat	PBM vs NSAID Knee osteoarthritis induced by papain	"The results from the present study indicate that treatment with PBMT is more effective in modulating the inflammatory process underlying OA when compared with the other therapies tested."	PubMed
	Joints	Osteoarthritis	de Oliveira	Brazil (São Paulo)	2016	Lasers Med Sci	**Photobiomodulation therapy in the modulation of inflammatory mediators and bradykinin receptors in an experimental model of acute osteoarthritis.**	Rat	PBM vs NSAID Osteoarthritis induced by papain	"We conclude that photobiomodulation therapy was able to promote the reduction of proinflammatory cytokines such as TNF-α and CINC-1, to reduce the gene and protein expression of the bradykinin receptor (B1 and B2), as well as increasing the stimulus response threshold of pressure in an experimental model of acute osteoarthritis."	PubMed
	Joints	Osteoarthritis	Huang	China (Chengdu)	2015	Osteoarthritis Cartilage	**Effectiveness of low-level laser therapy in patients with knee osteoarthritis: a systematic review and meta-analysis.**	Meta-analysis			PubMed
	Joints	Osteoarthritis	Atik OS	Turkey (Ankara)	2015	Photomed Laser Surg	**Can we treat knee osteoarthritis with photomedicine?**	Guest Editorial			PubMed

	Joints	Osteoarthritis	Wang	China (Chengdu)	2014	Lasers Med Sci	**Effects of low-level laser therapy on joint pain, synovitis, anabolic, and catabolic factors in a progressive osteoarthritis rabbit model.**	Rabbit		"The histological assessment of pain and synovitis showed that at least 6-week intermittent irradiation of LLLT could relief knee pain and control synovium inflammation." "Gross morphologic inspection and histological evaluation showed that 6 weeks of LLLT could decrease cartilage damage of medical femoral condyle and 8 weeks of LLLT could decrease cartilage damage of medical and lateral femoral condyles and medical tibial plateau." "Gene expression analysis revealed two results: At least 6 weeks of LLLT could decrease production of catabolic factors, for example, interleukin 1β (IL-1β), inducible nitric oxide synthase (iNOS), and MMP-3, and slow down the loss of anabolic factors, mainly TIMP-1." "Eight weeks of LLLT treatment could slow down the loss of collagen II, aggrecan, and anabolic factors, mainly transforming growth factor beta (TGF-β)." "The study suggests that LLLT plays a protective role against cartilage degradation and synovitis in rabbits with progressive OA by virtue of the regulation of catabolic and anabolic factors in the cartilage." Comment: It seems the results were quite modest.	PubMed
	Joints	Osteoarthritis	dos Santos	Brazil (São Paulo)	2014	Lasers Med Sci	**Comparative analysis of two low-level laser doses on the expression of inflammatory mediators and on neutrophils and macrophages in acute joint inflammation.**	Rat	Papain-induced joint inflammation Biphasic dose response	"Both laser modalities were efficient in reducing cellular inflammation and decreasing the expression of IL-1β and IL-6. However, the 2-J treatment led to more reduction in TNF-α than the 4-J treatment. A single application of LLLT with 2 J was more efficient in modulating inflammatory mediators and inflammatory cells."	PubMed
★	Joints	Osteoarthritis	Alves	Brazil (São Paulo)	2013	Arthritis Res Ther	**Effect of low-level laser therapy on the expression of inflammatory mediators and on neutrophils and macrophages in acute joint inflammation.**	Rat	Papain-induced joint inflammation Biphasic dose response	"Laser treatment with 50 mW was more efficient than 100 mW in reducing cellular inflammation, and decreased the expression of IL-1β and IL-6. However, the 100 mW treatment led to a higher reduction of TNFα compared with the 50 mW treatment." Star: In this paper, parameters are nicely reported in a table.	PubMed
	Joints	Osteoarthritis	Hsieh	Taiwan (Taipei)	2012	J Orthop Sports Phys Ther	**Therapeutic effects of short-term monochromatic infrared energy therapy on patients with knee osteoarthritis: a double-blind, randomized, placebo-controlled study.**	Human RCT/PB	MIRE treatment with "Anodyne" LED pad device	"Short-term MIRE therapy provided no beneficial effects to body functions, activities, participation, and quality of life in patients with knee OA." Comment: Because of the biphasic dose response, this dose might have been too high by a few orders of magnitude.	PubMed
	Joints	Osteoarthritis	Hsieh	Taiwan (Taipei)	2012	Arch Phys Med Rehabil	**Short-term effects of 890-nanometer radiation on pain, physical activity, and postural stability in patients with knee osteoarthritis: a double-blind, randomized, placebo-controlled study.**	Human RCT/PB	MIRE treatment with "Anodyne" LED pad device	"Short-term 890-nm radiation therapy for patients with knee OA provided no beneficial effect in improving pain, physical activity, and postural stability." Comment: Because of the biphasic dose response, this dose might have been too high by a few orders of magnitude.	PubMed
	Joints	Osteoarthritis	Bjordal	Norway (Bergen)	2007	BMC Musculoskelet Disord	**Short-term efficacy of physical interventions in osteoarthritic knee pain. A systematic review and meta-analysis of randomised placebo-controlled trials.**	Meta-analysis			PubMed
☹	Joints	Osteoarthritis	Cho	Korea (Gwangju)	2004	In vivo	**Effect of low-level laser therapy on osteoarthropathy in rabbit.**	Rabbit		"These results suggest that LLLT was effective in the treatment of chemically-induced OA." Note: The authors did not report wavelength or dose.	PubMed
★	Joints	Rheumatoid arthritis	Alves	Brazil (São Paulo)	2013	Lasers Med Sci	**Low-level laser therapy in different stages of rheumatoid arthritis: a histological study.**	Rat	Collagen-induced RA	"We observed that LLLT both at early and late RA progression stages significantly improved mononuclear inflammatory cells, exudate protein, medullary hemorrhage, hyperemia, necrosis, distribution of fibrocartilage, and chondroblasts and osteoblasts compared to RA group ($p < 0.05$). We can conclude that LLLT is able to modulate inflammatory response both in early as well as in late progression stages of RA."	
	Joints	Rheumatoid arthritis	Zhang	Japan (Matsudo)	2011	Laser Ther	**Reduction of CXCR4 expression in Rheumatoid Arthritis Rat Joints by low level diode laser irradiation.**	Rat	Collagen-induced RA	"CIA significantly increased swelling in the rat hind-paw and LLLI reduced the CIA-induced swelling." "Decreased CXCR4 expression may be one of the mechanisms in LLLI-mediated reduction of RA inflammation."	PubMed
	Joints	Rheumatoid arthritis	Yamaura	USA (Boston, MA)	2009	Lasers Surg Med	**Low level light effects on inflammatory cytokine production by rheumatoid arthritis synoviocytes.**	In vitro	(human synoviocytes)	"Radiation at 810 nm (5 J/cm(2)) given before or after TNF-alpha decreases the mRNA level of TNF-alpha and IL-1beta in RA synoviocytes. This treatment using 25 J/cm(2) also decreases the intracellular levels of TNF-alpha, IL-1beta, and IL-8 protein but did not affect the levels of seven other cytokines/chemokines. TNF-alpha-induced activation of NF-kappaB is not altered by 810 nm radiation using 25 J/cm(2)."	PubMed
★	Joints	Rheumatoid arthritis	Hall	UK	1994	Br J Rheumatol	**Low level laser therapy is ineffective in the management of rheumatoid arthritic finger joints.**	Human RCT	Hand arthritis Single probe vs cluster probe	"Using these irradiation parameters the efficacy of LLLT is ineffective." Star: Parameters were well reported.	PubMed
	Joints	Septic arthritis (experimental)	Araujo	Brazil (Cascavel)	2013	ISRN Rheumatol	**Effects of Low-Level Laser Therapy, 660 nm, in Experimental Septic Arthritis.**	Rat		"It was found that nociception increases in the right knee. There was a lack of results for the seeding of the synovial fluid. The morphological analysis showed slight recovery areas in the articular cartilage and synovia; however, there was the maintenance of the inflammatory infiltrate." "The parameters used were not effective in the nociception reduction, even with the slight tissue recovery due to the maintenance of inflammatory infiltrate, but produced no change in the natural history of resolution of the infectious process."	PubMed
★	Kidney	Diabetic kidney	Lim	USA (Bloomington, IN)	2010	J Photochem Photobiol B	**Effects of low-level light therapy on streptozotocin-induced diabetic kidney.**	Rat	LED phototherapy	↑cytochrome oxidase activity, ↑cytochrome oxidase expression, ↓serum BUN, ↓serum creatinine, ↓BUN/creatinine ratio, ↓8-hydroxy-2'-deoxyguanosine in kidney "LLLT may be broadly applicable to ameliorate kidney complications induced by diabetes that disrupt antioxidant defense mechanisms."	PubMed

	Kidney	Fibrosis	Oliveira	Brazil (Juiz de Fora)	2012	Photomed Laser Surg	**Low-level laser therapy decreases renal interstitial fibrosis.**	Rat	UUO --> renal interstitial fibrosis	"For the first time, we showed that LLLT had a protective effect regarding renal interstitial fibrosis. It is conceivable that by attenuating inflammation, LLLT can prevent tubular activation and transdifferentiation, which are the two processes that mainly drive the renal fibrosis of the UUO model." Note: See comment&reply of this paper. They discuss the mechanism a little bit	PubMed
★	Kidney	Glomerulonephritis	Yamata	Japan (Kobe)	2013	Lasers Med Sci	**Low-level laser therapy improves crescentic glomerulonephritis in rats.**	Rat	Glomerulonephritis (crescentic)	"Histological observations indicated that LLLT suppressed crescent formation and infiltration of ED1+ macrophages and CD8+ lymphocytes into the glomeruli. LLLT attenuated the levels of IL-1β and TNF-α messenger RNA in the renal cortex. Externally directed LLLT suppresses the activity of rat anti-GBM crescentic glomerulonephritis in rats. LLLT has the potential to be used for direct treatment of glomerulonephritis." Star: Parameters were well reported.	PubMed
	Kidney	Ischemia	Asghari	Iran (Tehran)	2016	Lasers Med Sci	**Effect of photobiomodulation on ischemia/reperfusion-induced renal damage in diabetic rats.**	Rat	Diabetic rats	Effects of photobiomodulation: ↑GSH, ↑SOD, ↑CAT ↓BUN, ↓MDA, ↓MPO, ↓NO, ↓creatinine, ↓histological injury "The results of present investigation revealed that PBM attenuated kidney damage induced by renal IR in diabetic rats."	PubMed
	Kidney	Meckel syndrome	Lim	USA (Bloomington, IN)	2011	Nephron Extra	**Acceleration of the meckel syndrome by near-infrared light therapy.**	Rat	Meckel syndrome LED phototherapy	"LED phototherapy initiated after the onset of symptoms was detrimental to MKS-induced pathology. NIR stimulates CCO thereby increasing the kidney's need for oxygen. We hypothesize that cystic compression of the vasculature impairs oxygen availability and the enhanced CCO activity produces more radicals, which are not sufficiently detoxified by the increased CAT activity."	PubMed
	Kidney	Metabolic syndrome	Ucero	Spain	2013	Photochem Photobiol	**Laser therapy in metabolic syndrome-related kidney injury.**	Rat	Kidney injury	↓ blood pressure ↑ glomerular filtration rate	PubMed
	Larynx	Reflux laryngitis	Marinho	Brazil (São Cristóvão)	2014	Lasers Med Sci	**Potential anti-inflammatory effect of low-level laser therapy on the experimental reflux laryngitis: a preliminary study.**	Rat	Experimental reflux laryngitis Combined wavelengths	"In conclusion, we demonstrated that 105-J/cm2 infrared laser irradiation is potentially useful to control reflux laryngitis secondary to nasogastric intubation by reducing the influx of neutrophils to the injured area and improving the reparative collagenization of the laryngeal tissues." "Therefore, we suggest that low-level laser is a promising therapy to be used in treatment of reflux-induced laryngitis."	PubMed
★	Larynx	Reflux laryngitis	Marinho	Brazil (São Cristóvão)	2013	J Photochem Photobiol B	**Potentiated anti-inflammatory effect of combined 780 nm and 660 nm low level laser therapy on the experimental laryngitis.**	Rat	Experimental reflux laryngitis Combined wavelengths	"In conclusion, we demonstrated that the combined 17.5 J/cm2 at 780 nm and 10.0 J/cm2 at 660 nm successfully modulated early inflammatory response in experimental model of nasogastric intubation-induced reflux laryngitis. The possible mechanism involves the reduction in neutrophil infiltration, modulation of mast cells degranulation, and improved granulation tissue formation and collagen deposition in the injured area." [Star: Parameters were very well reported - and the combined wavelength experiment was interesting.]	PubMed
	LED technology		Lim	Korea (Chungnam)	2015	Mol Cryst Liq Cryst	**Red/Infrared LED Unit with Moderate Light Intensity and Low Heat Generation for Personal Phototherapy Applications**			"A new phototherapy unit for personal and home application is developed based on red and infrared LEDs."	Taylor&Francis
	Lichen planus		Cafaro	Italy	2014	Lasers Med Sci	**Clinical evaluation of the efficiency of low-level laser therapy for oral lichen planus: a prospective case series.**	Case series		82 lesions were treated, and LLLT seemed to reduce the clinical score and pain. No control group.	PubMed
☹	Lichen planus		Gambino	Italy	2013	Ann Stomatol (Roma)	**LLLT in combination with non-surgical periodontal therapy in patients with gingival oral lichen planus: a pilot study.**	Case series		LLLT appeared to have some benefits. However, there was no control group. Parameters weren't reported.	PubMed
	Ligaments	ACL injury	Bublitz	Brazil (Santos)	2014	Lasers Med Sci	**Low-level laser therapy prevents degenerative morphological changes in an experimental model of anterior cruciate ligament transection in rats.**	Rat	Ligament transection Biphasic dose response	"Initial signs of tissue degradation were observed in CG. Interestingly, laser-treated animals presented a better tissue organization, especially at the fluence of 10 J/cm(2). Furthermore, laser phototherapy was able of modulating some of the aspects related to the degenerative process, such as the prevention of proteoglycans loss and the increase in cartilage area. However, LLLT was not able of modulating chondrocytes proliferation and the immunoexpression of markers related to inflammatory process (IL-1 and MMP-13). This study showed that 808 nm laser, at both fluences, prevented features related to the articular degenerative process in the knees of rats after ACLT."	PubMed
	Ligaments	MCL injury	Delbari	Iran (Tehran)	2007	Photomed Laser Surg	**Effect of low-level laser therapy on healing of medial collateral ligament injuries in rats: an ultrastructural study.**	Rat	Dose response	"On day 12, the fibril dimension of group 2 and their density were higher than of groups 1 and 3." "Although we could not find significant difference between density of fibrils of laser groups and other groups, the p value shows a difference almost at the range of significance (p = 0.059)."	PubMed
	Ligaments	MCL injury	Bayat	Iran (Tehran)	2005	Photomed Laser Surg	**Low-level laser therapy improves early healing of medial collateral ligament injuries in rats.**	Rat	Dose response	"The ultimate tensile strength (UTS) of group 2 on day 12 was significantly higher than that of groups 1 and 3." Comment: The dose of 0.01J/cm2 was ineffective, while 1.20J/cm2 was effective. Too small dose does often have no effect.	PubMed
	Ligaments	MCL injury	Ng	China (Hong Kong)	2004	Lasers Surg Med	**Comparison of single and multiple applications of GaAlAs laser on rat medial collateral ligament repair.**	Rat	Single vs multiple treatments	"Multiple laser therapy improves the normalized strength and stiffness of repairing rat MCLs at 3 weeks after injury. The multiple treatments seem to be superior to a single treatment when the cumulative dosages are comparable between the two modes of application."	PubMed
	Ligaments	MCL injury	Fung	China (Hong Kong)	2003	Lasers Surg Med	**Effects of a therapeutic laser on the ultrastructural morphology of repairing medial collateral ligament in a rat model.**	Rat		"Single application of low energy laser therapy increases the collagen fibril size of healing MCLs in rats."	PubMed
	Ligaments	MCL injury	Fung	China (Hong Kong)	2002	Lasers Surg Med	**Therapeutic low energy laser improves the mechanical strength of repairing medial collateral ligament.**	Rat		"The UTS of laser and sham groups were comparable."	PubMed

	Liver	Diabetes	Lim	USA (Bloomington, IN)	2009	J Biochem Mol Toxicol	**Effects of low-level light therapy on hepatic antioxidant defense in acute and chronic diabetic rats.**	Rat	Diabetic rats LED phototherapy	"Light treatment was ineffective as an antioxidant therapy in chronic diabetes, but light treatment for 18 days in acutely diabetic rats resulted in the normalization of hepatic glutathione reductase and superoxide dismutase activities and a significant increase in glutathione peroxidase and glutathione-S transferase activities. The results of this study suggest that 670 nm photobiomodulation may reduce, at least in part, acute hepatic oxidative stress by enhancing the antioxidant defense system in the diabetic rat model." Light therapy also didn't affect blood glucose levels. ATP and CCO activity were increased.	PubMed
	Liver	Liver cirrhosis	Oliveira-Junior	Brazil (São Paulo)	2013	Photochem Photobiol	**Low-level laser therapy ameliorates CCl4-induced liver cirrhosis in rats.**	Rat	Liver cirrhosis (CCl4)	↓ aspartate aminotransferase (P < 0.001) ↓ alkaline phosphatase (P < 0.001) ↓ gamma-glutamyl transferase (P < 0.001) ↓ lactate dehydrogenase (P < 0.01) activity, as well as ↓ total proteins (P < 0.05) and ↓ globulins (P < 0.01) ↓ number of cirrhotic areas ↓ collagen accumulation ↓ hepatic inflammatory infiltrate ↓ CCl(4)-increased number of Kupffer cells (P < 0.05) and ↓ hepatic stellate cells (P < "We conclude that LLLT presents beneficial effects on liver function and structure in an	PubMed
	Liver	Liver regeneration	Araújo	Brazil (São Paulo)	2015	Lasers Med Sci	**Low-power laser irradiation fails to improve liver regeneration in elderly rats at 48 h after 70 % resection.**	Rat	Hepatectomy	"this study demonstrated that the main molecular pathway, i.e. HGF/Met→Akt and Erk 1/2→PCNA, involved in the hepatic regeneration process was not improved by LPLI in elderly hepatectomized rats, which in turn rules out LPLI as an adjuvant therapy, as observed in this protocol of liver regeneration evaluation (i.e. at 48 h after 70 % resection), in elderly."	PubMed
	Liver	Liver regeneration	Araújo	Brazil (São Paulo)	2013	Lasers Med Sci	**Liver regeneration following partial hepatectomy is improved by enhancing the HGF/Met axis and Akt and Erk pathways after low-power laser irradiation in rats.**	Rat	Hepatectomy -> Liver regeneration	"Our results show that LPLI can improve liver regeneration as shown by increased HGF protein expression and the phosphorylation levels of Met, Akt, and Erk 1/2 accompanied by higher levels of the PCNA and Ki-67 protein in the remnant livers. In summary, our results suggest that LPLI may play a clinical role as a simple, fast, and easy-to-perform strategy in order to enhance the liver regenerative capacity of a small liver remnant after hepatectomy."	PubMed
	Liver	Liver regeneration	Oron	Israel	2010	Photomed Laser Surg	**Enhanced liver regeneration following acute hepatectomy by low-level laser therapy.**	Rat	Hepatectomy -> Liver regeneration	↑↑ BrdU positive cells per area in the regenerating regions of the livers ↑↑ The density of the newly formed blood vessels and c-kit immunopositive cells in the regenerating area	PubMed
	Liver	Liver regeneration	Castro-e-Silva	Brazil (Sao Carlos)	2007	Braz J Med Biol Res	**The use of light-emitting diodes to stimulate mitochondrial function and liver regeneration of partially hepatectomized rats**	Rat	Hepatectomy -> Liver regeneration LED phototherapy vs laser	"In conclusion, the present results suggest that LED irradiation promotes biological stimulatory effects during the early stage of liver regeneration and that LED is as effective as laser light, independent of the coherence, divergence and cromaticity."	SciELO
☹	Liver	Liver regeneration	Oliveira	Brazil (Ribeirão Preto)	2006	Acta Cir Bras	**The effect of laser on remanescent liver tissue after 90% hepatectomy in rats.**	Rat	Hepatectomy -> Liver regeneration	"Laser did not cause hepatic injuries additional to the partial hepatectomy and perhaps led to a benefit by stimulating the proliferative activity." Comment: Parameters were poorly reported.	PubMed
☹	Liver	Liver regeneration	Melo	Brazil (Sergipe)	2005	Dig Dis Sci	**Enhancement of liver regeneration by the association of Hyptis pectinata with laser therapy.**	Rat	Hepatectomy -> Liver regeneration	"The present study shows that the association of the aqueous extract of Hyptis pectinata leaves at 200 mg/kg with intraoperative laser therapy can stimulate liver regeneration and cause a reduction in liver mitochondrial respiratory function without altering its phosphorylative activity."	PubMed
	Liver	Minimal hepatic encephalopathy	Arias	Spain	2016	Lasers Med Sci	**Low-light-level therapy as a treatment for minimal hepatic encephalopathy: behavioural and brain assessment.**	Rat	LED phototherapy Cytochrome oxidase	"Taking these findings into account, an improvement in the PH + LLLT group due to LLLT treatment should show not only a correct acquisition of the behavioural task, indicated by the behavioural differences between PH and PH + LLLT and their absence when compared to the SHAM group, but also a decrease in C.O., due to an improvement in the enzyme activity produced by the LLLT treatment, and similarities between brain networks." [For more information, read additional info]	PubMed
★	LLLT: past and future		Anders	USA (Bethesda, MD)	2015	Photomed Laser Surg	**Low-level light/laser therapy versus photobiomodulation therapy.**	Editorial			PubMed
	LLLT: past and future		Moore KC	UK (Oldham)	2013	Photomed Laser Surg	**Photomedicine: the early years.**	Guest Editorial			PubMed
	LLLT: past and future		Arany PR	USA (Boston, MA)	2012	Photomed Laser Surg	**Photobiomodulation: poised from the fringes.**	Editorial			PubMed
	LLLT: past and future		Karu, Pyatibrat & Kalendo		2001	Toxicol Lett	**Donors of NO and pulsed radiation at lambda = 820 nm exert effects on cell attachment to extracellular matrices.**			Nitric oxide donors can prevent the effects of LLLT.	PubMed
★	LLLT: past and future		Karu & Afanas'eva		1995	Dokl Akad Nauk	**[Cytochrome c oxidase as the primary photoacceptor upon laser exposure of cultured cells to visible and near IR-range light]. [Article in Russian]**			First paper suggesting the importance of cytochrome c oxidase.	PubMed
	LLLT: past and future		Tadakuma T	Japan	1993	Keio J Med	**Possible application of the laser in immunobiology.**	Review			PubMed
	LLLT: past and future		Bakeeva	Russia	1993	Mol Biol (Mosk).	**[Formation of gigantic mitochondria in human blood lymphocytes under the effect of an He-Ne laser]. [Article in Russian]**			"Reconstruction of mitochondria from ultrathin sections through the whole lymphocyte showed that 1 h after the irradiation the number of mitochondria was reduced to 9-12 compared to 40-45 in the control cells. In the irradiated lymphocytes 2-4 branching giant mitochondria were revealed instead of small discrete mitochondria in the control cells. Other 6-7 mitochondria were found to retain their shape and volume. It is suggested that the giant mitochondria are formed by fusion of small mitochondria. Formation of giant mitochondria may reflect the increase in the energy exchange level."	PubMed
	LLLT: past and future		Lubart	Israel	1992	J Photochem Photobiol B	**Effects of visible and near-infrared lasers on cell cultures.**	In vitro (fibroblasts)		"It is suggested that low-level laser therapy in the visible and in the near-infrared region is due to cell respiration stimulation by either the endogenous porphyrins in the cell, or by the cytochromes."	PubMed

★	LLLT: past and future	Mester E		1985	Lasers Surg Med	**The biomedical effects of laser application.**	Review			PubMed
	LLLT: past and future	Lobko, Karu & Letokhov		1985	Biofizika	**[Is the coherence of low-intensity laser light essential for its effect on biological objects?]. [Article in Russian]**	?		"It means that the role of coherent interaction processes is negligible. This conclusion is confirmed by the experimental results obtained with living cells of different types."	PubMed
	LLLT: past and future	Sato	Germany	1984	Andrologia	**The effects of laser light on sperm motility and velocity in vitro.**	In vitro		"Total sperm motility increased after Laser irradiation at 4 J/cm2, 8 J/cm2 and 32 J/cm2 respectively with respect to control. However, no influence on sperm velocity was demonstrated after Laser irradiation. This observation suggests that Laser light stimulates non-motile live spermatozoa."	PubMed
★	LLLT: past and future	Passarella	Italy (Bari)	1984	FEBS Lett	**Increase of proton electrochemical potential and ATP synthesis in rat liver mitochondria irradiated in vitro by helium-neon laser.**	In vitro	Rat liver mitochondria	First paper showing increased ATP after LLLT irradiation. "This paper clearly shows that the irradiation of isolated rat liver mitochondria in vitro by low power He-Ne laser causes an increase in membrane potential, proton gradient and ATP synthesis."	PubMed
	LLLT: past and future	Karu	Russia	1984	Vopr Kurortol Fizioter Lech Fiz Kult	**[Phototherapy of gastric and duodenal peptic ulcer patients based on cell stimulation with low-intensity red light]. [Article in Russian]**	Human		LLLT was already being studied in humans in 1984.	PubMed
	LLLT: past and future	Salet	France (Paris)	1979	Exp Cell Res	**A study of beating frequency of a single myocardial cell. III. Laser micro-irradiation of mitochondria in the presence of KCN or ATP.**	In vitro		An ancient paper showing cellular changes in myocardial cell, after green light irradiation. The authors suspect that the changes might be related to ATP production. The authors discuss the effects of light on animals. "If our inferences concerning ATP involvement are valid, this emphasizes the similarities between mitochondria and bacteria, especially Halobacteria, which are able to produce ATP on light illumination" Note: A wavelength of typical LLLT range (600-1100nm) was not used.	PubMed
	LLLT: past and future	Mester	Hungary	1968	Acta Chir Acad Sci Hung	**Lasers in clinical practice.**	Review?			PubMed
	LLLT: past and future	Mester	Hungary	1968	Radiobiol Radiother (Berl).	**[The effect of laser beams on the growth of hair in mice].[Article in German]**	Mouse			PubMed
★	LLLT: past and future	Mester	Hungary	1968	Langenbecks Arch Chir	**[Studies on the inhibiting and activating effects of laser beams]. [Article in German]**	In vitro & in vivo ??		"Laser beams of low energy were tested on four biological systems and were found to promote the cell functions. Higher radiant energy causes inhibition. Repeated small doses of radiation have a cumulative effect. The knowledge of these facts is essential if any therapeutic use is intended." Original title: "Untersuchungen über die hemmende bzw. fördernde Wirkung der Laserstrahlen"	PubMed
	LLLT: past and future	Mester E	Hungary	1966	Orv Hetil	**[The use of the laser beam in therapy]. [Article in Hungarian]**			First scientific paper on LLLT?	
★	Lymphedema	Storz	Germany (Homburg)	2016	Photodermatol Photoimmunol Photomed	**Photobiomodulation Therapy in breast cancer-related lymphedema: a randomized placebo-controlled trial.**	Human RCT/DB	LED phototherapy LED array (16)	"PBMT using a compactly designed treatment regime in combination with a cluster laser device did not significantly improve quality of life, pain scores, grip strength and limb volume over the time course." "A too high amount of total energy applied per point could be a possible explanation for our results. It's particularly worth mentioning, that we increased the energy dose in order to cut the total amount of sessions. So it's hard to determine, whether the applied doses are really too high or whether the amount of sessions is simply insufficient. [...] We assume that in treating chronic conditions such as lymphedema, the application of our chosen energy dose and density simply constituted a too strong stimulus in a too short time frame." Star: The parameters and treatment methods were exceptionally well reported in a	PubMed
	Lymphedema	Jang	Korea (Incheon & Seoul)	2016	Lasers Med Sci	**Anti-inflammatory and lymphangiogenetic effects of low-level laser therapy on lymphedema in an experimental mouse tail model.**	Mouse		"The thickness of the tail rapidly increased until 6 days in the laser and sham groups. The mice in the laser group showed a significantly decreased thickness compared with the sham group at 10 and 12 days. Immunohistochemistry assay revealed that LLLT reduced inflammation and induced new lymphatic vessel growth. qPCR showed that expressions of VEGFR3 were (p = 0.002) increased in the laser group. These results suggest that LLLT has anti-inflammatory and lymphangiogenetic effects for the management of lymphedema."	PubMed
	Lymphedema	Smoot	USA (San Francisco, CA)	2015	J Cancer Surviv	**Effect of low-level laser therapy on pain and swelling in women with breast cancer-related lymphedema: a systematic review and meta-analysis.**	Meta-analysis			PubMed
	Lymphedema	Hwang	Korea	2015	J Phys Ther Sci	**Complex decongestive physical therapy and low-level laser therapy for the treatment of pediatric congenital lymphedema: a case report.**	Human Case report			PubMed
	Lymphedema	E Lima	Brazil (Rio de Janeiro)	2014	Lasers Med Sci	**Low-level laser therapy in secondary lymphedema after breast cancer: systematic review.**	Systematic review			PubMed
☹	Lymphedema	Ridner	USA (Nashville, TN)	2013	Oncol Nurs Forum	**A pilot randomized trial evaluating low-level laser therapy as an alternative treatment to manual lymphatic drainage for breast cancer-related lymphedema.**	Human RCT	Comparison trial	"No statistically significant between-group differences were found in volume reduction; however, all groups had clinically and statistically significant reduction in volume. No group differences were noted in psychological and physical symptoms or QOL; however, treatment-related improvements were noted in symptom burden within all groups. Skin improvement was noted in each group that received LLLT." "LLLT with bandaging may offer a time-saving therapeutic option to conventional MLD. Alternatively, compression bandaging alone could account for the demonstrated volume reduction." "Lasers may provide effective, less burdensome treatment for lymphedema." Comment: Parameters were very poorly reported.	PubMed

	Lymphedema		Omar	Egypt (Giza)	2012	Support Care Cancer	**A systematic review of the effect of low-level laser therapy in the management of breast cancer-related lymphedema.**	Systematic review			PubMed
	Lymphedema		Mayrovitz & Davey	USA (Lauderdale, FL)	2011	Lymphology	**Changes in tissue water and indentation resistance of lymphedematous limbs accompanying low level laser therapy (LLLT) of fibrotic skin.**	Human		?	PubMed
	Lymphedema		Dirican	USA (Pittsburgh, PA)	2011	Support Care Cancer	**The short-term effects of low-level laser therapy in the management of breast-cancer-related lymphedema.**	Human Observational		"Patients with BCRL received additional benefits from LLLT when used in conjunction with standard lymphedema treatment. These benefits include reduction in limb circumference, pain, increase in range of motion and scar mobility. Additionally, two cycles of LLLT were found to be superior to one in this study."	PubMed
	Lymphedema		Ahmed Omar	Egypt (Cairo)	2011	J Surg Res	**Treatment of post-mastectomy lymphedema with laser therapy: double blind placebo control randomized study.**	Human RCT/DB		"Laser treatment was found to be effective in reducing the limb volume, increase shoulder mobility, and hand grip strength in approximately 93% of patients with postmastectomy lymphedema."	PubMed
	Lymphedema		Lau&Cheing	China (Hong Kong)	2009	Photomed Laser Surg	**Managing postmastectomy lymphedema with low-level laser therapy.**	Human RCT/SB		"LLLT was effective in the management of PML, and the effects were maintained to the 4 wk follow-up."	PubMed
	Lymphedema		Kozanoglu	Turkey (Adana)	2009	Clin Rehabil	**Efficacy of pneumatic compression and low-level laser therapy in the treatment of postmastectomy lymphoedema: a randomized controlled trial.**	Human RCT		"Group II had better long-term results than group I. Low-level laser might be a useful modality in the treatment of postmastectomy lymphoedema." Comment: Parameters were poorly reported.	PubMed
	Lymphedema		Kaviani	Iran (Tehran)	2006	Lasers Med Sci	**Low-level laser therapy in management of postmastectomy lymphedema.**	Human		"Reduction in limb circumference was detected in both groups, although it was more pronounced in the laser group up to the end of 22nd week. Desire to continue treatment at each session and baseline score in the laser group was greater than in the sham group in all sessions. Pain reduction in the laser group was more than in the sham group except for the weeks 3 and 9. No substantial differences were seen in other two parameters between the two treatment groups."	PubMed
	Lymphedema		Carati	Australia (Adelaide)	2003	Cancer	**Treatment of postmastectomy lymphedema with low-level laser therapy: a double blind, placebo-controlled trial.**	Human RCT/DB		"Two cycles of laser treatment were found to be effective in reducing the volume of the affected arm, extracellular fluid, and tissue hardness in approximately 33% of patients with postmastectomy lymphedema at 3 months after treatment."	PubMed
	Lymphedema		Piller&Thelander	Australia (Adelaide)	1998	Lymphology	**Treatment of chronic postmastectomy lymphedema with low level laser therapy: a 2.5 year follow-up.**	Human Case series		"The data suggest that laser treatment, at least initially, improved most objective and subjective parameters of arm lymphedema."	PubMed
	Mechanisms	Editorial	Abrahamse H	South Africa (Johannesburg)	2015	Photomed Laser Surg	**Stimulation of Cellular Proliferation and Migration: Is It a Viable Measure of Photobiomodulation?**	Guest Editorial			PubMed
	Mechanisms	Editorial	Karu T	Russia (Troitsk)	2010	Photomed Laser Surg	**Mitochondrial mechanisms of photobiomodulation in context of new data about multiple roles of ATP.**	Guest Editorial			PubMed
	Mechanisms	Editorial	Enwemeka CS	USA (Milwaukee, WI)	2006	Photomed Laser Surg	**The place of coherence in light induced tissue repair and pain modulation.**	Editorial			PubMed
	Mechanisms	Original research	Amaroli	Italy (Genoa)	2016	Photomed Laser Surg	**An 808-nm Diode Laser with a Flat-Top Handpiece Positively Photobiomodulates Mitochondria Activities.**	In vitro	Bovine liver mitochondria Flat-top handpiece	"Our data show for the first time that even the higher fluences (64 J/cm2-1 W), similar to the low fluences, can photobiostimulate the mitochondria respiratory chain without uncoupling them and can induce an increment in the ATP production. These results suggest that the negative effects of higher fluences observed to date are not unequivocally due to higher fluence per se but might be a consequence of the irradiation carried by handpieces with a Gaussian profile."	PubMed
	Mechanisms	Original research	Wang	USA (Texas)	2016	Sci Rep	**Interplay between up-regulation of cytochrome-c-oxidase and hemoglobin oxygenation induced by near-infrared laser.**	Human		"For the first time, we demonstrated that 1064 nm laser can induce significant increases of CCO and HbO concentrations in a dose-dependent manner over time, as compared with placebo treatment. In addition, Δ[CCO] and Δ[HbO] displayed a clear linear relationship as the dose of LLLT increased. " "These results demonstrate the tremendous potential of broadband NIRS as a non-invasive, in vivo means to study mechanisms of photobiomodulation and perform treatment evaluations of LLLT. "	PubMed
★	Mechanisms	Original research	Wang	USA (Boston, MA)	2016	Biochim Biophys Acta	**Photobiomodulation of human adipose-derived stem cells using 810nm and 980nm lasers operates via different mechanisms of action.**	In vitro	Stem cells 980nm --> calcium channels, TRPV1, TRPC	"The use of NIR wavelengths such as 810nm is reasonably well accepted to stimulate mitochondrial activity and ATP production via absorption of photons by cytochrome c oxidase. However, the mechanism of action of 980nm is less well understood." [See additional info]	PubMed
	Mechanisms	Original research	Tang	USA (Bethesda, MD)	2016	J Periodontal Res	**Laser-activated transforming growth factor-β1 induces human β-defensin 2: implications for laser therapies for periodontitis and peri-implantitis.**	In vitro	TGF-β1 Periodontium & peri-implantitis	"Laser-activated TGF-β1 signaling and induced expression of HBD-2, both of which are individually capable of promoting healing in tissues adjacent to high-power surgical laser applications."	PubMed
	Mechanisms	Original research	Quirk & Whelan	USA (Milwaukee, WI)	2016	Photomed Laser Surg	**Effect of Red-to-Near Infrared Light on the Reaction of Isolated Cytochrome c Oxidase with Cytochrome c.**	In vitro		"The oxidation of cytochrome c by isolated CCO has not been shown to be affected by R-NIR irradiation, whether applied prior to or concurrently with the enzymatic assays. This lack of effect by R-NIR calls into question the CCO activity model of R-NIR photobiomodulation." "There could still be a role for CCO in R-NIR-PBM. Although the activity may not be affected, it may be possible that R-NIR reception by CCO in some manner results in increased expression of the same enzyme. It is difficult, however, to envision how such a result could be achieved. Perhaps CCO modulation by R-NIR does not affect the rate of cytochrome c oxidation, but rather increases its efficiency by increasing the proton pumping rate per electron transferred, as argued in a study of isolated rat liver mitochondria. This could improve the production of adenosine triphosphate (ATP), with all of the implied cellular benefits." "We have only studied one part of the CCO reaction. In this work, the other substrate, oxygen, is considered to be saturating and not rate limiting. It is possible that the kinetics of the reduction of oxygen by CCO may be affected by R-NIR even if the cytochrome c oxidation may not. It is our intention to study oxygen uptake in a respiration chamber using the Clark electrode technique." Comment: Still, the in vitro setting with isolated CCO, instead of a living cell, could possibly explain these results. Hopefully we get some clarity about the mechanism during the following years.	PubMed

Mechanisms	Original research	Ball	USA (Boulder, CO)	2011	J Photochem Photobiol B	**Low intensity light stimulates nitrite-dependent nitric oxide synthesis but not oxygen consumption by cytochrome c oxidase: Implications for phototherapy.**	In vitro		"By using a series of bandpass filters and light emitting devices (LEDs) we have determined that maximal stimulation of Cco/NO activity is achieved by exposure to light whose central wavelength is 590 ± 14 nm. This wavelength of light stimulates Cco/NO synthesis at physiological nitrite concentrations. These findings raise the interesting possibility that low intensity light exerts a beneficial effect on cells and tissues by increasing NO synthesis catalyzed by Cco and offer a new explanation for the increase in NO bioavailability experienced by tissue exposed to light."	PubMed
Mechanisms	Original research	Heger	Netherlands (Amsterdam)	2010	J Photochem Photobiol B	**Absence of 633-nm laser irradiation-induced effects on glucose phosphorylation by hexokinase.**	In vitro		"No differences in reaction rates between the NROF-irradiated and control groups were found at either temperature." Note: Amat published a critical comment to this paper.	PubMed
Mechanisms	Original research	Anders	USA (Bethesda, MD)	2008	IEEE J Sel Top Quantum Electron	**Light Supports Neurite Outgrowth of Human Neural Progenitor Cells In Vitro: The Role of P2Y Receptors**	In vitro		"The data presented here establish the neuritogenic potential of light on NHNPCs in a growth factor and serum-free environment. Based on these findings, we propose that the light caused an increase in ATP that acted through P2Y receptors and downstream signaling pathways leading to neurite outgrowth." Note: A correction has been published. The Figure 4 (especially images D, E and F) was incorrect.	IEEE
Mechanisms	Original research	Arany	India (Karnataka)	2007	Wound Repair Regen	**Activation of latent TGF-beta1 by low-power laser in vitro correlates with increased TGF-beta1 levels in laser-enhanced oral wound healing.**	Rat	Wound healing	"Low-power laser irradiation is capable of activating the latent TGF-beta1 complex in vitro and its expression pattern in vivo suggests that TGF-beta play a central role in mediating the accelerated healing response."	PubMed
Mechanisms	Original research	Karu	Russia (Troitsk)	2005	Photomed Laser Surg	**Exact action spectra for cellular responses relevant to phototherapy.**	In vitro	HeLa cells	"The peak positions are between 613.5 and 623.5 nm (in one spectrum, at 606 nm), in the red maximum. The far-red maximum has exact peak positions between 667.5 and 683.7 nm in different spectra. Two near infrared maxima have peak positions in the range 750.7-772.3 nm and 812.5-846.0 nm, respectively."	PubMed
Mechanisms	Original research	Amat	Spain (Reus)	2005	J Photochem Photobiol B	**Modification of the intrinsic fluorescence and the biochemical behavior of ATP after irradiation with visible and near-infrared laser light.**	In vitro ATP irradiation		"In conclusion, visible and near-infrared light modifies the biochemical behavior of ATP in the hexokinase reaction and the fluorescence intensity of the molecule thus altering the Mg2+ binding strength to the oxygen atoms in the phosphate group." Note: Heger et al published a paper which claimed to disprove these findings. However, they used different parameters (9-fold lower irradiance), which could explain the different results.	PubMed
Mechanisms	Original research	Lanzafame	USA (Rochester, NY)	2004	Photomed Laser Surg	**Temperature-controlled 830-nm low-level laser therapy of experimental pressure ulcers.**	Mouse		LLLT improved wound healing compared to control. The effect was noted also in the temperature-controlled group, so the benefit isn't caused by the thermal effects of LLLT.	PubMed
Mechanisms	Original research	Greco	Italy (Bari)	2001	Lasers Surg Med	**Helium-Neon laser irradiation of hepatocytes can trigger increase of the mitochondrial membrane potential and can stimulate c-fos expression in a Ca2+-dependent manner.**	In vitro	Isolated hepatocytes Isolated liver mitochondria	"As a result of irradiation, increase of the mitochondrial membrane potential was found to occur in irradiated hepatocytes both in the presence or in the absence of CaCl2. The hyperpolarization of the mitochondrial membrane is assumed to cause an increase in mitochondrial Ca2+ uptake that was measured in isolated mitochondria. Finally, an increase in c-fos expression was found in irradiated hepatocytes when incubated in the presence of CaCl2." "This paper gives additional information on the mechanism by which He-Ne laser light, either directly or in a cascade-like effect dependent on increase in cell Ca2+, can cause cell stimulation."	PubMed
Mechanisms	Original research	Pastore	Italy (Campobasso)	2000	Int J Radiol Biol	**Specific helium-neon laser sensitivity of the purified cytochrome c oxidase.**	In vitro		"Cytochrome c oxidation catalysed by COX was affected by He-Ne laser irradiation of the purified enzyme." "This study shows that purified COX is a specific target of He-Ne laser light; therefore, COX may be considered to be a mitochondrial photo-acceptor."	PubMed
Mechanisms	Original research	Yu	USA (Rochester, NY)	1997	Photochem Photobiol	**Photomodulation of oxidative metabolism and electron chain enzymes in rat liver mitochondria.**	In vitro	Isolated liver mitochondria	"Photoirradiation significantly increased oxygen consumption (0.6 J/cm2 and 1.2 J/cm2, P < 0.05), phosphate potential, and the energy charge (1.8 J/cm2 and 2.4 J/cm2, P < 0.05) of rat liver mitochondria and enhanced the activities of NADH: ubiquinone oxidoreductase, ubiquinol: ferricytochrome C oxidoreductase and ferrocytochrome C: oxygen oxidoreductase (0.6 J/cm2, 1.2 J/cm2, 2.4 J/cm2 and 4.8 J/cm2, P < 0.05). The activities of succinate ubiquinone oxidoreductase, ATPase, and lactate dehydrogenase were not affected by photoirradiation." Note: A highly cited article (238 in Google Scholar in 10/2016).	PubMed
Mechanisms	Original research	Vacca	Italy (Bari)	1997	Biochem Mol Biol Int	**The irradiation of hepatocytes with He-Ne laser causes an increase of cytosolic free calcium concentration and an increase of cell membrane potential, correlated with it, both increases taking place in an oscillatory manner.**	In vitro	Isolated hepatocytes	"Irradiation resulted in an enhancement in cytosolic free Ca2+ concentration that requires the presence of Ca2+ in the phase outside hepatocytes; consistently an increase in cell membrane potential was measured correlated with it."	PubMed
Mechanisms	Original research	Manteifel	Russia (Troitsk)	1997	J Photochem Photobiol B	**Ultrastructural changes in chondriome of human lymphocytes after irradiation with He-Ne laser: appearance of giant mitochondria.**	In vitro		"Three-dimensional reconstruction of mitochondria from ultrathin sections trough the whole lymphocyte showed that the number of mitochondria was reduced to 9-12 in the irradiated cells compared with 40-45 in the control cells. In the irradiated lymphocytes, 2-4 giant branching mitochondria were also observed among small discrete mitochondria."	PubMed
Mechanisms	Original research	Gagliardi	Italy (Bari)	1997	Biochem Mol Biol Int	**A novel property of adenine nucleotides: sensitivity to helium-neon laser in mitochondrial reactions.**	In vitro		"While no change in ATP synthase kinetics was observed as a result of ADP irradiation, adenine nucleotides proved to be sensitive to He-Ne laser irradiation when their interaction with ADP/ATP carrier and adenylate kinase was considered."	PubMed
Mechanisms	Original research	Vacca	Italy (Bari)	1996	J Photochem Photobiol B	**Increase in cytosolic and mitochondrial protein synthesis in rat hepatocytes irradiated in vitro by He-Ne laser.**	In vitro	Isolated hepatocytes Coherence	"Both cytosolic and mitochondrial protein synthesis increased as a result of irradiation, as demonstrated by the measurement of hepatocytes previously treated with chloramphenicol and cycloheximide respectively. An initial investigation showed that stimulation of protein synthesis also occurred in hepatocytes irradiated with a non-coherent radiation source (fluence, 0.24 J cm(-2))."	PubMed

	Mechanisms	Original research	Pastore	Italy (Campobasso)	1994	Biochem Mol Biol Int	**Increase in <--H+/e- ratio of the cytochrome c oxidase reaction in mitochondria irradiated with helium-neon laser.**	In vitro	Isolated liver mitochondria	"A low, but statistically significant increase in the oxygen uptake was found, as polarographically measured, in the presence of rotenone and antimycin A, with ascorbate and TMPD used as substrate pair. Measurements were also made both of the electron transfer and of proton pumping activity: as a result of a major stimulation in the proton pumping activity, about 55% increase of <--H+/e- ratio was found in irradiated mitochondria."	PubMed
	Mechanisms	Original research	Greco	Italy (Bari)	1991	J Photochem Photobiol B	**Helium-neon laser irradiation of rat liver mitochondria gives rise to a new subpopulation of mitochondria: isolation and first biochemical characterization.**	In vitro	Isolated liver mitochondria	In the irradiated sample, two bands were observed, one corresponding to normal mitochondria and the other to atypical mitochondria.	PubMed
	Mechanisms	Original research	Greco	Italy (Bari)	1989	Biochem Biophys Res Commun	**Increase in RNA and protein synthesis by mitochondria irradiated with helium-neon laser.**	In vitro		"Following mitochondrial irradiation, both the rate and amount of incorporation of alpha-[32P]UTP and L-[35S]methionine, used to monitor RNA and protein synthesis respectively, proved to increase. Electrophoretic analysis made of the synthesis products clearly shows that He-Ne laser irradiation stimulates the synthesis of all mitochondrial transcription and translation products."	PubMed
	Mechanisms	Original research	Passarella	Italy (Bari)	1988	Biochem Biophys Res Commun	**Increase in the ADP/ATP exchange in rat liver mitochondria irradiated in vitro by helium-neon laser.**	In vitro	Isolated liver mitochondria	"As a result of experiments carried out with mitochondria loaded with either ATP or ADP, the increase in the activity of the ADP/ATP translocator is here proposed to depend on the increase in the electrochemical proton gradient which occurs owing to irradiation of mitochondria."	PubMed
	Mechanisms	Rapid communication	Santana-Blank	Venezuela (Caracas)	2013	Photomed Laser Surg	**Photobiomodulation of aqueous interfaces: finding evidence to support the exclusion zone in experimental and clinical studies.**	Rapid Communication			PubMed
★	Mechanisms	Review	Freitas & Hamblin	Brazil&USA	2016	IEEE J Sel Top Quantum Electron	**Proposed Mechanisms of Photobiomodulation or Low-Level Light Therapy**	Review			IEEE
	Mechanisms	Review	Arany PR	USA (Buffalo, NY)	2016	J Dent Res	**Craniofacial Wound Healing with Photobiomodulation Therapy: New Insights and Current Challenges.**	Review			PubMed
	Mechanisms	Review	Sommer AP	Germany	2015	Ann Transl Med	**A mechanism for ultrasound/light-induced biostimulation.**	(Review)	Alternative ideas		PubMed
	Mechanisms	Review	Sommer AP	Germany	2015	Ann Transl Med	**Tuning the mitochondrial rotary motor with light.**	(Review)			PubMed
★	Mechanisms	Review	Passarella & Karu	Italy & Russia	2014	J Photochem Photobiol B	**Absorption of monochromatic and narrow band radiation in the visible and near IR by both mitochondrial and non-mitochondrial photoacceptors results in photobiomodulation.**	Review			PubMed
	Mechanisms	Review	Hong P Kim	Korea	2014	Biomol Ther (Seoul)	**Lightening up Light Therapy: Activation of Retrograde Signaling Pathway by Photobiomodulation**	Review			PubMed
	Mechanisms	Review	Farivar	Iran	2014	J Lasers Med Sci	**Biological effects of low level laser therapy.**	Review			PubMed
★	Mechanisms	Review	Agrawal	USA (Boston, MA)	2014	Dose Response	**Pre-conditioning with low-level laser (light) therapy: light before the storm.**	Review	Preconditioning		PubMed
★	Mechanisms	Review	Wu & Xing	China (Guangzhou))	2013	Laser Photon Rev	**Intracellular signaling cascades following light irradiation**	Review			Wiley
	Mechanisms	Review	Rojas & Gonzalez-Lima	USA (Austin, TX)	2013	Biochem Pharmacol	**Neurological and psychological applications of transcranial lasers and LEDs**	Review	Brain		PubMed
★	Mechanisms	Review	Prindeze	USA (Washington)	2013	Exp Biol Med (Maywood)	**Mechanisms of action for light therapy: a review of molecular interactions.**	Review			PubMed
	Mechanisms	Review	Liebert	Australia	2013	Med Hypotheses	**Protein conformational modulation by photons: a mechanism for laser treatment effects.**	Review			PubMed
	Mechanisms	Review	Kushibiki	Japan (Tokorozawa)	2013	Int J Mol Sci	**Regulation of miRNA expression by low-level laser therapy (LLLT) and photodynamic therapy (PDT).**	Review			PubMed
★	Mechanisms	Review	Chung	USA (Boston, MA)	2012	Ann Biomed Eng	**The nuts and bolts of low-level laser (light) therapy.**	Review			PubMed
★	Mechanisms	Review	Quirk & Whelan	USA (Milwaukee, WI)	2011	Photomed Laser Surg	**Near-infrared irradiation photobiomodulation: the need for basic science.**				PubMed
	Mechanisms	Review	Poyton & Ball	USA (Colorado)	2011	Discov Med	**Therapeutic photobiomodulation: nitric oxide and a novel function of mitochondrial cytochrome c oxidase.**	Review			PubMed
	Mechanisms	Review	Karu & Pyatibrat	Russia (Troitsk)	2011	IUBMB Life	**Gene expression under laser and light-emitting diodes radiation for modulation of cell adhesion: Possible applications for biotechnology.**	Review			PubMed
	Mechanisms	Review	Huang	USA & China	2011	Dose Response	**Biphasic dose response in low level light therapy - an update.**	Review			PubMed
	Mechanisms	Review	Tafur	USA (San Diego, CA)	2010	Photomed Laser Surg	**Biophoton detection and low-intensity light therapy: a potential clinical partnership.**	Review			PubMed
★	Mechanisms	Review	Karu T	Russia (Troitsk)	2010	IUBMB Life	**Multiple Roles of Cytochrome c Oxidase in Mammalian Cells Under Action of Red and IR-A Radiation**	Review			PDF
	Mechanisms	Review	Hashmi	USA (Boston, MA)	2010	PM R	**Role of low-level laser therapy in neurorehabilitation.**	Review			PubMed
★	Mechanisms	Review	Lane N	UK	2009	Nature	**Cell biology: power games.**	News feature (Review)			PubMed
	Mechanisms	Review	Gao & Xing	China (Guangzhou)	2009	J Biomed Sci	**Molecular mechanisms of cell proliferation induced by low power laser irradiation.**	Review			PubMed
	Mechanisms	Review	Tafur & Mills	USA (La Jolla, CA)	2008	Photomed Laser Surg	**Low-intensity light therapy: exploring the role of redox mechanisms.**	Review			PubMed
	Mechanisms	Review	Karu TI	Russia (Troitsk)	2008	Photochem Photobiol	**Mitochondrial signaling in mammalian cells activated by red and near-IR radiation. K**	Review			PubMed
	Mechanisms	Review	Yeager	USA (IN)	2007	Med Hypotheses	**Melatonin as a principal component of red light therapy.**	Review	Melatonin		PubMed
	Mechanisms	Review	Amat	Spain	2006	J Photochem Photobiol B	**The electric field induced by light can explain cellular responses to electromagnetic energy: a hypothesis of mechanism.**	Review			
	Mechanisms	Review	Eells	USA (Milwaukee, WI)	2004	Mitochondrion	**Mitochondrial signal transduction in accelerated wound and retinal healing by near-infrared light therapy.**	Review			PubMed

	Mechanisms	Review	Karu TI	Russia (Troitsk)	1999	J Photochem Photobiol B	**Primary and secondary mechanisms of action of visible to near-IR radiation on cells.**	Review			PubMed
	Mechanisms	Review	Laakso	Australia	1993	Aust J Physiother	**Factors affecting Low Level Laser Therapy.**	Review			PubMed
	Mechanisms	Review	Kitchen & Partridge		1991	Physiotherapy	**A Review of Low Level Laser Therapy: Part I: Background, Physiological Effects and Hazards**	Review			Link
	Mechanisms	Review	Karu TI	Russia (Troitsk)	1989	Health Phys	**Photobiology of low-power laser effects.**	Review			PubMed
	Mechanisms	Review	Belkin & Schwartz	Israel (Ramat Gan)	1989	Health Phys	**New biological phenomena associated with laser radiation.**	Review			PubMed
	Mechanisms	Review	Karu TI	Russia (Troitsk)	1988	Lasers Life Sci	**Molecular Mechanism of the Therapeutic Effect of Low-Intensity Laser Radiation**	Review			PDF
	Mechanisms	Review	Smith KC		1981	J Invest Dermatol	**Photobiology and photomedicine: the future is bright.**	Review			Link
	Mechanisms	Review	Lane (Nick)	UK		(none)	**Are mitochondria the alpha and omega of retinal disease?**	Review	Retinal diseases		PDF
	Muscle	Action potential	Comelekoglu	Turkey (Mersin)	2002	Lasers Surg Med	**Electrophysiologic effect of gallium arsenide laser on frog gastrocnemius muscle.**	Frog		"This study revealed that at the different repetition rate and exposure time, low energy GaAs laser does not have any significant effect on frog gastrocnemius action potential."	PubMed
	Muscle	Atrophy	Rochkind & Shainberg	Israel (Ramat Gan)	2013	Photomed Laser Surg	**Protective effect of laser phototherapy on acetylcholine receptors and creatine kinase activity in denervated muscle.**	Rat	Muscle denervation	"In the early stages of muscle atrophy, laser phototherapy may preserve the denervated muscle by maintaining CK activity and the amount of AChR."	PubMed
	Muscle	Cachexia (burn)	Martins	Brazil (Santos)	2015	Acta Cir Bras	**Low-level laser therapy modulates musculoskeletal loss in a skin burn model in rats.**	Rat		"Low-level laser therapy had positive effects on gastrocnemius muscle, improving tissue muscle morphology, increasing cross sectional area and MyoD immunoexpression."	PubMed
	Muscle	Energy metabolism	Nguyen	USA (Gainesville, FL)	2014	Mitochondrion	**Effect of near-infrared light exposure on mitochondrial signaling in C2C12 muscle cells.**	In vitro	Biphasic dose response	"Repeated NIR light exposure (4 days) appeared to elevate oxidative stress and increase the upstream mitochondrial regulatory proteins AMPK (3.1-fold), p38 (2.8-fold), PGC-1α (19.7%), Sirt1 (26.8%), and reduced RIP140 (23.2%), but downstream mitochondrial regulation/content (Tfam, NRF-1, Sirt3, cytochrome c, ETC subunits) was unaltered. Our data indicates that NIR light alters mitochondrial biogenesis signaling and may represent a mechanistic link to the clinical benefits."	PubMed
	Muscle	Energy metabolism	Hayworth	USA (Austin, TX)	2010	Photochem Photobiol	**In vivo low-level light therapy increases cytochrome oxidase in skeletal muscle.**	Rat LED phototherapy LED cluster (149x)	Cytochrome oxidase	"The findings showed for the first time that in vivo LLLT induced a dose- and fiber type-dependent increase in cytochrome oxidase in muscle fibers. LLLT was particularly effective at enhancing the aerobic capacity of intermediate and red fibers. The findings suggest that LLLT may enhance the oxidative energy metabolic capacity of different types of muscle fibers, and that LLLT may be used to enhance the aerobic potential of skeletal muscle."	PubMed
	Muscle	Energy metabolism	Ferraresi	Brazil (São Carlos)	2015	Photochem Photobiol	**Low-level laser (light) therapy increases mitochondrial membrane potential and ATP synthesis in C2C12 myotubes with a peak response at 3-6 h.**	In vitro C2C12 myotubes		"LEDT employed a cluster of LEDs with 20 red (630 ± 10 nm, 25 mW) and 20 near-infrared (850 ± 10 nm, 50 mW) delivering 28 mW cm(2) for 90 s (2.5 J cm(2)) with analysis at 5 min, 3 h, 6 h and 24 h post-LEDT. LEDT-6 h had the highest MMP, followed by LEDT-3 h, LEDT-24 h, LEDT-5 min and Control with significant differences. The same order (6 h > 3 h > 24 h > 5 min > Control) was found for ATP with significant differences. A good correlation was found (r = 0.89) between MMP and ATP. These data suggest an optimum time window of 3-6 h for LEDT stimulate muscle cells." Comment: The increase in ATP levels at 6h was quite huge. Interesting.	PubMed
	Muscle	Energy metabolism	Albuquerque-Pontes	Brazil (São Paulo)	2015	Photochem Photobiol	**Effect of pre-irradiation with different doses, wavelengths, and application intervals of low-level laser therapy on cytochrome c oxidase activity in intact skeletal muscle of rats.**	Rat Biphasic dose response (?)		"Our results show that LLLT increased ($p < 0.05$) cytochrome c oxidase expression mainly with the following wavelengths and doses: 660 nm with 1 J, 830 nm with 3 J, and 905 nm with 1 J at all time points." "We conclude that LLLT can increase cytochrome c oxidase activity in intact skeletal muscle and that it contributes to our understanding of how LLLT can enhance performance and protect skeletal muscles against fatigue development and tissue damage." Comment: At some time points, the Cox expression was lower than in control group. It doesn't seem the result is as straightforward as the abstract makes it seem...	PubMed
	Muscle	Energy metabolism	Larkin-Kaiser	Canada (Calgary)	2015	J Athl Train	**Near-infrared light therapy to attenuate strength loss after strenuous resistance exercise.**	Human Crossover		"Applied to skeletal muscle before resistance exercise, NIR light therapy effectively attenuated strength loss. Therefore, NIR light therapy may be a beneficial, noninvasive modality for improving muscle function during rehabilitation after musculoskeletal injury. However, future studies using higher treatment doses are warranted."	PubMed
	Muscle	Energy metabolism	Xu	China (Guangzhou)	2008	Photomed Laser Surg	**Low-intensity laser irradiation improves the mitochondrial dysfunction of C2C12 induced by electrical stimulation.**	In vitro	Biphasic dose response	"Our data (as shown in Fig. 2) suggest that doses of 0.33–8.22 J/cm2 do no harm to the mitochondrial function of normal cells, while doses of 11.22–14.16 J/cm2 are beyond the point at which PBM is beneficial, and such doses can actually worsen cellular function (p 0.01), a finding consistent with that of the study done by Lavi et al. Our current research also showed that LIL irradiation at doses of 0.33–8.22 J/cm2 had a photobiomodulating effect on C2C12 myotubes, as manifested by the improvement of mitochondrial function compared with 75 min of electrical stimulation (p 0.01), and that LIL doses of 0.33 and 1.338 J/cm2 reversed the dysfunctional state induced by the electrical stimulation, as shown in Fig. 2."	PubMed
	Muscle	Exercise	De Marchi	Brazil (Caxias do Sul)	2017 epub	Lasers Med Sci	**Does photobiomodulation therapy is better than cryotherapy in muscle recovery after a high-intensity exercise? A randomized, double-blind, placebo-controlled clinical trial.**	Human RCT/DB	LED phototherapy LED cluster (34+35)	↓DOMS, ↓CK (serum), ↓TBARS (serum), ↓oxidative damage (serum), ↑MVC (post-exercise) "The clinical impact of these findings is clear because they demonstrate that the use of phototherapy is more effective than the use of cryotherapy for muscle recovery, additionally cryotherapy decreases PBMT efficacy."	PubMed

	Muscle	Exercise	Vanin	Brazil (São Paulo)	2016	Lasers Med Sci	**What is the best moment to apply phototherapy when associated to a strength training program? A randomized, double-blinded, placebo-controlled trial : Phototherapy in association to strength training.**	Human RCT/DB	LED phototherapy LED+LLLT cluster	"Volunteers from group treated with phototherapy before and placebo after training sessions showed significant ($p < 0.05$) changes in MVC and 1-RM tests for both exercises (leg extension and leg press) when compared to other groups. With an apparent lack of side effects and safety due to no thermal damage to the tissue, we conclude that the application of phototherapy yields enhanced strength gains when it is applied before exercise"	PubMed
	Muscle	Exercise	Aver Vanin	Brazil (São Paulo)	2016	Photomed Laser Surg	**Pre-Exercise Infrared Low-Level Laser Therapy (810 nm) in Skeletal Muscle Performance and Postexercise Recovery in Humans, What Is the Optimal Dose? A Randomized, Double-Blind, Placebo-Controlled Clinical Trial.**	Human RCT/DB	Dose response	"Pre-exercise LLLT, mainly with 50 J dose, significantly increases performance and improves biochemical markers related to skeletal muscle damage and inflammation." "However, LLLT had no effect in decreasing DOMS. No differences ($p > 0.05$) were found for 30 J dose in any of the outcomes measured." Comment: Since six sites were irradiated, 50J group refers to the 300J total dose.	PubMed
	Muscle	Exercise	Fritsch	Brazil (Porto Alegre)	2016	Lasers Med Sci	**Effects of low-level laser therapy applied before or after plyometric exercise on muscle damage markers: randomized, double-blind, placebo-controlled trial.**	Human RCT/DB	LED phototherapy LED cluster (5)	"In summary, the LLLT protocol used in this study had no effect on strength fall induced by muscle damage; then, caution is needed for recommending phototherapy to reduce this functional impairment. However, LLLT applied both before and after plyometric exercise was able to reduce the muscular echo intensity, indicating a reduced inflammatory response mediated by phototherapy. In addition, our findings suggest a slight effect (not statistically significant) on muscle soreness, which might seem too small for most individuals but can make a crucial difference for high-performance athletes."	PubMed
★📷	Muscle	Exercise	Ferraresi	Brazil (São Carlos)	2016	Am J Phys Med Rehabil	**Effects of Light-Emitting Diode Therapy on Muscle Hypertrophy, Gene Expression, Performance, Damage, and Delayed-Onset Muscle Soreness: Case-control Study with a Pair of Identical Twins.**	Human RCT Twin study	LED phototherapy	"Compared with placebo, LEDT increased the maximal load in exercise and reduced fatigue, creatine kinase, and visual analog scale. Gene expression analyses showed decreases in markers of inflammation (interleukin 1β) and muscle atrophy (myostatin) with LEDT. Protein synthesis (mammalian target of rapamycin) and oxidative stress defense (SOD2 [mitochondrial superoxide dismutase]) were up-regulated with LEDT, together with increases in thigh muscle hypertrophy." "Light-emitting diode therapy can be useful to reduce muscle damage, pain, and atrophy, as well as to increase muscle mass, recovery, and athletic performance in	PubMed
	Muscle	Exercise	Rossato	Brazil (Florianópolis)	2016	Lasers Med Sci	**Effect of pre-exercise phototherapy applied with different cluster probe sizes on elbow flexor muscle fatigue.**	Human RCT/DB Crossover	LED phototherapy LED cluster (33 or 9)	"In both large and small cluster probes (according parameters tested in this study) led to reduced fatigue in elbow flexor muscles, without difference between them."	PubMed
	Muscle	Exercise	Malta Ede	Brazil (Rio Claro)	2016	Lasers Med Sci	**Acute LED irradiation does not change the anaerobic capacity and time to exhaustion during a high-intensity running effort: a double-blind, crossover, and placebo-controlled study : Effects of LED irradiation on anaerobic capacity and performance in running.**	Human RCT/DB Crossover		"In summary, LEDT after a high-intensity running effort did not alter the MAODALT, metabolic energy pathways, or high-intensity running performance."	PubMed
	Muscle	Exercise	Larkin-Kaiser	Canada (Calgary)	2016	Lasers Med Sci	**Photobiomodulation delays the onset of skeletal muscle fatigue in a dose-dependent manner.**	Human RCT	Biphasic dose response (?)	"The 240-J dose significantly extended TTF by 26 % ($p = 0.032$) compared with the sham dose. TTF for the 240-J dose was strongly associated with a decrease in muscle fatigue ($R (2) = 0.54$, $p = 0.024$). Our findings show that a 240-J dose of NIR light therapy is efficacious in delaying the onset and extent of muscle fatigue during submaximal isometric positioning tasks. Our findings suggest that NIR light therapy may be used as an ergogenic aid during functional tasks or post-injury rehabilitation." Comment: The 480J dose was less effective.	PubMed
	Muscle	Exercise	Nampo	Brazil (São Cristóvão)	2016	Lasers Med Sci	**Effect of low-level phototherapy on delayed onset muscle soreness: a systematic review and meta-analysis.**	Meta-analysis			PubMed
★📷	Muscle	Exercise	Ferraresi	Brazil (São Paulo)	2016	J Biophotonics	**Photobiomodulation in human muscle tissue: an advantage in sports performance?**	Review	Parameters Optimal Dose		PubMed
	Muscle	Exercise	Zagatto	Brazil (Bauru)	2016	Lasers Med Sci	**Effects of low-level laser therapy on performance, inflammatory markers, and muscle damage in young water polo athletes: a double-blind, randomized, placebo-controlled study.**	Human RCT/DB		"In conclusion, LLLT resulted in a non-significant, but small to moderate effect on inflammatory and muscle damage markers and a moderate effect on performance in water polo players. In addition, the lack of positive results could be due to the small area covered by irradiation and this should be considered in future studies."	PubMed
	Muscle	Exercise	Miranda	Brazil (São Paulo)	2016	J Athl Train	**Using Pre-Exercise Photobiomodulation Therapy Combining Super-Pulsed Lasers and Light-Emitting Diodes to Improve Performance in Progressive Cardiopulmonary Exercise Tests.**	Human Crossover		"The combination of lasers and LEDs increased the time, distance, and pulmonary ventilation and decreased the score of dyspnea during a cardiopulmonary test."	PubMed
	Muscle	Exercise	Toma	Brazil	2016	Lasers Med Sci	**Low level laser therapy associated with a strength training program on muscle performance in elderly women: a randomized double blind control study.**	Human RCT/DB	Muscle performance	LLLT seemed a little bit better than the control, but is it clinically/statistically relevant (between-the-group)?	PubMed
	Muscle	Exercise	Pinto	Brazil (São Paulo)	2016	J Strength Cond Res	**Photobiomodulation Therapy Improves Performance and Accelerates Recovery of High-Level Rugby Players in Field Test: A Randomized, Crossover, Double-Blind, Placebo-Controlled Clinical Study.**	Human RCT/DB		"Photobiomodulation therapy significantly ($p \leq 0.05$) improved the average time of sprints and fatigue index in BST. Photobiomodulation therapy significantly decreased percentage of change in blood lactate levels ($p \leq 0.05$) and perceived fatigue ($p \leq 0.05$). Pre-exercise PBMT with the combination of super-pulsed laser (low-level laser), red LEDs, and infrared LEDs can enhance performance and accelerate recovery of high-level rugby players in field test. This opens a new avenue for wide use of PBMT in real clinical practice in sports settings."	PubMed

★	Muscle	Exercise	Perini	Brazil (Porto Alegre)	2016	Lasers Med Sci	**Long-term low-level laser therapy promotes an increase in maximal oxygen uptake and exercise performance in a dose-dependent manner in Wistar rats.**	Rat	Dose response	"The 61.2 J/cm(2)-LLLT group increased VO2basal (~40 %), VO2max (~24 %), VCO2max (~17 %), and distance covered (~34 %) after LLLT application on the skeletal muscle. No significant results were found comparing before and after conditions for the studied variables considering P-LLLT and 8.7 J/cm(2)-LLLT groups. The LLLT promoted in a dose-dependent manner an increase in oxygen consumption uptake and a performance increment of male Wistar rats." Comment: Parameters were well reported.	PubMed
	Muscle	Exercise	de Paiva	Brazil (São Paulo)	2016	Lasers Med Sci	**Photobiomodulation therapy (PBMT) and/or cryotherapy in skeletal muscle restitution, what is better? A randomized, double-blinded, placebo-controlled clinical trial.**	Human RCT/DB	Restitution after exercise GameDay™ device	"We conclude that PBMT used as single treatment is the best modality for enhancement of post-exercise restitution, leading to complete recovery to baseline levels from 24 h after high-intensity eccentric contractions."	PubMed
	Muscle	Exercise	Leal-Junior	Brazil (São Paulo)	2015	Lasers Med Sci	**Effect of phototherapy (low-level laser therapy and light-emitting diode therapy) on exercise performance and markers of exercise recovery: a systematic review with meta-analysis.**	Meta-analysis			PubMed
	Muscle	Exercise	Francisco Cde	Brazil (São Carlos)	2015	Trials	**Evaluation of acute effect of light-emitting diode (LED) phototherapy on muscle deoxygenation and pulmonary oxygen uptake kinetics in patients with diabetes mellitus: study protocol for a randomized controlled trial.**	Study protocol	Diabetic patients	"The main objective of this study is to evaluate the acute effects of muscular pre-conditioning using LED phototherapy on pulmonary oxygen uptake, muscle oxygenation, heart rate, and arterial pressure dynamics during dynamic moderate exercise. We hypothesize that phototherapy may be beneficial to optimize aerobic fitness in the DM population."	PubMed
	Muscle	Exercise	Ferraresi	Brazil (São Carlos)	2015	Lasers Med Sci	**Light-emitting diode therapy (LEDT) before matches prevents increase in creatine kinase with a light dose response in volleyball players.**	Human RCT/DB	LED phototherapy LED cluster	"LEDT prevented significant increases of CK in blood in athletes when applied before official matches with a light dose response of 210-315 J, suggesting athletes might consider applying LEDT before competition." Nampo et al published a brief criticism of this paper: "Due to the fragilities we pointed above, we agreed that the validity of this paper does not allow safe conclusions. To produce valid and meaningful results, we recommend to increase sample size, evaluate functional outcomes to establish clinical relevance, evaluate better established indicators of muscle damage (i.e., imaging), and do better	PubMed
	Muscle	Exercise	Ferraresi	Brazil (São Carlos)	2015	Physiother Theory Pract	**Muscular pre-conditioning using light-emitting diode therapy (LEDT) for high-intensity exercise: a randomized double-blind placebo-controlled trial with a single elite runner.**	Human (n=1)	LED phototherapy LED cluster	"LEDT improved the speed of the muscular VO2 adaptation (~-9 s), decreased O2 deficit (~-10 L), increased the VO2 from the slow component phase (~+348 ml min(-1)), and increased the time limit of exercise (~+589 s)." Note: A photograph is supplied, but it is black-and-white.	PubMed
★	Muscle	Exercise	Ferraresi	Brazil (São Carlos)	2015	Lasers Med Sci	**Time response of increases in ATP and muscle resistance to fatigue after low-level laser (light) therapy (LLLT) in mice.**	Mouse	LED phototherapy LED cluster	"LEDT-6 h was the subgroup with the highest ATP content in soleus and gastrocnemius compared to all subgroups ($P < 0.001$). In addition, mice in LEDT-6 h group performed more repetitions in the fatigue test ($P < 0.001$) compared to all subgroups: LEDT-sham and LEDT-5 min (~600 %), LEDT-3 h (~200 %), and LEDT-24 h (~300 %). A high correlation between the fatigue test repetitions and the ATP content in soleus ($r = 0.84$) and gastrocnemius ($r = 0.94$) muscles was observed. LEDT increased ATP content in muscles and fatigue resistance in mice with a peak at 6 h. Although the time response in mice and humans is not the same, athletes might consider applying LEDT at 6 h before competition."	PubMed
★	Muscle	Exercise	Ferraresi	Brazil (São Paulo)	2015	J Biophotonics	**Light-emitting diode therapy in exercise-trained mice increases muscle performance, cytochrome c oxidase activity, ATP and cell proliferation.**	Mouse	LED phototherapy LED cluster	"Six bi-daily training sessions LEDT-After and LEDT-Before-After regimens more than doubled muscle performance and increased ATP more than tenfold. The effectiveness of LEDT on improving muscle performance and recovery suggest applicability for high performance sports and in training programs." Star: Parameters are well reported. Results are interesting. A photograph is supplied.	PubMed
	Muscle	Exercise	Amadio	Brazil (São Paulo)	2015	Lasers Med Sci	**The action of pre-exercise low-level laser therapy (LLLT) on the expression of IL-6 and TNF-α proteins and on the functional fitness of elderly rats subjected to aerobic training.**	Rat		"These results suggest that laser therapy in conjunction with aerobic training may provide a therapeutic approach for reducing the inflammatory markers (IL-6 and TNF-α), however, LLLT without exercise was not able to improve physical performance of aged rats." Comment: Exercise was beneficial, but the importance of LLLT seems unclear/minimal.	PubMed
	Muscle	Exercise	Assis	Brazil (Santos)	2015	Braz J Phys Ther	**Effect of low-level laser therapy (808 nm) on skeletal muscle after endurance exercise training in rats.**	Rat		"Both trained groups showed significant increase in speed compared to the CG. The TLG demonstrated a significantly reduced lactate level, increased tibialis anterior (TA) fiber cross-section area, and decreased TA fiber density."	PubMed
	Muscle	Exercise	Kakihata	Brazil (Cascavel)	2015	Einstein (Sao Paulo)	**Influence of low-level laser therapy on vertical jump in sedentary individuals.**	Human		"The low intensity laser on the triceps surae, in sedentary individuals, had no significant effects on the variables evaluated."	PubMed
★	Muscle	Exercise	da Costa Santos	Brazil (Londrina)	2014	Lasers Med Sci	**LED therapy or cryotherapy between exercise intervals in Wistar rats: anti-inflammatory and ergogenic effects.**	Rat		"The [passive rest] group presented a high frequency of necrosis, but the LED group had fewer necrotic areas. Edema formation was prevented, and fewer areas of inflammatory cells were observed in the LED group. The time to exhaustion was greater in both the LED and Cryo groups, without differences in CK levels. CRP was decreased in LED animals. We conclude that LED therapy and cryotherapy can improve performance, although LED therapy is more efficient in preventing muscle damage and local and systemic inflammation." Comment: Results are very interesting. Parameters weren't well reported, though.	PubMed
	Muscle	Exercise	Borges	Brazil (Jequie)	2014	Lasers Med Sci	**Light-emitting diode phototherapy improves muscle recovery after a damaging exercise.**			"Our results showed that the muscle soreness, muscle strength loss, and ROM impairments were significantly reduced up to 96 h after a damaging eccentric exercise bout for the LEDT group compared with the PLACEBO group. A single LEDT (630 nm) intervention immediately after a damaging eccentric exercise bout was effective in terms of attenuating the muscle soreness and muscle strength loss and ROM impairments."	PubMed
	Muscle	Exercise	de Brito Vieira	Brazil (Natal)	2014	Photomed Laser Surg	**Use of low-level laser therapy (808 nm) to muscle fatigue resistance: a randomized double-blind crossover trial.**	Human RCT/DB Crossover		"LLLT group increased RM (52%; p=0.002) with a small EFI for the vastus medialis (p=0.004) and rectus femoris (p=0.004)."	PubMed

	Muscle	Exercise	Dos Reis	Brazil (Campo Grande)	2014	Photomed Laser Surg	**Effects of pre- or post-exercise low-level laser therapy (830 nm) on skeletal muscle fatigue and biochemical markers of recovery in humans: double-blind placebo-controlled trial.**	Human RCT/DB		"The number of repetitions (p=0.8965), RM (p=0.9915), and duration of fatigue (p=0.8424) were similar among the groups. Post-fatigue laser treatment significantly decreased the serum lactate concentration relative to placebo treatment (p<0.01) and also within the group over time (after 5 min vs. after 10 and 15 min, p<0.05 both). The CK level was lower in the post-fatigue laser group (p<0.01)."	PubMed
	Muscle	Exercise	da Silva Alves	Brazil (Santos)	2014	Lasers Med Sci	**Acute effects of low-level laser therapy on physiologic and electromyographic responses to the cardiopulmonary exercise testing in healthy untrained adults.**	Human RCT/DB Crossover		"The LLLT acutely increases exercise performance in healthy untrained adults probably due to increased O2 extraction by peripheral muscles without causing a significant impact on muscle fatigue."	PubMed
	Muscle	Exercise	Santos	Brazil (São Paulo)	2014	Lasers Med Sci	**Effects of pre-irradiation of low-level laser therapy with different doses and wavelengths in skeletal muscle performance, fatigue, and skeletal muscle damage induced by tetanic contractions in rats.**	Rat		"Several LLLT doses showed some positive effects on peak force and time to decay for one or more contractions, but in terms of total work, only 3 J/660 nm and 1 J/905 nm wavelengths prevented significantly ($p < 0.05$) the development of skeletal muscle fatigue" "Optimal doses of LLLT significantly delayed the development skeletal muscle performance and protected skeletal muscle tissue against damage. Our findings also demonstrate that optimal doses are partly wavelength specific and, consequently, must be differentiated to obtain optimal effects on development of skeletal muscle fatigue and tissue preservation. Our findings also lead us to think that the combined use of wavelengths at the same	
	Muscle	Exercise	Felismino	Brazil (Natal)	2014	Lasers Med Sci	**Effect of low-level laser therapy (808 nm) on markers of muscle damage: a randomized double-blind placebo-controlled trial.**	Human RCT/DB		"In conclusion, the LLLT attenuated CK activity 72 h after the muscle damage protocol but did not have a positive effect on the recovery of strength performance."	PubMed
	Muscle	Exercise	Paolillo	Brazil (São Carlos)	2014	Lasers Surg Med	**Low-level laser therapy associated with high intensity resistance training on cardiac autonomic control of heart rate and skeletal muscle remodeling in wistar rats.**	Rat		"The main results of the present study found that LLLT in conjunction with HIT increased MMP-2 gene expression and some HRV indices. It also appears LLLT has independent positive effects on HRV."	PubMed
★	Muscle	Exercise	Baroni	Brazil (Porto Alegre)	2014	Eur J Appl Physiol	**Effect of low-level laser therapy on muscle adaptation to knee extensor eccentric training.**	Human RCT	Muscle growth LLLT cluster	"Subjects from [training + LLLT group] reached significantly higher percent changes compared to subjects from [training group] for sum of muscles' thicknesses (15.4 vs. 9.4%), isometric peak torque (20.5 vs. 13.7%), and eccentric peak torque (32.2 vs. 20.0%)." Star: Interesting results. A topic worth investigating. Comment: LLLT spot size or energy density was not reported.	PubMed
	Muscle	Exercise	de Oliveira	Brazil (São Paulo)	2014	Trials	**What is the ideal dose and power output of low-level laser therapy (810 nm) on muscle performance and post-exercise recovery? Study protocol for a double-blind, randomized, placebo-controlled trial.**	Study protocol		"Our intention, is to determine optimal laser therapy application parameters capable of slowing down the physiological muscle fatigue process, reducing injuries or micro-injuries in skeletal muscle stemming from physical exertion and accelerating post-exercise muscle recovery."	PubMed
★	Muscle	Exercise	Antonialli	Brazil (São Paulo)	2014	Lasers Med Sci	**Phototherapy in skeletal muscle performance and recovery after exercise: effect of combination of super-pulsed laser and light-emitting diodes.**	Human RCT/DB	Muscle performance and recovery LED phototherapy LED cluster	"Pre-exercise phototherapy with combination of low-level laser and LEDs, mainly with 30 J dose, significantly increases performance, decreases DOMS, and improves biochemical marker related to skeletal muscle damage." Comment: The parameters are quite complex in this study - read the full text for further information. Star: An interesting paper with parameters well reported and good outcome!	PubMed
	Muscle	Exercise	Gomes	Brazil (São Paulo)	2014	Trials	**Efficacy of pre-exercise low-level laser therapy on isokinetic muscle performance in individuals with type 2 diabetes mellitus: study protocol for a randomized controlled trial.**	Study protocol		"The purpose of this randomized clinical trial is to evaluate the efficacy of pre-exercise LLLT on the performance of the quadriceps muscle (peak torque, total muscle work, maximum power and fatigue index - normalized by body mass) in individuals with DM-2. The study will support the practice of evidence-based to the use of LLLT in improving muscle performance in Individuals with DM-2. Data will be published after the study is completed."	PubMed
	Muscle	Exercise	Higashi	Brazil (Santos)	2013	Photomed Laser Surg	**Effects of low-level laser therapy on biceps braquialis muscle fatigue in young women.**	Human RCT Crossover	Biceps braquialis	"No statistical differences were found for eletromyographic fatigue and blood lactate values between groups. Mean numbers of elbow flexion-extension repetitions were 22.6 ± 7.58 after placebo, and 25.1 ± 9.89 after active LLLT group, but these differences were not statistically significant ($p=0.342$)."	PubMed
	Muscle	Exercise	Aquino	Brazil (São Carlos)	2013	Lasers Med Sci	**Low-level laser therapy (LLLT) combined with swimming training improved the lipid profile in rats fed with high-fat diet.**	Rat	Blood lipids, cholesterol	"LLLT decreased the total cholesterol ($p < 0.05$), triglycerides ($p < 0.01$), low-density lipoprotein cholesterol ($p < 0.05$), and relative mass of fat tissue ($p < 0.05$), suggesting increased metabolic activity and altered lipid pathways. The combination of exercise and LLLT increased the benefits of exercise alone. However, LLLT without exercise tended to increase body weight and fat content."	PubMed
	Muscle	Exercise	Borsa	USA (Gainesville, FL)	2013	J Athl Train	**Does phototherapy enhance skeletal muscle contractile function and postexercise recovery? A systematic review.**	Systematic review			PubMed
	Muscle	Exercise	Toma	Brazil (Santos)	2013	Lasers Med Sci	**Effect of 808 nm low-level laser therapy in exercise-induced skeletal muscle fatigue in elderly women.**	Human RCT/DB Triple-blinded Crossover		"The results showed no difference in the slope comparing placebo LLLT and active LLLT groups ($p = 0.293$). However, a significant difference was observed in the number of repetitions between groups, after active LLLT, subjects demonstrated significantly higher number of repetitions ($p = 0.047$). In this study, LLLT was efficient in increasing the mean number of repetitions during knee flexion-extension exercise, although results have not shown delay electromyographic fatigue."	PubMed
	Muscle	Exercise	Patrocinio	Brazil (São Carlos)	2013	Photomed Laser Surg	**Effect of low-level laser therapy (808 nm) in skeletal muscle after resistance exercise training in rats.**	Rat		"Analysis demonstrated that TGL demonstrated significantly reduced resting lactate level and decreased muscle glycogen depletion than the animals that were exercised only, and significantly increased the cross-section area of TA muscle fibers compared with thoseo in the other groups."	PubMed
	Muscle	Exercise	de Almeida	Brazil (São Paulo)	2012	Lasers Med Sci	**Red (660 nm) and infrared (830 nm) low-level laser therapy in skeletal muscle fatigue in humans: what is better?**	Human RCT Crossover	Wavelength comparison	"The mean peak force was significantly greater ($p < 0.05$) following red (12.14%) and infrared LLLT (14.49%) than following placebo LLLT, and the mean average force was also significantly greater ($p < 0.05$) following red (13.09%) and infrared LLLT (13.24%) than following placebo LLLT. There were no significant differences in mean average force or mean peak force between red and infrared LLLT. We conclude that both red than infrared LLLT are effective in delaying the development skeletal muscle fatigue and in enhancement of skeletal muscle performance."	PubMed

	Muscle	Exercise	Vieira	Brazil (Natal)	2012	Lasers Med Sci	**Effects of low-level laser therapy (808 nm) on isokinetic muscle performance of young women submitted to endurance training: a randomized controlled clinical trial.**	Human RCT		"The results suggest that an endurance training program combined with LLLT leads to a greater reduction in fatigue than an endurance training program without LLLT. This is relevant to everyone involved in sport and rehabilitation."	PubMed
	Muscle	Exercise	De Marchi	Brazil (Caxias do Sul)	2012	Lasers Med Sci	**Low-level laser therapy (LLLT) in human progressive-intensity running: effects on exercise performance, skeletal muscle status, and oxidative stress.**	Human RCT/DB Crossover		"Compared to placebo, active LLLT significantly increased exercise performance (VO(2 max) p = 0.01; time to exhaustion, p = 0.04) without changing the aerobic and anaerobic thresholds. LLLT also decreased post-exercise lipid (p = 0.0001) and protein (p = 0.0230) damages, as well as the activities of SOD (p = 0.0034), CK (p = 0.0001) and LDH (p = 0.0001) enzymes. LLLT application was not able to modulate CAT activity. The use of LLLT before progressive-intensity running exercise increases exercise performance, decreases exercise-induced oxidative stress and muscle damage, suggesting that the modulation of the redox system by LLLT could be related to the delay in skeletal muscle fatigue observed after the use of LLLT."	PubMed
	Muscle	Exercise	Leal Junior	Brazil (São Paulo)	2011	Lasers Med Sci	**Comparison between cold water immersion therapy (CWIT) and light emitting diode therapy (LEDT) in short-term skeletal muscle recovery after high-intensity exercise in athletes--preliminary results.**	Human RCT/DB Crossover		"There were no significant differences in the work performed during the three Wingate tests (p > 0.05). All biochemical parameters increased from baseline values (p < 0.05) after the three exercise tests, but only active LEDT decreased blood lactate levels (p = 0.0065) and CK activity (p = 0.0044) significantly after treatment. There were no significant differences in CRP values after treatments."	PubMed
	Muscle	Exercise	Ferraresi	Brazil (São Carlos)	2011	Lasers Med Sci	**Effects of low level laser therapy (808 nm) on physical strength training in humans.**	Human RCT		"The TLG subjects showed an increase of 55% in the 1RM leg-press test, which was significantly higher than the increases in the TG subjects (26%, P = 0.033) and in the CG subjects (0.27%, P < 0.001). The TLG was the only group to show an increase in muscle performance in the isokinetic dynamometry test compared with baseline. The increases in thigh perimeter in the TLG subjects and TG subjects were not significantly different (4.52% and 2.75%, respectively; P = 0.775). Strength training associated with LLLT can increase muscle performance compared with strength training only."	PubMed
★	Muscle	Exercise	de Almeida	Brazil (São Paulo)	2011	Photochem Photobiol	**Low-level laser therapy improves skeletal muscle performance, decreases skeletal muscle damage and modulates mRNA expression of COX-1 and COX-2 in a dose-dependent manner.**	Rat	Electrical stimulation of muscle	Comment: In the paper they report beam area as 0.0028 cm2, but since many other papers from Brazil have been 0.028, it is possible that they are misreporting something "The 1.0 and 3.0 J groups showed significant enhancement (P < 0.01) in total work performed in six tetanic contractions compared with control group. All laser groups, except the 3.0 J group, presented significantly lower post-exercise CK activity than control group. Additionally, 1.0 J group showed increased COX-1 and decreased COX-2 mRNA expression compared with control group and 0.1, 0.3 and 3.0 J laser groups (P < 0.01)."	PubMed
	Muscle	Exercise	Demura	Japan (Kanazawa)	2011	J Physiol Anthropol	**Effect of linear polarized near-infrared light irradiation and light exercise on muscle performance.**	Human	Super Lizer™	"In conclusion, skin and muscle temperatures increased significantly with the active and passive warm-ups selected in this study. However, muscle strength, muscle power, and controlled force-exertion performance did not improve with either warm-up."	PubMed
	Muscle	Exercise	Sussai	Brazil (Campo Grande)	2010	Lasers Med Sci	**Low-level laser therapy attenuates creatine kinase levels and apoptosis during forced swimming in rats.**	Rat	Swimming	"There was a significant difference in CK levels between groups (P < 0.0001) as well as between the 24 h and 48 h levels in the control group, whereas there was no significant intra-group difference in the LLLT group at the same evaluation times."	PubMed
	Muscle	Exercise	Leal Junior	Norway (Bergen)	2010	Eur J Appl Physiol	**Effect of low-level laser therapy (GaAs 904 nm) in skeletal muscle fatigue and biochemical markers of muscle damage in rats.**	Rat	Biphasic dose response	"We conclude that pre-exercise irradiation with a laser dose of 1.0 J and 904 nm wavelength significantly delays muscle fatigue and decreases post-exercise blood lactate and CK in this rat model." Note: The first author is from Brazil. The last author is from Norway. Maybe this was some kind of collaboration project	PubMed
	Muscle	Exercise	Baroni	Brazil (Porto Alegre)	2010	Eur J Appl Physiol	**Low level laser therapy before eccentric exercise reduces muscle damage markers in humans.**	Human	LLLT cluster (5)	"In conclusion, LLLT treatment before eccentric exercise was effective in terms of attenuating the increase of muscle proteins in the blood serum and the decrease in muscle force."	PubMed
	Muscle	Exercise	Baroni	Brazil (Porto Alegre)	2010	Photomed Laser Surg	**Effect of light-emitting diodes therapy (LEDT) on knee extensor muscle fatigue.**	Human RCT/DB Crossover	LED cluster (34+35)	"LEDT treatment produced a smaller maximal isometric torque decrease after high-intensity concentric isokinetic exercise, which is consistent with an increase in performance."	PubMed
★	Muscle	Exercise	Leal Junior	Brazil (São Paulo)	2010	J Orthop Sports Phys Ther	**Effects of low-level laser therapy (LLLT) in the development of exercise-induced skeletal muscle fatigue and changes in biochemical markers related to postexercise recovery.**	Human	LLLT cluster (5)	"Active LLLT increased the number of repetitions by 14.5% (mean +/- SD, 39.6 +/- 4.3 versus 34.6 +/- 5.6; P = .037) and the elapsed time before exhaustion by 8.0% (P = .034), when compared to the placebo treatment. The biochemical markers also indicated that recovery may be positively affected by LLLT, as indicated by postexercise blood lactate levels (P<.01), creatine kinase activity (P = .017), and C-reactive protein levels (P = .047), showing a faster recovery with LLLT application prior to the exercise."	PubMed
	Muscle	Exercise	Leal Junior	Brazil (Caxias do Sul)	2009	Lasers Surg Med	**Effect of cluster multi-diode light emitting diode therapy (LEDT) on exercise-induced skeletal muscle fatigue and skeletal muscle recovery in humans.**	Human RCT/DB Crossover	LED phototherapy LED cluster (69)	"Active LEDT increased the number of biceps humeri contractions by 12.9% (38.60 [SD +/-9.03] vs. 34.20 [SD +/-8.68], P = 0.021) and extended the elapsed time to perform contractions by 11.6% (P = 0.036) versus placebo. In addition, post-exercise levels of biochemical markers decreased significantly with active LEDT: Blood Lactate (P = 0.042), Creatine Kinase (P = 0.035), and C-Reative Protein levels (P = 0.030), when compared to placebo LEDT."	PubMed
	Muscle	Exercise	Leal Junior	Brazil (Caxias do Sul)	2009	Photomed Laser Surg	**Comparison between single-diode low-level laser therapy (LLLT) and LED multi-diode (cluster) therapy (LEDT) applications before high-intensity exercise.**	Human RCT/DB Crossover	LLLT vs LED LED phototherapy LED cluster	"In this experimental set-up, only the active LEDT probe decreased post-exercise CK levels after the Wingate cycle test. Neither performance nor blood lactate levels were significantly affected by this protocol of pre-exercise LEDT or LLLT."	PubMed
	Muscle	Exercise	Leal Junior	Brazil (Caxias do Sul)	2009	Lasers Med Sci	**Effect of 830 nm low-level laser therapy applied before high-intensity exercises on skeletal muscle recovery in athletes.**	Human RCT/DB Crossover		"LLLT irradiation before the Wingate test seemed to inhibit an expected post-exercise increase in CK level and to accelerate post-exercise lactate removal without affecting test performance."	PubMed

	Muscle	Exercise	Leal Junior	Brazil (Caxias do Sul)	2009	Lasers Med Sci	**Effect of 830 nm low-level laser therapy in exercise-induced skeletal muscle fatigue in humans.**	Human RCT/DB Crossover		"After active LLLT the mean number of repetitions was significantly higher than after placebo irradiation [mean difference 4.5, standard deviation (SD) +/- 6.0, P = 0.042], the blood lactate levels increased after exercises, but there was no significant difference between the treatments. We concluded that 830 nm LLLT can delay the onset of skeletal muscle fatigue in high-intensity exercises, in spite of increased blood lactate levels."	PubMed
	Muscle	Exercise	Leal Junior	Brazil (Caxias do Sul)	2008	Photomed Laser Surg	**Effect of 655-nm low-level laser therapy on exercise-induced skeletal muscle fatigue in humans.**	Human RCT/DB		"Compared to the first session (on day 1), the mean number of repetitions increased significantly by 8.5 repetitions (+/- 1.9) in the active LLLT group at the second session (on day 8), while in the placebo LLLT group the increase was only 2.7 repetitions (+/- 2.9) (p = 0.0001)."	PubMed
	Muscle	Exercise	Demura	Japan (Kanazawa)	2008	J Hum Ergol (Tokyo)	**Effect of linear polarized near-infrared light irradiation on muscle fatigue recovery after repeated handgrip exercise.**	Human	Super Lizer™	"It is inferred that PL-irradiation maintains a high skin temperature and blood flow, but it may not contribute to recover muscle contraction performance in muscle fatigue."	PubMed
	Muscle	Exercise	Lopes-Martins	Brazil (São Paulo)	2006	J Appl Physiol (1985)	**Effect of low-level laser (Ga-Al-As 655 nm) on skeletal muscle fatigue induced by electrical stimulation in rats.**	Rat	Biphasic dose response	"Laser groups receiving 0.5 and 1.0 J/cm2 showed significant increases in mean performed work compared with both the control group and their first contraction values."	PubMed
	Muscle	Muscle activity	Vassão	Brazil (Santos)	2016	Lasers Med Sci	**Effects of photobiomodulation on the fatigue level in elderly women: an isokinetic dynamometry evaluation.**	Human RCT/DB		"Muscle performance was evaluated using an isokinetic dynamometer. The results showed that photobiomodulation was able of reducing muscle fatigue by a significant increase of electromyographic fatigue index (EFI) (p = 0.047) and decreasing significantly lactate concentration 6 min after the performance of the fatigue protocol (p = 0. 0006) compared the placebo laser session. However, the photobiomodulation was not able of increasing muscle performance measured by the isokinetic dynamometer."	PubMed
	Muscle	Muscle activity	Kelencz	Brazil (Paraiba)	2010	Photomed Laser Surg	**Effect of low-power gallium-aluminum-arsenium noncoherent light (640 nm) on muscle activity: a clinical study.**	Human	LED phototherapy	"It was concluded that LED can be used as a clinical tool to increase muscle activity (1.044 J per point) and to prevent fatigue (2.088 J per point), without change in the muscle force."	PubMed
★	Muscle	Muscle atrophy	Muniz	Brazil (Ribeirão Preto)	2015	Muscle Nerve	**Properties of the tibialis anterior muscle after treatment with laser therapy and natural latex protein following sciatic nerve crush.**	Rat		"We observed a subsequent improvement in atrophy that was most prominent after 4 weeks in the groups that received P1 protein, but which also was present after 8 weeks in the groups that received LLLT." "Treatment using only P1 proved most efficient, revealing a negative interaction between P1 and LLLT." Comment: Parameters were well reported	PubMed
	Muscle	Muscle atrophy	Silva-Couto	Brazil (São Carlos)	2012	Rev Bras Fisioter	**Effects of low-level laser therapy after nerve reconstruction in rat denervated soleus muscle adaptation.**	Rat	Nerve injury	"LLLT applied to the nerve post-reconstruction was ineffective in delaying degenerative changes to the slow-twitch denervated muscles and in functional recovery in rats."	PubMed
	Muscle	Muscle fatigue	Lopes-Martins	Brazil (São Paulo)	2016	Photomed Laser Surg	**Laser Therapy and Muscle Fatigue: A Promising Research Area.**				PubMed
	Muscle	Muscle fatigue	Gorgey	USA (Indianapolis, IN)	2008	Photomed Laser Surg	**The effect of low-level laser therapy on electrically induced muscle fatigue: a pilot study.**	Human RCT Crossover		"LLLT did not attenuate muscle fatigue evoked by NMES, but this needs to be further addressed in human studies and clinical settings. The lack of significant findings could be explained by the small sample size and the selection of LLLT parameters."	PubMed
	Muscle	Muscle inflammation	Mantineo	Portugal (Coimbra)	2014	J Biomed Opt	**Low-level laser therapy on skeletal muscle inflammation: evaluation of irradiation parameters.**	Rat	Cytokine-induced muscle inflammation Pulsing vs continuous Biphasic dose response	"Our results show treatment effects, particularly for irradiation with the 830-nm laser. At day 6, the concentration of all measured proinflammatory cytokines in the 30 and 40 mW groups was significantly lower than for the control group. IL-6 concentration was reduced for all treatment groups and TNF-α for all but the 50-mW group. The number of inflammatory cells in muscle tissue samples was also significantly lower in all treatment groups when compared to the control animals"	PubMed
★	Muscle	Muscle injury	Ribeiro	Brazil (São Paulo)	2015 epub	Lasers Surg Med	**The effect of low-level laser therapy (LLLT) applied prior to muscle injury.**	Rat		"LLLT applied prior to muscle injury led to a reduction in myonecrosis and inflammatory cells, an increase of blood vessels and immature muscle fibers. An increase in MMP-2 activity and a decrease in collagen deposition were also found, with a better collagen organization and distribution." "LLLT applied immediately prior to injury had positive effects during the muscle regeneration process." Star: Parameters were well reported!	PubMed
	Muscle	Muscle injury	Ozaki	Brazil (Campinas)	2016	Lasers Med Sci	**Analysis of photobiomodulation associated or not with platelet-rich plasma on repair of muscle tissue by Raman spectroscopy.**	Rat		"It is concluded that either PBM or PRP, and the association of both, was able to reduce the oxidative stress promoted by injury and modulate collagen production at the site of the injury. Furthermore, although both treatments individually were effective for repairing the damage caused by muscle injury, the association of both demonstrated a better histological aspect."	PubMed
	Muscle	Muscle injury	de Melo	Brazil (São Paulo)	2016	Lasers Med Sci	**Light-emitting diode therapy increases collagen deposition during the repair process of skeletal muscle.**	Rat	Cryoinjury LED phototherapy	"LED therapy at 850 nm induced a significant reduction in inflammation, decreased MMP-2 activity, and increased the amount of immature muscle and collagen fibers during the muscle repair process following acute injury."	PubMed
	Muscle	Muscle injury	Ribeiro	Brazil (São Paulo)	2016	PLoS One	**Red and Infrared Low-Level Laser Therapy Prior to Injury with or without Administration after Injury Modulate Oxidative Stress during the Muscle Repair Process.**	Rat		"The administration of red and infrared laser therapy at different times positively modulates the activity of antioxidant enzymes and reduces stress markers during the muscle repair process."	PubMed
	Muscle	Muscle injury	Takhtfooladi	Iran	2016	Lasers Med Sci	**Evaluation of low-level laser therapy on skeletal muscle ischemia-reperfusion in streptozotocin-induced diabetic rats by assaying biochemical markers and histological changes.**	Rat	Muscle injury Diabetes	"LLLT has a beneficial effect on the IR muscle injury treatment in the diabetic rats"	PubMed
	Muscle	Muscle injury	Morais	Brazil (Araçatuba)	2016	Lasers Med Sci	**Strength training prior to muscle injury potentiates low-level laser therapy (LLLT)-induced muscle regeneration.**	Rat	Muscle regeneration	"Cryolesion induced massive muscle degeneration associated with inflammatory infiltrate. Prior ST improved skeletal regeneration 14-days after cryolesion and potentiated the regenerative response to LLLT."	PubMed
	Muscle	Muscle injury	Alves	Brazil (São Paulo)	2014	Am J Phys Med Rehabil	**Effects of low-level laser therapy on skeletal muscle repair: a systematic review.**	Systematic review			PubMed

★	Muscle	Muscle injury	de Almeida	Brazil (São Paulo)	2014	Lasers Med Sci	**What is the best treatment to decrease pro-inflammatory cytokine release in acute skeletal muscle injury induced by trauma in rats: low-level laser therapy, diclofenac, or cryotherapy?**	Rat	Muscle trauma Inflammation Biphasic dose response PBM vs diclofenac	"LLLT with 1 J dose significantly decreased ($p < 0.05$) IL-1β, IL-6, and TNF-α levels compared to non-treated injured group as well as diclofenac and cryotherapy groups." For inflammation marker reduction, the 1J dose was the most efficient (a biphasic dose response)!	PubMed
	Muscle	Muscle injury	Brunelli	Brazil (Campinas)	2014	Lasers Med Sci	**The effects of 780-nm low-level laser therapy on muscle healing process after cryolesion.**	Rat		"The G10 and G50 during the 7 days showed a significant reduction ($p < 0.05$) of lesion area compared to the CG, without differences between groups treated for 14 and 21 days. The G10 showed an increase of the amount of vessels after 14 days compared to the G50, but not in relation to controls. With regard to the immunohistochemical analyses of the MyoD factor, the G10 and G50 during the 7 days showed higher concentrations of immunomarkers than controls."	PubMed
	Muscle	Muscle injury	Alves	Brazil (São Paulo)	2014	Lasers Med Sci	**Modulating effect of low level-laser therapy on fibrosis in the repair process of the tibialis anterior muscle in rats.**	Rat		"The results revealed that LLLT induced a reduction in inflammatory infiltrate and myonecrosis after 1 day, an increase in the number of blood vessels after 3 and 7 days as well as an increase in the number of immature muscle fibers and MMP-2 gelatinase activity after 7 days. In conclusion, LLLT has a positive effect on the inflammatory process, MMP2 activity and collagen organization and distribution in the repair process of rat skeletal muscle."	PubMed
	Muscle	Muscle injury	Silveira	Brazil (Criciúma)	2013	Lasers Med Sci	**Effects of low-level laser therapy (GaAs) in an animal model of muscular damage induced by trauma.**	Rat		"LLLT accelerated the muscular healing by significantly decreasing superoxide anion production, TBARS levels, the activity of SOD, and hydroxyproline content. The data strongly indicate that increased ROS production and augmented collagen synthesis are elicited by traumatic muscular injury, effects that were significantly decreased by LLLT."	PubMed
	Muscle	Muscle injury	Luo	China (Suzhou)	2013	Lasers Med Sci	**Effects of low-level laser therapy on ROS homeostasis and expression of IGF-1 and TGF-β1 in skeletal muscle during the repair process.**	Rat		"The results showed that LLLT markedly promoted the regeneration of muscle and reduced scar formation. LLLT also significantly enhanced muscle SOD activity and significantly decreased muscle MDA levels 1, 2, and 3 days after injury."	PubMed
	Muscle	Muscle injury	de Paiva Carvalho	Brazil (São Paulo)	2013	Photochem Photobiol	**Effects of low-level laser therapy (LLLT) and diclofenac (topical and intramuscular) as single and combined therapy in experimental model of controlled muscle strain in rats.**	Rat	PBM vs diclofenac	"LLLT showed better effects than TD and ID regarding PGE2 levels and walking track analysis ($P < 0.05$)." "We can conclude that LLLT has more efficacy than topical and intramuscular diclofenac in treatment of muscle strain injury in acute stage."	PubMed
	Muscle	Muscle injury	França	Brazil (São Paulo)	2013	Lasers Med Sci	**Effect of laser therapy on skeletal muscle repair process in diabetic rats.**	Rat	Diabetic rats	"On day 14, the LLLT group was in the remodeling phase; the D group was still in the proliferative phase, with fibrosis, chronic inflammation, and granulation tissue; and the D-LLLT group was in an intermediary state in relation to the two previous groups. Under polarized light, on day 14, the LLLT and D-LLLT groups had organized collagen bundles in the perimysium, whereas the diabetic groups exhibited fibrosis."	PubMed
★	Muscle	Muscle injury	de Almeida	Brazil (São Paulo)	2013	Photochem Photobiol	**Low-level laser therapy and sodium diclofenac in acute inflammatory response induced by skeletal muscle trauma: effects in muscle morphology and mRNA gene expression of inflammatory markers.**	Rat	Muscle trauma Inflammation Biphasic dose response PBM vs diclofenac	"LLLT with all doses improved morphological aspects of muscle tissue, showing better results than injury and diclofenac groups." "All LLLT doses also decreased ($P < 0.05$) COX-2 compared to injury group at all time points, and to diclofenac group at 24 h after trauma. In addition, LLLT decreased ($P < 0.05$) TNF-α compared both to injury and diclofenac groups at all time points. LLLT mainly with dose of 9 J is better than topical application of diclofenac in acute inflammation after muscle trauma." For inflammation marker reduction, the 1J dose was the most efficient (a biphasic dose	PubMed
	Muscle	Muscle injury	Rodrigues	Brazil (São Carlos)	2013	J Photochem Photobiol B	**Low-level laser therapy (LLLT) (660nm) alters gene expression during muscle healing in rats.**	Rat		"Irradiated groups presented less inflammatory process than control group after 14 and 21 days. Cox-2 levels were downregulated in all irradiated groups after 7, 14 and 21 days. On day 7, both treated groups had a downregulation of Vegf levels, and an upregulation after 14 and 21 days, mainly with 50J/cm(2). The MyoD levels were upregulated with high dose in all periods and with low dose after 21 days. Myogenin expression was downregulated in both treated groups after 7 days, and was	PubMed
	Muscle	Muscle injury	Assis	Brazil (São Carlos)	2013	Lasers Med Sci	**Low-level laser therapy (808 nm) contributes to muscle regeneration and prevents fibrosis in rat tibialis anterior muscle after cryolesion.**	Rat	Cryolesion	"LLLT significantly reduced the lesion percentage area in the injured muscle ($p<0.05$), increased mRNA levels of the transcription factors MyoD and myogenin ($p<0.01$) and the pro-angiogenic vascular endothelial growth factor ($p<0.01$). Moreover, LLLT decreased the expression of the profibrotic transforming growth factor TGF-β mRNA ($p<0.01$) and reduced type I collagen deposition ($p<0.01$). These results suggest that LLLT could be an effective therapeutic approach for promoting skeletal muscle regeneration while preventing tissue fibrosis after muscle injury."	PubMed
	Muscle	Muscle injury	Fernandes	Brazil (São Paulo)	2013	Lasers Med Sci	**Effect of photobiomodulation on expression of IL-1β in skeletal muscle following acute injury.**	Rat	Acute injury	"In conclusion, LLLT was able to decrease IL-1β expression during the skeletal muscle repair following an acute injury."	PubMed
	Muscle	Muscle injury	Rodrigues	Brazil (São Carlos)	2013	J Rehabil Res Dev	**Effects of 660 nm low-level laser therapy on muscle healing process after cryolesion.**	Rat	Cryolesion	"Histopathological findings revealed a lower inflammatory process in the laser-treated groups after 7 d. After 14 d, irradiated animals at both fluences showed higher granulation tissue, new muscle fibers, and organized muscle structure. After 21 d, full tissue repair was observed in all groups. Moreover, irradiated animals at both fluences showed smaller necrosis area in the first experimental period evaluated."	PubMed

	Muscle	Muscle injury	Pertille	Brazil (Piracicaba)	2012	Rev Bras Fisioter	**Evaluation of muscle regeneration in aged animals after treatment with low-level laser therapy.**	Rat	(Sarcopenia)	"Considering the morphological and molecular analyzes performed, as well as the parameters used, it may be concluded that low-level laser therapy affects muscle regeneration of aged animals through its anti-inflammatory effects alone, as the results did not demonstrate an effect on the contents of the proteins studied." Comment: The results suggest that LLLT increased the recovery of cross sectional area of muscles quite markedly, but the authors claim there was no difference. Maybe it's a matter of statistical significance.	PubMed
	Muscle	Muscle injury	Silva	Brazil (São Paulo)	2012	Lasers Med Sci	**GaAs 904-nm laser irradiation improves myofiber mass recovery during regeneration of skeletal muscle previously damaged by crotoxin.**	Mouse	Crotoxin	"GaAs laser at a dose of 3 J, but not 1.5 J, significantly increased the CSA of regenerating myofibers and reduced the PIMA and the area density of intramuscular connective tissue of CTX-injured muscles." "Our results suggest that GaAs laser treatment at a dose of 3 J improves skeletal muscle regeneration by accelerating the recovery of myofiber mass."	PubMed
	Muscle	Muscle injury	Assis	Brazil (São Carlos)	2012	Lasers Surg Med	**Low-level laser therapy (808 nm) reduces inflammatory response and oxidative stress in rat tibialis anterior muscle after cryolesion.**	Rat		"LLLT reduced oxidative and nitrative stress in injured muscle, decreased lipid peroxidation, nitrotyrosine formation and NO production, probably due to reduction in iNOS protein expression. Moreover, LLLT increased SOD gene expression, and decreased the inflammatory response as measured by gene expression of NF-kβ and COX-2 and by TNF-α and IL-1β concentration."	PubMed
	Muscle	Muscle injury	de Souza	Brazil (São Paulo)	2011	Lasers Med Sci	**Phototherapy with low-level laser affects the remodeling of types I and III collagen in skeletal muscle repair.**	Rat	Cryoinjury	"InGaAlP diode laser within the power parameters and conditions tested had a biostimulatory effect at the regenerative and fibrotic phases of the skeletal muscle repairs, by promoting angiogenesis, reducing myonecrosis, and inducing types I and III collagen synthesis, following cryoinjury in rat."	PubMed
	Muscle	Muscle injury	Baptista	Brazil (São Paulo)	2011	Photomed Laser Surg	**Influence of laser photobiomodulation on collagen IV during skeletal muscle tissue remodeling after injury in rats.**	Rat	Cryoinjury	"It was demonstrated that LLLT promotes an increase in collagen IV immunolabeling in skeletal muscle in the first 7 days after acute trauma caused by cryoinjury, but does not modify the duration of the tissue-repair process. Even with LLLT, the injured muscle tissue needs ~21 days to achieve the same state of organization as that in the noninjured muscle."	PubMed
	Muscle	Muscle injury	Mesquita-Ferrari	Brazil (São Paulo)	2011	Lasers Med Sci	**Effects of low-level laser therapy on expression of TNF-α and TGF-β in skeletal muscle during the repair process.**	Rat		"LLLT caused a decrease in TNF-α mRNA expression at 1 and 7 days following injury and in TGF-β mRNA expression at 7 days following cryoinjury in comparison to the control group."	PubMed
	Muscle	Muscle injury	Lakyová	Slovakia (Kosõice)	2010	Lasers Surg Med	**Low-level laser therapy for protection against skeletal muscle damage after ischemia-reperfusion injury in rat hindlimbs.**	Rat		"LLLT confers a protective effect against early inflammatory tissue response, further atrophy, and necrosis of the muscle and it stimulates neovascularization after I/R injury."	PubMed
	Muscle	Muscle injury	Liu	China (Wuman)	2009	Photomed Laser Surg	**Effects of low-level laser irradiation on rat skeletal muscle injury after eccentric exercise.**	Rat	Exercise-induced muscle injury Dose response	"He-Ne laser irradiation at 43 J/cm2 inhibited muscle inflammation, significantly enhanced muscle SOD activity and significantly reduced serum CK activity and muscle MDA level at both 24 and 48 h after exercise, whereas the irradiation at 12 or 28 J/cm2 slightly inhibited muscle inflammation and significantly reduced serum CK activity at 48 h after exercise only (P<0.05)." "The photobiomodulation was dose-dependent, and the 43 J/cm2 dose was the most efficient among the doses used."	PubMed
	Muscle	Muscle injury	Cressoni	Brazil (São Paulo)	2008	Photomed Laser Surg	**The effects of a 785-nm AlGaInP laser on the regeneration of rat anterior tibialis muscle after surgically-induced injury.**	Rat	Surgically induced injury	"Quantitative data showed that the number of both polymorphonuclear and mononuclear leukocytes in the inflammatory infiltrate at the injury site was smaller in the ILI(1), ILI(2), and ILI(4) subgroups compared with their respective control subgroups (IN(1), IN(2), and IN(4)) for sessions 1, 2, and 4, respectively (p < 0.05)." "With regard to the regeneration of muscle fibers following injury, only after the fourth treatment session was it possible to find muscle precursor cells such as myoblasts and some myotubes in the ILI(4) subgroup."	PubMed
	Muscle	Muscle injury	Avni	Israel (Tel Aviv)	2005	Photomed Laser Surg	**Protection of skeletal muscles from ischemic injury: low-level laser therapy increases antioxidant activity.**	Rat		"It was found that laser irradiation markedly protects skeletal muscles from degeneration following acute I-R injury. This was evident by significantly (p < 0.05) higher content of creatine phosphokinase activity and lower (p < 0.05) activity of acid phosphatase in the LLLT-treated muscles relative to the injured non-irradiated ones. The content of antioxidants and heat shock proteins was also higher (p < 0.05) in the LLLT-treated muscles relative to that of injured non-irradiated muscles."	PubMed
	Muscle	Muscle injury	Bibikova		1994	Anat Embryol (Berl).	**Enhancement of angiogenesis in regenerating gastrocnemius muscle of the toad (Bufo viridis) by low-energy laser irradiation.**		Angiogenesis	Red light (632.8nm) promotes angiogenesis in the injured zone.	PubMed
	Muscle	Muscle injury	Bibikova & Oron		1993	Anat Rec	**Promotion of muscle regeneration in the toad (Bufo viridis) gastrocnemius muscle by low-energy laser irradiation.**		Muscle injury regeneration	"Young myofibers in the laser-irradiated muscles populated 15.5% +/- 7.9% and 65.0% +/- 9.5% of the injured area at 9 and 14 days of muscle regeneration, respectively, while in control muscles these structures were not evident at 9 days and made up only 5.3% +/- 2.9% of the traumatized area at 14 days postinjury."	PubMed
	Muscle	Muscle injury	Weiss & Oron		1992	Anat Embryol (Berl).	**Enhancement of muscle regeneration in the rat gastrocnemius muscle by low energy laser irradiation.**		Muscle injury regeneration	"It is concluded that He-Ne laser irradiation during the regeneration process promotes muscle maturation in the injured zone following partial excision of the rat gastrocnemius muscle."	PubMed
	Muscle	Myopathy	Macedo	Brazil (Campinas)	2015	PLoS One	**Low-Level Laser Therapy (LLLT) in Dystrophin-Deficient Muscle Cells: Effects on Regeneration Capacity, Inflammation Response and Oxidative Stress.**	In vitro	Mdx muscle cells	"Together, these results suggest that the laser treatment improved regenerative capacity and decreased inflammatory response and oxidative stress in dystrophic muscle cells, indicating that LLLT could be a helpful alternative therapy to be associated with other treatment for dystrophinopathies."	PubMed
	Muscle	Myopathy	Silva	Brazil (São Paulo)	2015	Lasers Med Sci	**Pre-exercise low-level laser therapy improves performance and levels of oxidative stress markers in mdx mice subjected to muscle fatigue by high-intensity exercise.**	Mouse	Mdx mice	"The mdx mice treated with LLLT showed significantly lower levels of creatine kinase (CK) and oxidative stress than mdx mice that underwent forced high-intensity exercise on a treadmill. The activities of the antioxidant enzyme superoxide dismutase (SOD) were higher in control mdx mice than in WT mice. LLLT also significantly reduced the level of this marker. LLLT had a beneficial effect also on the skeletal muscle performance of mdx mice."	PubMed
★	Muscle	Myopathy	Leal-Junior	Brazil & UK & Norway	2014	PLoS One	**Superpulsed low-level laser therapy protects skeletal muscle of mdx mice against damage, inflammation and morphological changes delaying dystrophy progression.**	Mouse	Mdx mice	"Irradiation of superpulsed LLLT on successive days five times per week for 14 weeks decreased morphological changes, skeletal muscle damage and inflammation in mdx mice. This indicates that LLLT has potential to decrease progression of Duchenne muscular dystrophy." Star: The parameters were well reported, and the article was well written. A photograph of LLLT treatment was included.	PubMed

	Muscle	Myopathy	Dávila	Argentina (Córdoba)	2011	Laser Ther	**Low level laser therapy on experimental myopathy.**		Experimental myopathy	"In the present work, LLLT caused great changes in inflammatory biomarkers, with decreased levels of NO in rats with experimental myopathies and significant muscle recovery." Comment: Parameters were reported incompletely.	PubMed
	Muscle	Myopathy	Servetto	Argentina (Córdoba)	2010	Lasers Surg Med	**Evaluation of inflammatory biomarkers associated with oxidative stress and histological assessment of low-level laser therapy in experimental myopathy.**	Rat	Experimental myopathy	"LLLT caused significant changes in inflammatory biomarkers and oxidative stress: decreased levels of fibrinogen, L-citrulline and SOD as opposed to the increase of NO in rats with experimental myopathies and significant muscle recovery." Comment: Parameters were reported incompletely. Laser spot size wasn't reported. However, results are interesting.	PubMed
	Muscle	Review	Leal-Junior EC	Brazil (São Paulo)	2015	Photomed Laser Surg	**Photobiomodulation therapy in skeletal muscle: from exercise performance to muscular dystrophies.**		Guest Editorial		PubMed
★	Muscle	Sarcopenia	Corazza	Brazil (Piracicaba)	2013	Lasers Med Sci	**Phototherapy and resistance training prevent sarcopenia in ovariectomized rats.**	Rat	Ovaryectomized rats	"Significant increases ($p < 0.05$) were noted for the muscle volume of the T (68.1 ± 19.7%), the L (74.1 ± 5.1%), and the LT (68.2 ± 11.5%) groups compared to the C group (60.4 ± 5.5%). There were also significant increases in the concentrations of IGF-1, IL-1, and TNF-α in the muscles of the treated groups ($p < 0.05$)."	PubMed
	Muscle	Spasticity	das Neves	Brazil (São José dos Campos)	2016	Lasers Med Sci	**Effects of low-level laser therapy (LLLT 808 nm) on lower limb spastic muscle activity in chronic stroke patients.**	Human DB	Stroke patients	"After the real LLLT intervention, we observed significant reduction in the visual analogue scale for pain intensity ($p = 0.0038$), increased time to onset of muscle fatigue ($p = 0.0063$), and increased torque peak ($p = 0.0076$), but no significant change in the root mean square (RMS) value (electric signal in the motor unit during contraction, as obtained with surface electromyography). Our results suggest that the application of LLLT may contribute to increased recruitment of muscle fibers and, hence, to increase the onset time of the spastic muscle fatigue, reducing pain intensity in stroke patients with spasticity, as has been [illegible]."	PubMed
	Muscle	Spasticity	dos Reis	Brazil (Urbanova)	2015	Lasers Med Sci	**Immediate effects of low-intensity laser (808 nm) on fatigue and strength of spastic muscle.**	Human DBB		"After application of LILT, we found increased torque as well as decreased in lactate level in patients with spasticity."	PubMed
	Nerves	CNS	Ashworth	Australia (Crawley)	2016	BMC Neurosci	**Comparative assessment of phototherapy protocols for reduction of oxidative stress in partially transected spinal cord slices undergoing secondary degeneration.**	In vitro	Spinal cord	"Our results indicate that R/NIR-LT is an effective antioxidant therapy, and indicate that effective wavelengths and ranges of intensities of treatment can be adapted for a variety of CNS injuries and conditions, depending upon the transmission properties of the tissue to be treated."	PubMed
	Nerves	CNS	Ng & Chu	China (Hong Kong)	2014	J Chiropr Med	**Treatment of Bell's Palsy Using Monochromatic Infrared Energy: A Report of 2 Cases.**	Human Case series	Bell's palsy MIRE treatment with "Anodyne" LED pad device	"The acute case received 19 treatments in 6 weeks. He reported an improvement of 95%. The chronic case received a total of 45 treatments in 9 months. She rated an improvement of 50%." "These 2 patients seemed to respond to a different degree to the MIRE therapy. As 71% of patients with Bell's palsy recover uneventfully without any treatment, the present study describes the course of care but cannot confirm the effectiveness of MIRE therapy in the management of Bell's palsy."	PubMed
	Nerves	CNS	Alayat	Egypt (Cairo)	2014	Lasers Med Sci	**Efficacy of high and low level laser therapy in the treatment of Bell's palsy: a randomized double blind placebo-controlled trial.**	Human RCT	Bell's palsy HILT vs LLLT	"The result showed that both HILT and LLLT significantly improved the recovery of patients with Bell's palsy. Moreover, HILT was the most effective treatment modality compared to LLLT and massage with exercises."	PubMed
	Nerves	Cranial	Buchaim	Brazil (Marilia)	2016	Lasers Med Sci	**The new heterologous fibrin sealant in combination with low-level laser therapy (LLLT) in the repair of the buccal branch of the facial nerve.**	Rat		"LLLT exhibited satisfactory results on facial nerve regeneration, being therefore a useful technique to stimulate axonal regeneration process."	PubMed
	Nerves	Cranial	Snyder	USA (Bethesda, MD)	2002	Lasers Surg Med	**Quantitation of calcitonin gene-related peptide mRNA and neuronal cell death in facial motor nuclei following axotomy and 633 nm low power laser treatment.**	Rat	Axotomy	"These findings demonstrate that 633 nm laser light upregulates CGRP mRNA and support the theory that laser irradiation increases the rate of regeneration, target reinnervation, and neuronal survival of the axotomized neuron."	PubMed
	Nerves	Cranial	Anders	USA (Bethesda, MD)	1993	Lasers Surg Med	**Low power laser irradiation alters the rate of regeneration of the rat facial nerve.**	Rat	Nerve injury n. facialis	"The most effective laser parameters for the low power treatment included daily irradiation with a helium-neon (HeNe) or argon pumped tunable dye laser a wavelength of 633 nm, with a power of 8.5 mW for 90 minutes (45.9 J, 162.4 J/cm2)." "These data indicate that transcutaneous low power irradiation with the lasers and parameters involved in this study increased the rate of regeneration of rat facial nerve following crush injury."	PubMed
☹	Nerves	Diabetic neuropathy	Cg	India (Manipal)	2015	Laser Ther	**Efficacy of low level laser therapy on painful diabetic peripheral neuropathy.**	Human Observational		"The result analysis showed significant reduction in Pain using VAS scale (6.47 ± 0.84 to 1.21 ± 0.78 ($p<0.001$), MNSI (5.52 ± 1.26 to 2.71 ± 0.97 (reduction in Vibration perception threshold (32.68 ± 6.08 to 24.84 ± 4.29 (<0.001) and a significant increase in the temperature from baseline to post intervention (30.01 ± 2.11 to 31.75 ± 1.03 ($p<0. 001$)." Comment: Parameters were poorly reported. The article had interesting results but wasn't very well written...	PubMed
☹	Nerves	Diabetic neuropathy	Bashiri H	Iran (Kermanshah)	2013	Acta Med Iran	**Evaluation of low level laser therapy in reducing diabetic polyneuropathy related pain and sensorimotor disorders.**	Human RCT		"Laser therapy resulted in improved neuropathy outcomes in diabetic patients who received it relative to the group that received sham therapy, evaluating before and after LLLT assessments." Comment: A poorly written paper	PubMed
☹	Nerves	Diabetic neuropathy	Yamany & Sayed	Egypt (Giza)	2012	J Adv Res	**Effect of low level laser therapy on neurovascular function of diabetic peripheral neuropathy**	Human RCT/SB		"Pain was significantly decreased ($p \leqslant 0.05$) and electrophysiological parameters and foot skin microcirculation were significantly improved ($p \leqslant 0.05$) in the laser group, while no significant change was obtained in the control group. Low level laser therapy within the applied parameters and technique could be an effective therapeutic modality in reducing pain and improving neurovascular function in patients with diabetic polyneuropathy." Comment: The parameters were poorly reported. The other parts of paper seem fine.	ScienceDirect
	Nerves	Diabetic neuropathy	Nawfar & Yacob	Malaysia (Kota Bharu)	2011	Singapore Med J	**Effects of monochromatic infrared energy therapy on diabetic feet with peripheral sensory neuropathy: a randomised controlled trial.**	Human RCT/SB	MIRE treatment with "Anodyne" LED pad device	"No improvement of neuropathy was observed following MIRE treatment in the neuropathic feet of diabetic patients."	PubMed

	Nerves	Diabetic neuropathy	Khamseh	Iran (Tehran)	2011	Lasers Med Sci	**Diabetic distal symmetric polyneuropathy: effect of low-intensity laser therapy.**	Human		"At the end of the study, the subjects showed a significant increase in neural potential amplitudes ($p < 0.05$). This study clearly demonstrated a significant positive effect of LILT on improvement of nerve conduction velocity on diabetic distal symmetric polyneuropathy (DSP)." Comment: The parameters were insufficiently reported.	PubMed
	Nerves	Diabetic neuropathy	Swislocki	USA (Martinez, CA)	2010	J Pain Symptom Manage	**A randomized clinical trial of the effectiveness of photon stimulation on pain, sensation, and quality of life in patients with diabetic peripheral neuropathy.**	Human RCT	LED phototherapy LED cluster	"No differences, over time, in any pain intensity scores (i.e., pain intensity immediately post-treatment, average pain, worst pain) or pain relief scores were found between the placebo and treatment groups." "Four treatments with photon stimulation resulted in significant improvements in some pain qualities, sensation, and QOL outcomes in a sample of patients with a significant amount of pain and disability from their diabetes. A longer duration study is needed to further refine the photon stimulation treatment protocol in these chronically ill patients and to evaluate the sustainability of its effects." Comment: Parameters were quite shortly reported. These studies on diabetic	PubMed
	Nerves	Diabetic neuropathy	Lavery	USA (Temple, TX)	2008	Diabetes Care	**Does anodyne light therapy improve peripheral neuropathy in diabetes? A double-blind, sham-controlled, randomized trial to evaluate monochromatic infrared photoenergy.**	Human RCT/DB	MIRE treatment with "Anodyne" LED pad device	"Anodyne MIRE therapy was no more effective than sham therapy in the treatment of sensory neuropathy in individuals with diabetes."	PubMed
	Nerves	Diabetic neuropathy	Perić Z	Serbia	2007	Srp Arh Celok Lek	**[Influence of low-intensity laser therapy on spatial perception threshold and electroneurographic finding in patients with diabetic polyneuropathy].** **[Article in Serbian]**	Human		"In this study we registered significant decrease of SPT and increase of NMMCV after LILT and that indicated a favourable effect of this treatment in analysed patients with painful DPN. In our opinion these results need further investigation."	PubMed
☹	Nerves	Diabetic neuropathy	Powell	USA (Springdale, AR)	2006	Age Ageing	**Reversal of diabetic peripheral neuropathy with phototherapy (MIRE) decreases falls and the fear of falling and improves activities of daily living in seniors.**	Human Retrospective		"Incidence of falls and fear of falling decreased within 1 month after reversal of peripheral neuropathy and remained low after 1 year. Likewise, improved ADL were evident soon after reversal of peripheral neuropathy and showed further improvement after 1 year. Overall, reversal of peripheral neuropathy in a clinician's office and subsequent use of MIRE at home was associated with a 78% reduction in falls, a 79% decrease in balance-related fear of falling and a 72% increase in ADL ($P < 0.0002$ for all results)." Comment: Parameters were not reported at all.	PubMed
☹	Nerves	Diabetic neuropathy	Arnall	USA (Johnson City, TN)	2006	Acta Diabetol	**The restorative effects of pulsed infrared light therapy on significant loss of peripheral protective sensation in patients with long-term type 1 and type 2 diabetes mellitus.**	Human	LED phototherapy LED cluster	"PILT improved peripheral protective sensation (PPS) even in patients with long-standing chronic neuropathies whose initial pre-study sensation was not measurable with a 200-g SWM. PILT significantly improves PPS. While the exact mechanism of action is not understood, infrared light may improve peripheral neuropathies by improving foot perfusion by stimulating nitric oxide production." Comment: Parameters were poorly reported.	PubMed
	Nerves	Diabetic neuropathy	Clifft	USA (Memphis, TN)	2005	Diabetes Care	**The effect of monochromatic infrared energy on sensation in patients with diabetic peripheral neuropathy: a double-blind, placebo-controlled study.**	Human RCT/DB	MIRE treatment with "Anodyne" LED pad device	"Thirty minutes of active MIRE applied 3 days per week for 4 weeks was no more effective than placebo MIRE in increasing sensation in subjects with diabetic peripheral neuropathy. Clinicians should be aware that MIRE may not be an effective modality for improving sensory impairments in patients with diabetic neuropathy." Note: A comment to this study was published by Burke, who argued that the negative result could be due the selected parameters and other methodological factors.	PubMed
☹	Nerves	Diabetic neuropathy	Zinman	Canada (Toronto)	2004	Diabetes Care	**Low-intensity laser therapy for painful symptoms of diabetic sensorimotor polyneuropathy: a controlled trial.**	Human RCT/DB	MIRE treatment with "Anodyne" LED pad device	"Although an encouraging trend was observed with LILT, the study results do not provide sufficient evidence to recommend this treatment for painful symptoms of DSP." Jan Tuner's comment: "Unfortunately, this study cannot be evaluated since the documentation of the actual laser parameters is poor. The only information given about these essential facts is "The LILT device had a wavelength of 905 nm and an average power of 0-60 mW. All LILT treatments were for 5 min per site." Which output was actually used? Pulse repetition rate? Dose? Power density?"	PubMed
☹	Nerves	Diabetic neuropathy	Powell	USA (Springdale, AR)	2004	Adv Skin Wound Care	**Reversal of diabetic peripheral neuropathy and new wound incidence: the role of MIRE.**	Human Retrospective	MIRE treatment with "Anodyne" LED pad device	"After reversal of diabetic peripheral neuropathy following treatment with monochromatic near infrared photo energy, only 1 of 68 patients developed a new diabetic foot wound, for an incidence of 1.5%. Comparatively, the incidence previously reported in the Medicare-aged population with diabetes was 7.3%." Comment: Parameters were not reported at all.	PubMed
	Nerves	Diabetic neuropathy	Leonard	USA (Clearwater, FL)	2004	Diabetes Care	**Restoration of sensation, reduced pain, and improved balance in subjects with diabetic peripheral neuropathy: a double-blind, randomized, placebo-controlled study with monochromatic near-infrared treatment.**	Human RCT/DB	MIRE treatment with "Anodyne" LED pad device	"ATS treatments improve sensation in the feet of subjects with DPN, improve balance, and reduce pain."	PubMed
☹	Nerves	Diabetic neuropathy	Kochman	USA (Aurora, CO)	2002	J Am Podiatr Med Assoc	**Symptomatic reversal of peripheral neuropathy in patients with diabetes.**	Human		"On the basis of Semmes-Weinstein monofilament values, 48 subjects (98%) exhibited improved sensation after 6 treatments, and all subjects had improved sensation after 12 treatments. Therefore, MIRE may be a safe, drug-free, noninvasive treatment for the consistent and predictable improvement of sensation in diabetic patients with peripheral neuropathy of the feet." Comment: Parameters were not reported.	PubMed
	Nerves	In vitro	Huang	USA (Boston, MA)	2014	J Biophotonics	**Low-level laser therapy (810 nm) protects primary cortical neurons against excitotoxicity in vitro.**	In vitro	Primary cortical neurons Excitotoxicity Glutamate / NMDA / kainate	"Although the prevention of cell death was modest but significant, LLLT (3 J/cm(2) delivered at 25 mW/cm(2) over 2 min) gave highly significant benefits in increasing ATP, raising mitochondrial membrane potential, reducing intracellular calcium concentrations, reducing oxidative stress and reducing nitric oxide. The action of LLLT in abrogating excitotoxicity may play a role in explaining its beneficial effects in diverse central nervous system pathologies."	PubMed
	Nerves	In vitro	Burland	France (Montpellier)	2015	J Biophotonics	**Neurite growth acceleration of adult Dorsal Root Ganglion neurons illuminated by low-level Light Emitting Diode light at 645 nm.**	In vitro	LED phototherapy	"Although the axotomized neurons were naturally already in a rapid regeneration process, an enhancement was found to occur while irradiating with the LED light, which may be promising for therapy applications."	PubMed

	Nerves	In vitro	Giuliani	Italy (Bologna)	2009	BMC Complement Altern Med	**Low infra red laser light irradiation on cultured neural cells: effects on mitochondria and cell viability after oxidative stress.**	In vitro		"These data suggest that red light radiation protects the viability of cell culture in case of oxidative stress, as indicated by MMP measurement and MTT assay. It also stimulates neurite outgrowth, and this effect could also have positive implications for axonal protection."	PubMed
	Nerves	In vitro	Ignatov	Russia (Saint-Petersburg)	2005	Neurosci Behav Physiol	**Effects of helium-neon laser irradiation and local anesthetics on potassium channels in pond snail neurons.**	In vitro	Biphasic dose response (?)	"Combined application of laser irradiation at a dose of 0.7 x 10(-3) J increased the blocking effect of 10 microM bupivacaine on the slow potassium current, while an irradiation dose of 0.7 x 10(-4) J weakened the effect of bupivacaine."	PubMed
	Nerves	Neuromuscular junction	Pissulin	Brazil (Presidente Prudente)	2016 epub	J Photochem Photobiol B	**GaAs laser therapy reestablishes the morphology of the NMJ and nAChRs after injury due to bupivacaine**	Rat	Anesthetics-induced NMJ injury (bupivacaine)	"These results demonstrate that LLLT at the dose used in this study reduced structural alterations in the NMJ and molecular changes in nAChRs triggered by bupivacaine, providing important data supporting the use of LLLT in therapeutic protocols for injuries triggered by local anesthetics."	ScienceDirect
	Nerves	Neuromuscular junction	Nicolau	Brazil	2004	Lasers Surg Med	**Effect of low power 655 nm diode laser irradiation on the neuromuscular junctions of the mouse diaphragm.**	Mouse		This study showed that LLLT (655 nm) in these doses has no detectable physiological effect on the motor end-plate neurotransmitter release in mice.	PubMed
	Nerves	Neuronal growth	Rochkind	Israel (Tel Aviv)	2009	Lasers Surg Med	**Increase of neuronal sprouting and migration using 780 nm laser phototherapy as procedure for cell therapy.**	In vitro	Biphasic dose response	"780 nm laser phototherapy of embryonic rat brain cultures embedded in hyaluronic acid-laminin gel and attached to positively charged cylindrical MCs, stimulated migration and fiber sprouting of neuronal cells aggregates, developed large size neurons with dense branched interconnected network of neuronal fibers and, therefore, can be considered as potential procedure for cell therapy of neuronal injury or disease."	PubMed
	Nerves	Oral	Miloro	USA (Omaha, NE)	2002	Oral Surg Oral Med Oral Pathol Oral Radiol Endod	**Low-level laser effect on neural regeneration in Gore-Tex tubes.**	Rabbit	Inferior alveolar nerve	"Histomorphometric evaluation revealed increased axonal density in the laser treated group as compared with the control."	PubMed
	Nerves	PNS	Ziago	Brazil (Ribeirão Preto)	2017 epub	Lasers Med Sci	**Analysis of the variation in low-level laser energy density on the crushed sciatic nerves of rats: a morphological, quantitative, and morphometric study.**	Rat	Dose response Biphasic dose response	"Groups L0, L4, L10, and L50 exhibited diminished values of all the quantitative and morphometric parameters in comparison to the control group. The morphological, quantitative, and morphometric data revealed improvement after injury in groups L4, L10, and L50 (irradiated groups) compared to the injured-only group (L0); the best results, in general, were observed for the L10 group after 15 days of nerve injury."	PubMed
	Nerves	PNS	Yang & Huang	Taiwan (Taichung)	2016	J Tissue Eng Regen Med	**Synergistic effects of low-level laser and mesenchymal stem cells on functional recovery in rats with crushed sciatic nerves.**	Rat		"The MSCLLLT group showed a greater recovery in SFI, VA and AA, with significant difference from MSC, LLLT and control groups ($p < 0.05$). Moreover, markedly enhanced electrophysiological function and expression of S100 immunoreactivity, as well as fewer inflammatory cells and less vacuole formation were also demonstrated after nerve crush injury in the MSCLLLT group when compared with the groups receiving a single treatment ($p < 0.05$). MSC transplantation combined with LLLT could achieve better results in functional recovery than a conventional treatment of MSC or LLLT alone. LLLT has a synergistic effect in providing greater functional recovery with MSC transplantation after nerve	PubMed
	Nerves	PNS	Mandelbaum-Livnat	Israel (Tel Aviv)	2016	Photomed Laser Surg	**Photobiomodulation Triple Treatment in Peripheral Nerve Injury: Nerve and Muscle Response.**	Rat		"In the present study, the effectiveness of triple treatment laser phototherapy, namely, applied simultaneously at three areas: injured area of the peripheral nerve, corresponding segments of the spinal cord, and corresponding denervated muscle (triple treatment), was evaluated for the treatment of incomplete PNI in rats with the ultimate goal of achieving improved limb function." "The present study and our previous investigations showed that the laser phototherapy increases biochemical activity and improves morphological recovery in muscle and, thus, could have direct therapeutic applications on muscle, especially during progressive atrophy resulting from PNI."	PubMed
★	Nerves	PNS	de Oliveira	Brazil (São Paulo)	2015	Lasers Med Sci	**Benefits of laser phototherapy on nerve repair.**	Review	Parameters		PubMed
	Nerves	PNS	Buchaim	Brazil (Bauru)	2015	Injury	**Effect of low-level laser therapy (LLLT) on peripheral nerve regeneration using fibrin glue derived from snake venom.**	Rat	Nerve regeneration Sural nerve	"The present study demonstrated that the fibrin glue makes axonal regeneration feasible and is an efficient method to recover injured peripheral nerves, and the use of low-level laser therapy enhances nerve regeneration."	PubMed
	Nerves	PNS	Dias	Brazil (Ribeirão Preto)	2015	J Neurol Sci	**Morphometric and high resolution scanning electron microscopy analysis of low-level laser therapy and latex protein (Hevea brasiliensis) administration following a crush injury of the sciatic nerve in rats.**	Rat		"LLLT and F1 resulted in structural nerve improvements after 4 or 8 weeks of injury." "In general only F1 protein was more effective compared to LLLT and LLLT + F1"	PubMed
	Nerves	PNS	Takhtfooladi	Iran	2015	Lasers Med Sci	**Effect of low-level laser therapy (685 nm, 3 J/cm(2)) on functional recovery of the sciatic nerve in rats following crushing lesion.**	Rat		"The SFI and SSI results were significant when comparing two groups on the 14th and 21st postoperative days ($p < 0.05$). There were intra-group differences detected in laser group in different periods ($p < 0.05$). Low-level laser irradiation, with the parameters used in the present study, accelerated and improved sciatic nerve function in rats after crushing injury."	PubMed
	Nerves	PNS	Takhtfooladi & Sharifi	Iran	2015	Lasers Med Sci	**A comparative study of red and blue light-emitting diodes and low-level laser in regeneration of the transected sciatic nerve after an end to end neurorrhaphy in rabbits.**	Rabbit	Nerve injury LLLT vs LED	In LLLT group (680nm), increase in Schwann cells, large myelinic axons and neurons was noted, compared to other groups. Red LED (650nm) treatment wasn't beneficial in this study.	PubMed
★	Nerves	PNS	Wang	Taiwan (Kaohsiung)	2014	PLoS One	**Low-level laser irradiation improves functional recovery and nerve regeneration in sciatic nerve crush rat injury model.**	Rat	Nerve injury Sciatic nerve Biphasic dose response	"Taken together, these results suggest that 808-nm LLLT at a low energy density (3 J/cm(2) and 8 J/cm(2)) is capable of enhancing sciatic nerve regeneration following a crush injury."	PubMed

★	Nerves	PNS	Anders	USA (Bethesda, MD)	2014	Lasers Surg Med	**In vitro and in vivo optimization of infrared laser treatment for injured peripheral nerves.**	In vitro & Rabbit	Nerve injury	"In vitro, 980 nm wavelength light at 10 mW/cm(2) significantly improved neurite elongation at energy densities between 2 and 200 mJ/cm(2) ." "In vivo penetration of the infrared light measured in anesthetized rabbits showed that on average, 2.45% of the light applied to the skin reached the depth of the peroneal nerve." "The in vivo pilot study data revealed that the 4 W parameters inhibited nerve regeneration while the 2 W parameters significantly improved axonal regrowth." "For the final set of experiments, the irradiated group performed significantly better in the toe spread reflex test compared to the control group from week 7 post-injury, and the average length of motor endplates returned to uninjured levels." Star: An exceptionally thorough study, with a huge amount of interesting data!	PubMed
★	Nerves	PNS	Al-Shenqiti & Oldham	Saudi Arabia (Medina)	2014	Expert Rev Neurother	**The use of phototherapy in peripheral nerve regeneration: an updated critical review.**	Review			PubMed
	Nerves	PNS	Shen	Taiwan (Taichung)	2013	J Biomed Mater Res A	**Effects of large-area irradiated laser phototherapy on peripheral nerve regeneration across a large gap in a biomaterial conduit.**	Rat		"Histomorphometric assessments revealed that the EGT/laser group had undergone more rapid nerve regeneration than the EGT/sham group. The laser-treated group also presented greater neural tissue area as well as larger axon diameter and thicker myelin sheath than the tube group without the laser treatment, indicating improved nerve regeneration. Thus, these assessments demonstrate that LLL therapy can accelerate the repair of a transected peripheral nerve in rats after being bridged with EGT conduit."	
	Nerves	PNS	Shen	Taiwan (Taichung)	2013	J Biomed Mater Res A	**Neural regeneration in a novel nerve conduit across a large gap of the transected sciatic nerve in rats with low-level laser phototherapy.**	Rat		"Histomorphometric assessments showed that the EGT/LS group had undergone more rapid nerve regeneration than the EGT group. Therefore, motor function, electrophysiological reaction, muscular reinnervation, and histomorphometric assessments demonstrate that LLL therapy can accelerate the repair of a 15-mm transected peripheral nerve in rats after being bridged with the EGT nerve conduit."	PubMed
	Nerves	PNS	Alcântara	Brazil (São Carlos)	2013	Lasers Surg Med	**Effect of low-level laser therapy (LLLT) on acute neural recovery and inflammation-related gene expression after crush injury in rat sciatic nerve.**	Rat	Sciatic nerve	"The current study showed that LLLT increased MMPs activity, mainly MMP-9, and TNF-α protein level during the acute phase of nerve injury, modulating inflammation. Based on these results, it is recommended that LLLT should be started as soon as possible after peripheral nerve injury."	PubMed
	Nerves	PNS	Cidral-Filho	Brazil (Florianópolis)	2013	Eur J Pain	**Light-emitting diode therapy induces analgesia and decreases spinal cord and sciatic nerve tumour necrosis factor-α levels after sciatic nerve crush in mice.**	Mouse		"Compared with the SNC group, LEDT reduced mechanical hypersensitivity but not cold hypersensitivity which is induced by SNC, decreased spinal cord and sciatic nerve levels of tumour necrosis factor alpha (TNF-α) but did not alter interleukin (IL)-1β and IL-10 levels, and finally, failed to accelerate motor functional recovery and morphological nerve regeneration."	PubMed
	Nerves	PNS	Telemeco & Schrank	USA (Winchester, VA)	2013	J Lasers Med Sci	**The Effect of Light Therapy on Superficial Radial Nerve Conduction Using a Clustered Array of Infrared Super luminous Diodes and Red Light Emitting Diodes.**	Human RCT/SB	Nerve conduction LED phototherapy LED cluster	"Light irradiation using a cluster probe containing infrared super luminous and red light emitting diodes does not impact the neurophysiological properties of the superficial radial nerve."	PubMed
	Nerves	PNS	Sousa	Brazil (Ribeirão Preto)	2013	Acta Ortop Bras	**Lack of effectiveness of laser therapy applied to the nerve course and the correspondent medullary roots.**	Rat	Fibular nerve	"According to the statistical analysis there was no significant difference among groups and the authors conclude that low intensity laser irradiation has little or no influence on nerve regeneration and functional recovery." "The low power AsGaAl laser irradiation did not accelerate nerve recovery with any of the doses used."	PubMed
	Nerves	PNS	Sene	Brazil (Ribeirão Preto)	2013	Acta Ortop Bras	**Effects of laser therapy in peripheral nerve regeneration.**	Rat	Fibular nerve (common)		PubMed
	Nerves	PNS	Rochkind S	Israel (Tel Aviv)	2013	Photomed Laser Surg	**Phototherapy in peripheral nerve injury for muscle preservation and nerve regeneration.**	Guest Editorial			PubMed
	Nerves	PNS	Rochkind	Israel (Tel Aviv)	2013	BOOK: Int Rev Neurobiol	**Phototherapy and nerve injury: focus on muscle response.**	Review + new data			PubMed
	Nerves	PNS	Marcolino	Brazil (Ribeirão Preto)	2013	J Hand Microsurg	**Assessment of functional recovery of sciatic nerve in rats submitted to low-level laser therapy with different fluences. An experimental study: laser in functional recovery in rats.**	Rat		"It was possible to observe that the LLLT at fluency of 40 J/cm(2) and 80 J/cm(2) had a positive influence on the acceleration of the functional nerve recovery."	PubMed
	Nerves	PNS	Gomes	Brazil (Blumenau)	2012	Photomed Laser Surg	**The brain-derived neurotrophic factor, nerve growth factor, neurotrophin-3, and induced nitric oxide synthase expressions after low-level laser therapy in an axonotmesis experimental model.**	Rat	Axonotmesis	"Comparisons between groups showed that HeNe laser increased the mRNA expression of both BDNF and NGF factors after 14 days of LLLT, with peak expression at the 21st day. Increase in NT-3 mRNA expression was not observed. In addition, HeNe laser produced iNOS expression reduction, which played an important role in the inflammatory process."	PubMed
	Nerves	PNS	Hsieh	Taiwan (Taichung)	2012	J Comp Neurol	**Low-level laser therapy alleviates neuropathic pain and promotes function recovery in rats with chronic constriction injury: possible involvements in hypoxia-inducible factor 1α (HIF-1α).**	Rat	Chronic constructive injury (CCI) Allodynia Inflammation	"Low-level laser therapy significantly improved paw withdrawal threshold and the sciatic, tibial, and peroneal functional indices after CCI. The therapy also significantly reduced the overexpressions of HIF-1α, TNF-α, and IL-1β, and increased the amounts of VEGF, NGF, and S100 proteins. In conclusion, a low-level laser could modulate HIF-1α activity. Moreover, it may also be used as a novel and clinically applicable therapeutic approach for the improvement of tissue hypoxia/ischemia and inflammation in nerve entrapment neuropathy, as well as for the promotion of nerve regeneration. These findings might lead to a sufficient morphological and functional recovery of the peripheral nerve."	PubMed
	Nerves	PNS	Santos	Brazil (Diamantina)	2012	Lasers Med Sci	**Functional and morphometric differences between the early and delayed use of phototherapy in crushed median nerves of rats.**	Rat		"In the early group, the first laser treatment started immediately after surgery, and in the delayed group, after 7 days." "The untreated, early, and delayed groups presented a 50, 57, and 81% degree of functional recovery, respectively, at 21 days after injury, with a significant difference between the untreated and delayed groups. The results suggest that the nerves irradiated with low-power laser exhibit myelinated fibers of greater diameter and a better recovery of function."	PubMed
	Nerves	PNS	Yazdani	Iran (Tehran)	2012	J Photochem Photobiol B	**Effects of low level laser therapy on proliferation and neurotrophic factor gene expression of human schwann cells in vitro.**	In vitro	Schwann cells	"Our results demonstrate that low level laser therapy stimulate human schwann cell proliferation and NGF gene expression in vitro."	PubMed
	Nerves	PNS	Serafim	Brazil (Londrina)	2012	Lasers Med Sci	**Effects of 940 nm light-emitting diode (led) on sciatic nerve regeneration in rats.**	Rat	Nerve injury LED phototherapy	"The morphological analysis of the nerve indicated that phototherapy can reduce the migration of mononuclear cells to damaged tissue, which reduces areas of edema and fiber degeneration. A 940 nm LED phototherapy source seems to favor the early functional recovery of the injured sciatic nerve."	PubMed

Nerves	PNS	Chow R	Australia (Sydney)	2011	Photomed Laser Surg	**Phototherapy and the peripheral nervous system.**	Editorial			PubMed
Nerves	PNS	Câmara	Brazil (Belém)	2011	Acta Cir Bras	**Histological analysis of low-intensity laser therapy effects in peripheral nerve regeneration in Wistar rats.**	Rat		"The irradiation with low intensity laser (904nm) influenced positively the regeneration of the sciatic nerve in Wistar rats after being injured by crush (axonotmesis), becoming the nerve recovery more rapid and efficient."	PubMed
Nerves	PNS	Shen	Taiwan (Taichung)	2011	Injury	**Large-area irradiated low-level laser effect in a biodegradable nerve guide conduit on neural regeneration of peripheral nerve injury in rats.**	Rat	LLLT cluster	"Eight weeks after implantation, walking track analysis showed a significantly higher sciatic function index (SFI) score (P<0.05) and better toe spreading development in the laser-treated group than in the sham-irradiated control group. For electrophysiological measurement, both the mean peak amplitude and nerve conduction velocity of compound muscle action potentials (CMAPs) were higher in the laser-treated group than in the sham-irradiated group. The two groups were found to be significantly different during the experimental period (P<0.005). Histomorphometric assessments revealed that the qualitative observation and quantitative analysis of the regenerated nerve tissue in the laser-treated group were superior to those of the sham-irradiated group. Thus, the motor functional, electrophysiologic and histomorphometric assessments demonstrate that LLL therapy can accelerate neural repair of the corresponding transected peripheral nerve after bridging the GGT nerve guide conduit in rats."	PubMed
Nerves	PNS	Gigo-Benato	Brazil (São Carlos)	2010	Lasers Surg Med	**Effects of 660 and 780 nm low-level laser therapy on neuromuscular recovery after crush injury in rat sciatic nerve.**	Rat	Biphasic dose response	"Six hundred sixty nanometer LLLT either using 10 or 60 J/cm² restored muscle fiber, myelin and nerve fiber CSA compared to the normal group (N)."	PubMed
Nerves	PNS	Barbosa	Brazil (Ribeirão Preto)	2010	Lasers Med Sci	**Comparative effects of wavelengths of low-power laser in regeneration of sciatic nerve in rats following crushing lesion.**	Rat	Wavelength comparison	"Differences in SFI were found between group 660 nm and the other ones at the 14th day. One can observe that laser application at 660 nm with the parameters and methods utilised was effective in promoting early functional recovery, as indicated by the SFI, over the period evaluated." Comment: 830nm was not effective in this study. In the 660nm group, the SFI benefit was not very large	PubMed
Nerves	PNS	Zhang	China (Shenyang)	2010	Synapse	**Effects of 660-nm gallium-aluminum-arsenide low-energy laser on nerve regeneration after acellular nerve allograft in rats.**	Rat		"Compared with the ARSN group, laser therapy significantly increased nerve conduction velocity, restoration rate of tibialis anterior wet muscle weight, myelinated nerve number, and CGRP protein and mRNA expression of the L(4) spinal cord at the injury site." Comment: Irradiation parameters were insufficiently reported	PubMed
Nerves	PNS	Ishiguro	Japan (Kanazawa)	2010	J Orthop Sci	**Effect of near-infrared light-emitting diodes on nerve regeneration.**		LED phototherapy	"Nerve regeneration was promoted in the LED group. Antioxidation of the chamber fluid significantly decreased from 3 days to 7 days in the control group. In the LED group, antioxidation levels did not decrease until 7 days."	PubMed
Nerves	PNS	Belchior	Brazil (Campo Grande)	2009	Lasers Med Sci	**Influence of laser (660 nm) on functional recovery of the sciatic nerve in rats following crushing lesion.**	Rat		"The utilization of low-power gallium–aluminum–arsenide laser (660 nm) showed positive results with regard to functional recovery in the sciatic nerve of rats following crushing lesion."	PubMed
Nerves	PNS	Rochkind	Israel (Tel Aviv)	2009	Neurosurg Focus	**Phototherapy in peripheral nerve regeneration: From basic science to clinical study.**	Review			PubMed
Nerves	PNS	Rochkind	Israel (Tel Aviv)	2009	BOOK: Int Rev Neurobiol	**Phototherapy in peripheral nerve injury: effects on muscle preservation and nerve regeneration.**	Review			PubMed
Nerves	PNS	dos Reis	Brazil (Campo Grande)	2009	Lasers Med Sci	**Effect of laser therapy (660 nm) on recovery of the sciatic nerve in rats after injury through neurotmesis followed by epineural anastomosis.**	Rat		"The use of AlGaAs laser (660 nm) provided significant changes to the morphometrically assessed area of the myelin sheath, but it did not culminate in positive results for functional recovery in the sciatic nerve of the rats after injury through neurotmesis."	PubMed
Nerves	PNS	Rochkind	Israel (Tel Aviv)	2007	Photomed Laser Surg	**Laser phototherapy (780 nm), a new modality in treatment of long-term incomplete peripheral nerve injury: a randomized double-blind placebo-controlled study.**	Human RCT/DB		"The analysis of motor function during the 6-month follow-up period compared to baseline showed statistically significant improvement (p = 0.0001) in the laser-treated group compared to the placebo group. No statistically significant difference was found in sensory function. Electrophysiological analysis also showed statistically significant improvement in recruitment of voluntary muscle activity in the laser-irradiated group (p = 0.006), compared to the placebo group."	PubMed
Nerves	PNS	Mohammed	Iraq (Baghdad)	2007	Photomed Laser Surg	**Promotion of regenerative processes in injured peripheral nerve induced by low-level laser therapy.**	Rabbit		"This experiment affirms the beneficial effect of LLLT on nerve regeneration, since LLLT produced a significant amount of structural and cellular change. The results of the present study suggest that laser therapy may be a viable approach for nerve regeneration, which may be of clinical relevance in scheduled surgery or microsurgery."	PubMed
Nerves	PNS	Gigo-Benato	Italy (Orbassano)	2005	Muscle Nerve	**Phototherapy for enhancing peripheral nerve repair: a review of the literature.**	Review			PubMed
Nerves	PNS	Anders	USA (Bethesda, MD)	2004	Neurol Res	**Phototherapy promotes regeneration and functional recovery of injured peripheral nerve.**	Review			PubMed
Nerves	PNS	Gigo-Benato	Italy (Orbassano)	2004	Lasers Med Sci	**Low-power laser biostimulation enhances nerve repair after end-to-side neurorrhaphy: a double-blind randomized study in the rat median nerve model.**	Rat		"Results showed that laser biostimulation induces: (1) a statistically significant faster recovery of the lesioned function; (2) a statistically significant faster recovery of muscle mass; (3) a statistically significant faster myelination of the regenerated nerve fibers. From comparison of the three different types of laser emissions, it turned out that the best functional outcome was obtained by means of pulsed-continuous-combined laser	PubMed
Nerves	PNS	Shin	Korea (Seoul)	2003	Neurosci Lett	**Growth-associated protein-43 is elevated in the injured rat sciatic nerve after low power laser irradiation.**	Rat		"This immunocytochemical study using GAP-43 antibody study shows for the first time that LPLI has an effect on the early stages of the nerve recovery process following sciatic nerve iniury."	PubMed
Nerves	PNS	Bagis	Turkey (Adana)	2003	Lasers Med Sci	**No effect of GA-AS (904 nm) laser irradiation on the intact skin of the injured rat sciatic nerve.**	Rat		"No statistically significant difference (p > 0.05) was found regarding the amplitude, area, duration and conduction velocity of CMAP for each applied dose (0.31, 2.48 and 19 J/cm2) on the irradiated (right) side and the control (left) side, or between irradiated groups. Twenty-one days after injury there were no qualitative differences in the morphological pattern of the regenerated nerve fibres in either irradiated (0.31, 2.48 and 19 J/cm2) or control nerves when evaluated by light microscopy. This study showed that low-energy GaAs irradiation did not have any effect on the injured rat sciatic nerve."	PubMed

	Nerves	PNS	Shamir	Israel (Tel Aviv)	2001	J Reconstr Microsurg	**Double-blind randomized study evaluating regeneration of the rat transected sciatic nerve after suturing and postoperative low-power laser treatment.**	Rat	Nerve injury n. ischiadicus	"Positive somatosensory evoked responses were found in 69.2 percent of the irradiated rats (p = 0.019), compared to 18.2 percent of the non-irradiated rats. Immunohistochemical staining in the laser-treated group showed an increased total number of axons (p = 0.026), and better quality of the regeneration process, due to an increased number of large-diameter axons (p = 0.021), compared to the non-irradiated control group."	PubMed
	Nerves	PNS	Rochkind	Israel (Tel Aviv)	2001	Lasers Surg Med	**Effects of laser irradiation on the spinal cord for the regeneration of crushed peripheral nerve in rats.**	Rat	Nerve injury n. ischiadicus	"The electrophysiologic activity of the injured nerves (compound muscle action potentials--CMAPs) was found to be approximately 90% of the normal precrush value and remained so for up to a long period of time. In the control nonirradiated group, electrophysiologic activity dropped to 20% of the normal precrush value at day 21 and showed the first signs of slow recovery 30 days after surgery. The two groups were found to be significantly different during follow-up period (P < 0.001)." Comment: Parameters were insufficiently reported.	PubMed
	Nerves	PNS	Khullar	Norway (Oslo)	1995	Eur J Oral Sci	**The effects of low level laser treatment on recovery of nerve conduction and motor function after compression injury in the rat sciatic nerve.**	Rat		"At 21 d post-injury, the laser-treated group had a significantly lower median SFI than the sham laser-treated group, indicating that the real laser treatment had improved functional recovery in the nerve. However, no differences were found between the evoked cAP parameters that were measured in the laser-treated and sham laser-treated groups. Histological examination reiterated the lack of difference between the two groups. Consequently, the effects of LLL on recovery must have occurred more peripherally to the point measured."	PubMed
	Nerves	PNS	Rochkind	Israel (Tel Aviv)	1989	Neurosurgery	**Stimulatory effect of He-Ne low dose laser on injured sciatic nerves of rats.**	Rat	Nerve injury n. ischiadicus	"The action potential of the injured sciatic nerves that were laser-irradiated increased to values close to that of a noninjured nerve. The studies include follow-up for 1 year after the injury. This electrophysiological manifestation of the effect of laser treatment on injured nerves was accompanied by a diminution of the size of the scar tissue from these nerves. Yet to be resolved is whether these two phenomena (i.e., electrophysiological and morphological responses) coincide or whether they relate to each other."	PubMed
	Nerves	PNS	Rochkind	Israel (Tel Aviv)	1987	Lasers Surg Med	**Response of peripheral nerve to He-Ne laser: experimental studies.**	Rat		"Action potential (AP) in the healthy nerve increased by 33% following a single transcutaneous irradiation. Similar irradiation in crushed nerves caused AP to increase significantly over the AP of nonirradiated crushed nerve. Morphological observations revealed that a laser-irradiated injured nerve had diminished scar tissue as compared to an injured but not an irradiated nerve."	PubMed
	Nerves	PNS	Rochkind	Israel (Tel Aviv)	1978	Morphogen Regen	**Stimulation effect of laser energy on the regeneration of traumatically injured peripheral nerves. (Morphogen Regen 1978:83:25-27)**				
	Nerves	Spinal cord	Veronez	Brazil (São Paulo)	2016	Lasers Med Sci	**Effects of different fluences of low-level laser therapy in an experimental model of spinal cord injury in rats.**	Rat		"Functional evaluation and tactile sensitivity were improved after LLLT, at the higher fluence. Additionally, LLLT, at 750 and 1000 J/cm2, reduces the lesion volume and modulates the inflammatory process with decrease of CD-68 protein expression. These results suggest that LLLT at higher doses was effective in promoting functional recovery and modulating inflammatory process in the spinal cord of rats after SCI."	PubMed
	Nerves	Spinal cord	Hu	Australia (Canberra)	2016	J Neuroinflammation	**Red LED photobiomodulation reduces pain hypersensitivity and improves sensorimotor function following mild T10 hemicontusion spinal cord injury.**	Rat	Microglia LED phototherapy	"We demonstrate that red light penetrates through the entire rat spinal cord and significantly reduces signs of hypersensitivity following a mild T10 hemicontusion spinal cord injury. This is accompanied with improved dorsal column pathway functional integrity and locomotor recovery. The functional improvements were preceded by a significant reduction of dying (TUNEL(+)) cells and activated microglia/macrophages (ED1(+)) in the spinal cord. The remaining activated microglia/macrophages were predominantly of the anti-inflammatory/wound-healing subpopulation (Arginase1(+)ED1(+)) which were expressed early, and up to sevenfold greater than that found in sham-treated animals." "These findings demonstrate that a simple yet inexpensive treatment regime of red light reduces the development of hypersensitivity along with sensorimotor improvements following spinal cord injury and may therefore offer new hope for a currently treatment-resistant pain condition."	PubMed
★	Nerves	Spinal cord	Chen	Taiwan (Kaohsiung)	2014	PLoS One	**Effect of low level laser therapy on chronic compression of the dorsal root ganglion.**	Rat	Chronic compression of dorsal root ganglion	"Our data indicate that LLLT significantly decreased the tolerable sensitivity to pain and heat stimuli in the CCD groups. The expression levels of the pro-inflammatory cytokines TNF-α and IL-1β were increased following CCD, and we found that these increases could be reduced by the application of LLLT. Furthermore, the expression of GAP-43 was enhanced by LLLT. In conclusion, LLLT was able to enhance neural regeneration in rats following CCD and improve rat ambulatory behavior. The therapeutic effects of LLLT on the DRG during CCD may be exerted through suppression of the inflammatory response and induction of neuronal repair genes. These results suggest potential clinical applications for LLLT in the treatment of	PubMed
★	Nerves	Spinal cord	Paula	Brazil (São José dos Campos)	2014	Lasers Surg Med	**Low-intensity laser therapy effect on the recovery of traumatic spinal cord injury.**	Rat		"The results showed faster motor evolution in rats with spinal contusion treated with LILT, maintenance of the effectiveness of the urinary system, and preservation of nerve tissue in the lesion area, with a notorious inflammation control and increased number of nerve cells and connections. In conclusion, positive effects on spinal cord recovery after moderate traumatic spinal cord injury were shown after LILT."	PubMed

	Nerves	Spinal cord	Ando	Japan (Yokohama)	2013	J Biomed Opt	**Low-level laser therapy for spinal cord injury in rats: effects of polarization.**	Rat		"Regardless of the polarization direction, functional scores of SCI rats that were treated with the 808-nm laser irradiation were significantly higher than those of SCI alone group (Group 1) from day 5 after injury. The locomotive function of SCI rats irradiated parallel to the spinal column (Group 3) was significantly improved from day 10 after injury, compared to SCI rats treated with the linear polarization perpendicular to the spinal column (Group 2). There were no significant differences in ATP contents in the injured tissue among the three groups. We speculate that the higher efficacy with parallel irradiation is attributable to the	PubMed
	Nerves	Spinal cord	Wu	USA (Bethesda, MD)	2012	Lasers Med Sci	**Comparison of the effects of pulsed and continuous wave light on axonal regeneration in a rat model of spinal cord injury.**	Rat		"In conclusion, CW and pulsed laser light support axonal regeneration and functional recovery after SCI. Pulsed laser light has the potential to support axonal regrowth to spinal cord segments located farther from the lesion site. Therefore, the use of pulsed light is a promising noninvasive therapy for SCI."	PubMed
★	Nerves	Spinal cord	Wu	USA (Bethesda, MD)	2009	Lasers Surg Med	**810 nm Wavelength light: an effective therapy for transected or contused rat spinal cord.**	Rat		"The average length of axonal re-growth in the rats in the light treatment (LT) groups with the hemisection (6.89+/-0.96 mm) and contusion (7.04+/-0.76 mm) injuries was significantly longer than the comparable untreated control groups (3.66+/-0.26 mm, hemisection; 2.89+/-0.84 mm, contusion). The total axon number in the LT groups was significantly higher compared to the untreated groups for both injury models (P<0.05). For the hemisection model, the LT group had a statistically significant lower angle of rotation (P<0.05) compared to the controls. For contusion model, there was a statistically significant functional recovery (P<0.05) in the LT group compared to untreated control."	PubMed
★	Nerves	Spinal cord	Byrnes	USA (Bethesda, MD)	2005	Lasers Surg Med	**Light promotes regeneration and functional recovery and alters the immune response after spinal cord injury.**	Rat		"Light therapy applied non-invasively promotes axonal regeneration and functional recovery in acute SCI caused by different types of trauma. These results suggest that "PBM, with 6% power penetration to the spinal cord depth, significantly increased axonal number and distance of regrowth (P < 0.001). PBM also returned aspects of function to baseline levels and significantly suppressed immune cell activation and cytokine/chemokine expression." "Our results demonstrate that light, delivered transcutaneously, improves recovery after injury and suggests that light will be a useful treatment for human SCI." Star: Parameters were well reported and results were interesting.	PubMed
	Nerves	Spinal cord	Rochkind	Israel (Tel Aviv)	2002	Neurol Res	**Transplantation of embryonal spinal cord nerve cells cultured on biodegradable microcarriers followed by low power laser irradiation for the treatment of traumatic paraplegia in rats.**	Rat		"Eleven of the 15 (73%) showed different degrees of active leg movements and gait performance, compared to 4 (44%) of the 9 rats with implantation alone. In a control group of seven rats with spinal cord transection and no transplantation or laser, six (86%) remained completely paralyzed. Three months after transection, implantation and laser irradiation, SSEPs were elicited in 69% of rats (p = 0.0237) compared to 37.5% in the nonirradiated group. The control group had no SSEPs response. Intensive axonal sprouting occurred in the group with implantation and laser. In the control group, the transected area contained proliferating fibroblasts and blood capillaries only."	PubMed
	Nerves	Systemic effects	Rochkind	Israel (Tel Aviv)	1989	Lasers Surg Med	**Systemic effects of low-power laser irradiation on the peripheral and central nervous system, cutaneous wounds, and burns.**	Rat	Systemic effect	"HeNe laser irradiation applied to a crushed injured sciatic nerve in the right leg in a bilaterally inflicted crush injury, significantly increased the compound action potential in the left nonirradiated leg as well." "The bilateral retrograde degeneration of the motor neurons of the spinal cord expected after the bilateral crush injury of the peripheral nerves was greatly reduced in the laser treated group."	PubMed
	Nerves		Belkin & Schwartz	Israel (Ramat Gan)	1994	Neurosurg Rev	**Evidence for the existence of low-energy laser bioeffects on the nervous system.**	Review			PubMed
	Nerves		Rochkind & Ouaknine	Israel (Tel Aviv)	1992	Neurol Res	**New trend in neuroscience: low-power laser effect on peripheral and central nervous system (basic science, preclinical and clinical studies).**	Review			PubMed
	Oncology	Human research	Hode L	Sweden (Lidingo)	2016	Photomed Laser Surg	**Low-Level Laser Therapy May Have Cancer Fighting Role.**	Guest Editorial			PubMed
	Oncology	Human research	Mikhailov	Russia (Moscow)	2000	Proc. SPIE 4166	**Results of treatment of patients with second- to third-stage breast cancer by combination of low-level laser therapy (LLLT) and surgery: ten-year experience**	Human		"86.9% (76.19% in control group) of patients with stage II breast cancer survived 10 years after LLLT treatment. For patients with stage III breast cancer treated by LLLT the rate was 83.3% (68.4% in control group)."	SPIE
	Oncology	Supportive care	Robijns	Belgium (Hasselt)	2016 epub	Lasers Med Sci	**The use of low-level light therapy in supportive care for patients with breast cancer: review of the literature.**	Review			PubMed
☹	Oncology	Supportive care	Argenta	USA (Minneapolis, MN)	2016	Gynecol Oncol	**The effect of photobiomodulation on chemotherapy-induced peripheral neuropathy: A randomized, sham-controlled clinical trial.**	Human RCT/DD	Chemotherapy-induced peripheral neuropathy	LLLT improved the status of patients approximately by 40-50%, while sham treatment didn't have any effect. Comment: Parameters were extremely poorly reported.	PubMed
	Oncology	Tumor cells	Crous & Abrahamse	South Africa (Johannesburg)	2016	Photomed Laser Surg	**Low-Intensity Laser Irradiation at 636 nm Induces Increased Viability and Proliferation in Isolated Lung Cancer Stem Cells.**	In vitro	Isolated lung cancer stem cells	"Cellular morphology indicated an increase in cell density caused by cell proliferation over time. Biostimulatory effects were achieved in lung CSCs when examining viability and proliferation." "It should, therefore, be noted that a low wavelength of 636 nm at various fluences induces biostimulation, which may have detrimental effects when using LILI as a form of regeneration."	PubMed

★	Oncology	Tumor cells	Jeong, Andrew	USA (Boston, MA)	2016	DISSERTATION (Boston University)	**Safety evaluation of low level light therapy on cancer cells**	In vitro		"The application of LLL at 808 nm with energy densities ranging from 0.1 J/cm2 to 10 J/cm2 under an LED source did not induce cell proliferation or death compared to control (0 J/cm2) for each cell line in the absence or the presence of each drug, and no definite trend was observed with increasing energy density. The study suggests that LLLT at these parameters may be safe to use on cancer patients, but further studies on different cancer cell lines and animal models with different parameters (wavelength, energy density, dosage) of LLL are warranted."	OpenBU
	Oncology	Tumor cells	Ramos Silva	Brazil (São Paulo)	2016	J Biophotonics	**Exploring the effects of low-level laser therapy on fibroblasts and tumor cells following gamma radiation exposure.**	In vitro	Gamma radiated cells	"Regarding tumor cells, no influences of LLLT on cell viability are noticed. Whereas LLLT enhances cell populations in S and G2 /M cell cycle phases for both cellular lines, a decrease in proliferation and increase in senescence was verified only for tumor cells."	PubMed
	Oncology	Tumor cells	Peidaee	Australia (Melbourne)	2016	Med Biol Eng Comput	**In vitro evaluation of low-intensity light radiation on murine melanoma (B16F10) cells.**	In vitro	Murine melanoma (B16F10) cells	"From irradiation of selected visible and near-infrared wavelengths, no visible changes were detected in cellular viability of either normal or cancer cells."	PubMed
	Oncology	Tumor cells	Barasch	USA & Netherlands	2016	Support Care Cancer	**Effects of pre-radiation exposure to LLLT of normal and malignant cells.**	In vitro		"LLLT does not confer protection and may even sensitize cancer cells to IR killing"	PubMed
	Oncology	Tumor cells	Akbarzadeh	Iran (Tabriz)	2016	Lasers Med Sci	**Effects of combination of melatonin and laser irradiation on ovarian cancer cells and endothelial lineage viability.**	In vitro	LLLT + melatonin treatment	"Combination treatment of both cell lines caused a marked increase in apoptosis/necrosis rate, reactive oxygen species generation, and heat shock protein 70 expression compared to incubation of the cells with each agent alone ($p < 0.05$)"	PubMed
	Oncology	Tumor cells	Samoilova	Russia (Saint-Petersburg)	2015	Photomed Laser Surg	**Regulatory systemic effect of postsurgical polychromatic light (480-3400 nm) irradiation of breast cancer patients on the proliferation of tumor and normal cells in vitro.**	Human / in vitro		"The results suggest an effect at the systemic level where pVIS + pIR light may stimulate growth of human skin cells and simultaneously downregulate the proliferation of tumor cells, including BC cells. This argues in favor of the oncological safety of PT for BC patients postsurgically."	PubMed
	Oncology	Tumor cells	Knyazev	Russia (Saint-Petersburg)	2015	Photomed Laser Surg	**Downregulation of tumorogenicity and changes in the actin cytoskeleton of murine hepatoma after irradiation with polychromatic visible and IR light.**	In vitro (--> transplanted to mice)	Polychromatic light	"Polychromatic light of a wide range of doses did not change the viability and proliferation of cells. After transplantation of cells irradiated with VIS-IR light (4.8 and 9.6 J/cm(2)) and VIS light (38.4 J/cm(2)) the tumor volume was lower in the treated group than in the control group in vivo. Transplantability of the irradiated cells also decreased, whereas survival of tumor-bearing mice increased."	PubMed
	Oncology	Tumor cells	Dastanpour	Iran (Tehran)	2015	J Lasers Med Sci	**The effect of low-level laser therapy on human leukemic cells.**	In vitro		"Significant increase in cell proliferation was seen only after two exposures at energy density of 20J/cm2 (P=0.021)."	PubMed
	Oncology	Tumor cells	Sperandio	Brazil (São Paulo)	2013	J Biophotonics	**Low-level laser therapy can produce increased aggressiveness of dysplastic and oral cancer cell lines by modulation of Akt/mTOR signaling pathway.**	In vitro		"LLLT significantly modified the expression of proteins related to progression and invasion in all the cell lines, and could aggravate oral cancer cellular behavior, increasing the expression of pAkt, pS6 and Cyclin D1 proteins and producing an aggressive Hsp90 isoform."	PubMed
	Oncology	Tumor cells	Liu	Taiwan (Taichung)	2006	Lasers Med Sci	**Photoradiation could influence the cytoskeleton organization and inhibit the survival of human hepatoma cells in vitro.**	In vitro		"Therefore, the net effects by this photoradiation were reduced cell survival."	PubMed
	Oncology	Tumor cells	Liu	Taiwan (Taichung)	2004	Res Commun Mol Pathol Pharmacol	**Effects of diode 808 nm GaAlAs low-power laser irradiation on inhibition of the proliferation of human hepatoma cells in vitro and their possible mechanism.**	In vitro		"Two significant findings are raised in this study: (1) Diode 808 nm GaAlAs continuous wave laser has an inhibitory effect on the proliferation of human hepatoma cells line HepG2 and J-5. (2) The mechanism of inhibition might be due to down-regulation of synemin expression and alteration of cytokeratin organization that was caused by laser irradiation."	PubMed
	Oncology	Tumor cells	Kreisler	Germany (Mainz)	2003	Lasers Med Sci	**Low-level 809 nm GaAlAs laser irradiation increases the proliferation rate of human laryngeal carcinoma cells in vitro.**	In vitro		"The irradiated cells revealed a considerably higher proliferation activity. The differences were highly significant up to 72 h after irradiation (Mann-Whitney U test, $p < 0.001$). A cellular responsiveness of human laryngeal carcinoma cells to low-level laser irradiation is obvious. The cell line is therefore suitable for basic research investigations concerning the biological mechanisms of LLLT on cells."	PubMed
	Oncology	Tumor cells	Pinheiro	Brazil (Salvador, Bahia)	2002	Braz Dent J	**Does LLLT stimulate laryngeal carcinoma cells? An in vitro study.**	In vitro		"The results showed that 635nm laser light did not significantly stimulate the proliferation of H.Ep.2 cells at doses of 0.04 J/cm2 to 0.48 J/cm2, However, 670nm laser irradiation led to an increased cell proliferation when compared to both control and 635nm irradiated cells."	PubMed
	Oncology	Tumor cells	Pinheiro	Brazil (Salvador, Bahia)	2002	J Clin Laser Med Surg	**Effects of low-level laser therapy on malignant cells: in vitro study.**	In vitro		"It is concluded, that irradiation with 670-nm laser light applied at doses between 0.04 and 4.810(4) Jm(-2) could significantly increase proliferation of laryngeal cancer cells."	PubMed
★ ☎	Oncology	Tumor growth	Rhee	Korea (Cheonan)	2016	Photomed Laser Surg	**Low-Level Laser Therapy Promoted Aggressive Proliferation and Angiogenesis Through Decreasing of Transforming Growth Factor-β1 and Increasing of Akt/Hypoxia Inducible Factor-1α in Anaplastic Thyroid Cancer.**	Mouse		"In conclusion, LLLT led to a decrease in TGF-β1 and increase of p-Akt/HIF-1α which resulted to overproliferation and angiogenesis of anaplastic thyroid carcinoma (ATC). Therefore, we suggest that LLLT can influence cancer aggressiveness associated with TGF-β1 and Akt/HIF-1α cascades in some poorly differentiated head and neck cancers." Star: Parameters were listed in a table, and a photograph was supplied.	PubMed
	Oncology	Tumor growth	Ottaviani	Italy (Trieste)	2016	EBioMedicine	**Laser Therapy Inhibits Tumor Growth in Mice by Promoting Immune Surveillance and Vessel Normalization.**	Mouse	In vitro tumor cell irradiation	"While laser light increased cell metabolism in cultured cells, the in vivo outcome was reduced tumor progression. This striking, unexpected result, was paralleled by the recruitment of immune cells, in particular T lymphocytes and dendritic cells, which secreted type I interferons. Laser light also reduced the number of highly angiogenic macrophages within the tumor mass and promoted vessel normalization, an emerging strategy to control tumor progression. Collectively, these results set photobiomodulation as a safety procedure in oncological patients and open the way to its innovative use for cancer therapy." Comment: An interesting paper with many tables. However, parameter reporting should have been better (eg. beam area in the *in vivo* part of the study).	PubMed
	Oncology	Tumor growth	Myakishev-Rempel	USA (Rochester, NY)	2012	Photomed Laser Surg	**A preliminary study of the safety of red light phototherapy of tissues harboring cancer.**	Mouse		"This experiment suggests that LLLT at these parameters may be safe even when malignant lesions are present. Further studies on the effects of photoirradiation on neoplasms are warranted."	PubMed
	Oncology	Tumor growth	de C Monteiro	Brazil (Salvador, Bahia)	2011	Photomed Laser Surg	**Influence of laser phototherapy (λ660 nm) on the outcome of oral chemical carcinogenesis on the hamster cheek pouch model: histological study.**	Hamster		"It is concluded that LLLT, within the parameters used in the present study, caused a significant progression of the severity of SCC in the oral cavity of hamsters."	PubMed

	Oncology	Tumor growth	Frigo	Brazil (São Paulo)	2009	BMC Cancer	**The effect of low-level laser irradiation (In-Ga-Al-AsP - 660 nm) on melanoma in vitro and in vivo.**	Mouse In vitro	Melanoma	"This cancer-protective effect was not reproduced in the in vivo experiment where outcome measures for the 150 J/cm(2) dose group were not significantly different from controls. For the 1050 J/cm(2) dose group, there were significant increases in tumor volume, blood vessels and cell abnormalities compared to the other groups."	PubMed
	Oncology	Tumor growth	Ulrich	Germany (Hamburg)	1996	Book: Laser in der Medizin / Laser in Medicine	**Influence of Laser Light (830nm) on the Growth Kinetics of Rat Rhabdomyosarcomas**	Rat		"The results showed that after single doses of exposure no change of tumor growth in comparison to untreated controls was observed. During and after the fractionated exposure with doses of 15 and 1500 J/cm2, respectively, neither an enhanced tumor growth nor a significant tumor growth delay was obtained."	Springer
	Oncology	Tumor growth	Mikhailov	Russia (Moscow)	1993		**Investigations on the influence of low level diode laser irradiation of the growth of experimental tumors.**	Mouse		"Investigations on rats with an implanted tumour-carcinosarcoma of Walker (26 animals), cancer of the mammary glands, RMK-1 (75 animals) and in mice with spontaneous cancer of the mammary gland (188 animals)-have shown that the application of a low-level diode laser beam (890 nm) can effect the growth of the experimental tumour. Minimal doses produce a tumouro-static effect, while other doses produce different effects. Low level laser irradiation promotes dystrophic and necrotic changes in tumoural nodes."	J-STAGE
	Oncology	Tumor growth	Abe	Japan	1993	Keio J Med	**Role of 830 nm low reactive level laser on the growth of an implanted glioma in mice.**	Mouse		Direct and indirect LLLT inhibited tumor growth. In one model, indirect LLLT also increased tumor growth.	PubMed
	Oncology		Lanzafame RJ	USA (Rochester, NY)	2011	Photomed Laser Surg	**Photobiomodulation and cancer and other musings.**	Editorial			PubMed
	Opioid withdrawal	Morphine	Ojaghi	USA (Chicago, IL)	2014	Lasers Med Sci	**Role of low-intensity laser therapy on naloxone-precipitated morphine withdrawal signs in mice: is nitric oxide a possible candidate mediator?**	Mouse		"LILT and L-NAME (20, 50, and 100 mg/kg) per se significantly decreased escape jump count and stool weight in morphine-dependent naloxone-treated mice ($p < 0.01$). Coadministration of LILT and L-NAME (20, 50, and 100 mg/kg) also reduced escape jump and stool weight ($p < 0.05$) but with no synergetic or additive response. Here, LILT at this fluence may show its maximal effects on NO and therefore no noticeable effects appeared during coadministration use. Moreover, LILT and L-NAME follow the same track of changes in escape jump and stool weight. Conceivably, it seems that LILT acts partly via NO system, but the exact path is still obscure and rather intricate. The precise mechanisms need to be clarified."	PubMed
	Opioid withdrawal	Morphine	Mirzaii-Dizgah	Iran (Tehran)	2009	Behav Brain Res	**Attenuation of morphine withdrawal signs by low level laser therapy in rats.**	Rat		"One-way ANOVA showed that the LILT which applied immediately or 15min prior to naloxone injection significantly decreased total withdrawal score (TWS). These results suggest that LILT prior to naloxone injection attenuates the expression of withdrawal signs in morphine-dependent rats. Further studies may elucidate the likely role of LILT in clinical management of opioid withdrawal syndrome." Comment: The effect of LLLT was quite modest, but probably still relevant.	PubMed
	Oral	Analgesia	Chan	Australia (Sydney)	2012	J Dent Res	**Pulsed Nd: YAG laser induces pulpal analgesia: a randomized clinical trial.**	Human RCT	LLLT vs EMLA anesthetic cream Tooth extraction before orthodontic procedures	"The trial confirmed that the pulsed Nd:YAG laser effectively induced pulpal analgesia, by suppression of intradental nerve responses to electrical and mechanical stimuli. Such a laser provides an alternative for dental pain management."	PubMed
	Oral	Aphthous stomatitis	Pavlić	Serbia (?)	2015	Vojnosanit Pregl	**Treatment of recurrent aphthous stomatitis by laser therapy: A systematic review of the literature.**	Systematic review			PubMed
	Oral	Burning mouth syndrome	Sugaya	Brazil (São Paulo)	2016	Braz Oral Res	**Low Intensity laser therapy in patients with burning mouth syndrome: a randomized, placebo-controlled study.**	Human RCT		"According to the protocol used in this study, low intensity laser therapy is as beneficial to patients with BMS as placebo treatment, indicating a great emotional component of involvement in BMS symptomatology. Nevertheless, there were positive results in some statistical analyses, thus encouraging further research in BMS laser therapy with other irradiation parameters."	PubMed
	Oral	Burning mouth syndrome	Valenzuela & Lopez-Jornet	Spain (Murcia)	2016	J Oral Rehabil	**Effects of low-level laser therapy on burning mouth syndrome.**	Human RCT		"Overall improvements in VAS scores from baseline to the end of treatment were: Group I 15.7%; Group II 15.6%; Group III placebo 7.3%."	PubMed
	Oral	Burning mouth syndrome	Arduino	Italy (Turin)	2016	Lasers Med Sci	**A randomized pilot study to assess the safety and the value of low-level laser therapy versus clonazepam in patients with burning mouth syndrome.**	Human RCT Comparison	LLLT vs clonazepam	"Comparing the two groups, LLLT appeared to be superior in improving pain perception, but statistically only at 8 weeks after the end of the protocol proposed ($P = 0.026$)."	PubMed
	Oral	Burning mouth syndrome	Spanemberg	Brazil	2015	J Biomed Opt	**Efficacy of low-level laser therapy for the treatment of burning mouth syndrome: a randomized, controlled trial.**	Human RCT		LLLT appeared to be beneficial.	
	Oral	Burning mouth syndrome	dos Santos Lde	Brazil (São Paulo)	2015	Photochem Photobiol	**Phototherapy on the Treatment of Burning Mouth Syndrome: A Prospective Analysis of 20 Cases.**	Human Case series		"All volunteers reported reduced burning intensity in all sessions when compared to the previous one and reduction in VAS scores by up to 49% in the last clinical session when compared to the first session."	PubMed
	Oral	Burning mouth syndrome	Pezelj-Ribarić	Croatia	2013	Lasers Med Sci	**Proinflammatory cytokine levels in saliva in patients with burning mouth syndrome before and after treatment with low-level laser therapy.**	Human RCT		LLLT did not have beneficial effects in this study.	PubMed
	Oral	Burning mouth syndrome	Yang & Huang	Taiwan (Taichung)	2011	Photomed Laser Surg	**Treatment of burning mouth syndrome with a low-level energy diode laser.**	Human		"The results showed an average reduction in pain of 47.6% (ranging from 9.3% to 91.8%)." Note: A comment on this paper was published by Vukoja (et al).	PubMed
	Oral	Burning mouth syndrome	dos Santos Lde	Brazil (Recife)	2011	Photomed Laser Surg	**Effect of low-level laser therapy in the treatment of burning mouth syndrome: a case series.**	Human Case series		"All patients reported improvement in all sessions, with reduction in VAS scores by up to 58% in the tenth session."	PubMed
	Oral	Burning mouth syndrome	Romeo	Italy (L'Aquila)	2010	Ann Stomatol (Roma)	**The low level laser therapy in the management of neurological burning mouth syndrome. A pilot study.**	Human Pilot study		"Seventeen patients (68%) had relevant benefits from the treatment with valid reduction of NRS ratings. In 8 cases the differences of NRS rates were not relevant being under the limit of reliability established in study design. In no case there was a worsening of the symptoms."	PubMed
	Oral	Burning mouth syndrome	Kato	Brazil (São Paulo)	2010	Photomed Laser Surg	**Low-level laser therapy in burning mouth syndrome patients: a pilot study.**	Human Pilot study		"Burning intensity at the end of the laser therapy was statistically lower than at the beginning ($p < 0.01$). Patients reported an 80.4% reduction in the intensity of symptoms after laser treatment. There was no statistical difference between the end of the treatment and the 6-week follow-up, except for the tongue site."	PubMed
	Oral	Caries	Müller	Brazil (São Paulo)	2007	Arch Oral Biol	**Effects of low power red laser on induced-dental caries in rats.**	Rat		"The use of laser radiation alone did not promote any additional benefit on the control of dental caries since LG did not show any differences comparing to CG." [However, laser applied before the fluoride was associated with a little bit better outcome.]	PubMed
	Oral	Dental implants	Prados-Frutos	Spain	2016	Lasers Med Sci	**Lack of clinical evidence on low-level laser therapy (LLLT) on dental titanium implant: a systematic review.**	Systematic review			PubMed

	Oral	Dental implants	Gokmenoglu	Turkey (Ordu)	2014	Photomed Laser Surg	**The effect of light-emitting diode photobiomodulation on implant stability and biochemical markers in peri-implant crevicular fluid.**	Human	LED phototherapy	"In the control group, significant reduction of ISQ values from week 2 to week 12 were demonstrated. In the LED group, baseline ISQ values were maintained during the study and no significant changes were observed." "LED application to surgical area has a positive effect on the osseointegration process, and implant stability can be maintained."	PubMed
	Oral	Dental implants	Tang & Arany	USA (Bethesda, MD)	2013	J Periodontal Implant Sci	**Photobiomodulation and implants: implications for dentistry.**	Review			PubMed
	Oral	Dentin hypersensitivity	Sicilia	Spain	2009	J Clin Periodontol	**Immediate efficacy of diode laser application in the treatment of dentine hypersensitivity in periodontal maintenance patients: a randomized clinical trial.**	Human RCT		LLLT appeared to be clearly beneficial for dentin hypersensitivity.	PubMed
	Oral	Dentistry	Pandeshwar	India (Bangalore)	2016	J Investig Clin Dent	**Photobiomodulation in oral medicine: a review.**	Review			PubMed
	Oral	Dentistry	Nammour S	Belgium (Liege)	2016	Photomed Laser Surg	**Chronology of the Use of the Laser Beam in Dentistry, and the State of Postgraduate University Education Programs in this Domain.**	Guest Editorial			PubMed
★	Oral	Dentistry	Carroll	UK (Chesham)	2014	Dent Mater	**Developments in low level light therapy (LLLT) for dentistry.**	Review			PubMed
★	Oral	Dentistry	Ross G	Canada (Tottenham)	2012	Photomed Laser Surg	**Photobiomodulation in dentistry.**	Guest Editorial			PubMed
	Oral	Dentistry	Nammour S	Belgium (Brussels)	2012	2012	**Laser dentistry, current advantages, and limits.**	Guest Editorial			PubMed
	Oral	Denture stomatitis	Maciel	Brazil	2015	J Prosthodont	**Methylene Blue-Mediated Photodynamic Inactivation Followed by Low-Laser Therapy versus Miconazole Gel in the Treatment of Denture Stomatitis.**	Human Comparison trial	PDT + LLLT	Miconazole had a better cure rate than PDT (with methylene blue) + LLLT (80% vs 40%).	PubMed
	Oral	Denture stomatitis	Simunović-Soskić	Croatia	2010	Photomed Laser Surg	**Salivary levels of TNF-alpha and IL-6 in patients with denture stomatitis before and after laser phototherapy.**	Human RCT		TNF-alpha and IL-6 decreased significantly more in LLLT group.	PubMed
	Oral	Denture stomatitis	Maver-Biscanin	Croatia	2005	Photomed Laser Surg	**Effect of low-level laser therapy on Candida albicans growth in patients with denture stomatitis.**	Human		"Our observations indicate that LLLT might be valuable in the treatment of denture stomatitis."	PubMed
	Oral	Denture stomatitis	Maver-Biscanin	Croatia	2004	Lasers Surg Med	**Fungicidal effect of diode laser irradiation in patients with denture stomatitis.**	Human RCT		"A fungicidal effect was achieved in the laser treated and antimicotic treated groups, whereas most subjects in the placebo group were found to have unchanged conditions"	PubMed
	Oral	Dry mouth (xerostomia)	Lončar	Croatia	2011	Photomed Laser Surg	**The effect of low-level laser therapy on salivary glands in patients with xerostomia.**	Human (controlled)		"Effects of low-level laser therapy on salivary glands are not only stimulating, but also regenerative to a degree since the glandular response to the same amount of applied laser energy increased linearly over time."	PubMed
	Oral	Dry mouth (xerostomia)	Vidović Juras	Croatia	2010	Coll Antropol	**Effects of low-level laser treatment on mouth dryness.**	Human		"This simple non-invasive method could be used in everyday clinical practice for the treatment of MD."	PubMed
	Oral	Endodontics	Ramalho	Brazil (São Paulo)	2016	Lasers Med Sci	**A randomized placebo-blind study of the effect of low power laser on pain caused by irreversible pulpitis.**	Human RCT		"The application of 780-nm diode laser irradiation, at 4 and 40 J/cm2, showed no effect in reducing the pain in SIP in comparison to the placebo group. The fluence of 4 J/cm2 showed a negative effect in local anesthetics, resulting in significant increase of complimentary local anesthesia during emergency endodontic treatment." "LPT should be avoided in teeth with pain due to irreversible pulpitis."	PubMed
★ 📷	Oral	Endodontics	Moreira	Brazil (São Paulo)	2016	J Photochem Photobiol B	**In vivo experimental model of orthotopic dental pulp regeneration under the influence of photobiomodulation therapy.**	Rat		"Briefly, this tissue-engineered orthotopic model of dental pulp regeneration consisted of instrumentation of the dentinal walls with removal of dental pulp tissue from the mesial root canal of the first molar of rats, followed by treatment of the root canal walls with an acidic solution to release growth factors and induction of bleeding into the canal to create a blood clot (i.e., natural scaffold) rich in endogenous stem cells, prior to the laser PBM therapy application." "No tissue formation was observed in any specimen of the Control group (n = 12). In three out of the 11 teeth composing the PBM group, the mesial root canal was filled with an immature connective tissue (Fig. 2). This tissue was composed of fewer and thinner collagen fibers than the originally preserved dental pulp of the distal root of the same molar (Fig. 2A and B). A layer of cells in intimate contact with the dentin wall was observed to exhibit cytoplasmic extensions into the dentinal tubules (Fig. 2C). Immunohistochemical analysis of the tissue formed inside the experimental root canal showed an odontoblast-like cell layer labeled with anti-HSP-25 (Fig. 3A), blood vessels exhibiting SMA-positive cells in their walls (Fig. 3B), S-100-positive cells underneath the odontoblast-like cell layer (Fig. 3C) and a few STRO-1-positive cells in perivascular niches (Fig. 3D)." "Most importantly, our results corroborate the hypothesis that PBM therapy may be an adjunctive therapy that is able to improve dental pulp tissue regeneration."	PubMed
	Oral	Endodontics	Moura	Brazil (São Paulo)	2016	Braz Oral Res	**Low-intensity laser phototherapy enhances the proliferation of dental pulp stem cells under nutritional deficiency.**	In vitro	Dose response	"These findings indicate that LPT with 5 J/cm2 can enhance the growth of [stem cells from human exfoliated deciduous teeth] during situations of nutritional deficiency. Therefore, LPT could be a valuable adjunct treatment in tissue engineering when using stem cells derived from the dental pulp of primary teeth."	PubMed
★	Oral	Endodontics	de Carvalho	Brazil (Salvador, Bahia)	2015	Lasers Med Sci	**Effect of laser (λ 660 nm) and LED (λ 630 nm) photobiomodulation on formocresol-induced oral ulcers: a clinical and histological study on rodents.**	Rat	LED phototherapy LED and laser	"At the end of the experimental period (11 days), there was no difference regarding to the size of the ulcers between the laser and LED groups, although there was a difference between the treated and untreated groups (p=0.0019)." Comment: The difference between LLLT and LED groups, compared to the control group at the end of the study, are huge.	PubMed
☹	Oral	Endodontics	Bramante	Brazil (Bauru)	2015	J Endod	**Use of a 660-nm Laser to Aid in the Healing of Necrotic Alveolar Mucosa Caused by Extruded Sodium Hypochlorite: A Case Report.**	Case report		"The conventional treatment protocol was combined with low-level laser therapy. Clinical and radiographic examinations after 7 months revealed complete repair of the necrotic area with no paresthesia and further indicated the integrity of the apical region of the tooth where the extrusion of sodium hypochlorite occurred." Comment: The author didn't report dose parameters.	PubMed

	Oral	Endodontics	Turrioni	Brazil (Araraquara)	2015	Oper Dent	**Transdentinal cell photobiomodulation using different wavelengths.**	In vitro	odontoblast-like cells (MDPC-23).	"The infrared LED irradiation at an energy density of 4 J/cm(2) and red LED at an energy density of 25 J/cm(2) were the most effective parameters for transdentinal photobiomodulation of cultured odontoblast-like cells."	PubMed
	Oral	Endodontics	Montoro	Brazil (Araraquara)	2014	Int Endod J	**Infrared LED irradiation photobiomodulation of oxidative stress in human dental pulp cells.**	In vitro		"Biomodulation of oxidative stress of [human dental pulp cells] can be achieved by irradiation with a single dose of infrared LED. Within the range investigated, 15 J cm(-2) resulted in the least production of NO."	PubMed
☹	Oral	Endodontics	Shigetani	Japan (Nigata)	2011	J Endod	**GaAlAs laser irradiation induces active tertiary dentin formation after pulpal apoptosis and cell proliferation in rat molars.**	Rat		"The output energy determined pulpal healing patterns after GaAlAs laser irradiation; the higher energy induced the apoptosis in the affected dental pulp including odontoblasts followed by active cell proliferation in the intense HSP-25-immunoreactive areas surrounding the degenerative tissue, resulting in abundant tertiary dentin formation. Thus, the optimal GaAlAs laser irradiation elicited intentional tertiary dentin formation in the dental pulp." Comment: Some parameters such as energy density or spot size were not reported. Comment: I wonder whether the effect is based on photobiomodulation or heat-stress and hormesis.	PubMed
☹	Oral	Endodontics	Shiba	Japan (Hiroshima)	2009	J Endod	**Neodymium-doped yttrium-aluminium-garnet laser irradiation abolishes the increase in interleukin-6 levels caused by peptidoglycan through the p38 mitogen-activated protein kinase pathway in human pulp cells.**	In vitro		"Suppression of the phosphorylated p38 activity by low-power laser irradiation in HP cells culminates in inhibition of the increase in IL-6 induced by peptidoglycan, suggesting that low-power laser irradiation regulates intracellular signaling molecule activities to exert its anti-inflammatory effect." Comment: The parameters were strangely reported. Wavelength is unclear, though Nd:YAG seems to usually be 1064 nm.	PubMed
	Oral	Endodontics	Payer	Austria (Graz)	2005	Oral Surg Oral Med Oral Pathol Oral Radiol Endod	**The clinical effect of LLLT in endodontic surgery: a prospective study on 72 cases.**	Human Observational		"In routine endodontic surgery cases, LLLT does not achieve a significant clinical benefit. Further, the results indicate a prominent placebo effect of the soft laser therapy." Comment: Placebo irradiation appeared to be better than control. Comment: One reason for the lack of result is the fact that the pain levels were already very low, so there was really nothing to improve. Comment: Two photographs were supplied.	PubMed
	Oral	Endodontics	Kreisler	Germany (Mainz)	2004	Int J Oral Maxillofac Surg	**Efficacy of low level laser therapy in reducing postoperative pain after endodontic surgery-- a randomized double blind clinical study.**	Human RCT/DB		"The results revealed that the pain level in the laser group was lower than in the placebo group throughout the 7 day follow-up period. The differences, however, were significant only on the first postoperative day (Mann-Whitney U-test, p<0.05). Low level laser therapy can be beneficial for the reduction of postoperative pain. Its clinical efficiency and applicability with regard to endodontic surgery, however require further investigation. This is in particular true for the optimal energy dosage and the number of laser treatments needed after surgery." Comment: The pain levels were low in the control group. Therefore the need for extra pain reduction via LLLT/PBM might be not that important in this case.	PubMed
	Oral	Endodontics	Ohbayashi	Japan (Chiba)	1999	J Endod	**Stimulatory effect of laser irradiation on calcified nodule formation in human dental pulp fibroblasts.**	In vitro		"These results suggested that formation of calcified nodules in human dental pulp cells, as well as in alkaline phosphatase activity, the production of collagen and osteocalcin were enhanced by laser irradiation."	PubMed
	Oral	Graft-versus-host disease	Epstein	USA (Los Angeles, CA)	2016	Support Care Cancer	**Photobiomodulation therapy in the management of chronic oral graft-versus-host disease.**	Human Case series		"Oral pain, sensitivity, and dry mouth improved in most patients. These findings suggest PBM therapy may represent an additional approach for management of oral cGVHD, and suggest that controlled studies should be conducted to confirm the efficacy and safety of PBM therapy in oral cGVHD and to determine optimal PBM therapy protocols."	PubMed
	Oral	Mastication	Tullberg	Sweden (Huddinge)	2003	Pain	**Effects of low-power laser exposure on masseter muscle pain and microcirculation.**	Human RCT/DB		"The blood flow did not change significantly in the patients, but increased after active laser exposure and decreased after placebo exposure in the healthy individuals. The difference between active laser and placebo was significant. In conclusion, the results of this study do not support an effect of low-power laser exposure on masseter muscle microcirculation in patients with chronic orofacial pain of muscular origin." Comment: The abstract seems difficult to interpret...	PubMed
	Oral	Mucoleles	Amaral	Brazil (Belo Horizonte)	2012	Lasers Med Sci	**Low level laser effect after micro-marsupialization technique in treating ranulas and mucoceles: a case series report.**	Human Case series		"All treated oral ranulas and selected mucoceles presented clinical healing. No evidence of recurrence could be identified during a mean of 11.0-month follow-up period. The use of InGaAsP diode lasers, within the parameters tested, appears to present a good alternative treatment to reduce pain and heal oral ranulas and selected mucoceles associated with micro-marsupialization."	PubMed
	Oral	Nerves	de Oliveira Martins	Brazil (São Paulo)	2013	J Neurotrauma	**Laser therapy and pain-related behavior after injury of the inferior alveolar nerve: possible involvement of neurotrophins.**	Rat	IAN injury	"When the animals were subjected to the laser therapy technique, we observed a recovery of pain threshold to normal levels. These alterations were detected as early as day 2 and persisted at least until 1 month after surgery (Fig. 1). It is important to point out that all animals that received laser therapy sessions exhibit behavioral improvement." "In irradiated animals, there was an enhanced expression of NGF (53%) and a decreased BDNF expression (40%) after laser therapy." Comment: If irradiated area is 0.5cm2 with 6J/cm2, then the total radiant energy should	PubMed
	Oral	Oral mucosal disorders	Spanemberg	Brazil	2016	Altern Ther Health Med	**Low-level Laser Therapy: A Review of Its Applications in the Management of Oral Mucosal Disorders.**	Review			PubMed
★	Oral	Oral mucosal necrosis	Epstein	USA (Los Angeles, CA)	2016	Support Care Cancer	**Photobiomodulation therapy: management of mucosal necrosis of the oropharynx in previously treated head and neck cancer patients.**	Human Case series	LLLT intraoral + LED phototherapy extraorally LED cluster (69)	"We report three cases of symptomatic persisting oral ulcerations where the addition of photobiomodulation therapy resulted in a rapid resolution of the oral lesions and in patient symptoms."	PubMed

	Oral	Oral mucositis	Treister	USA (Boston, MA)	2016	Photomed Laser Surg	**A Feasibility Study Evaluating Extraoral Photobiomodulation Therapy for Prevention of Mucositis in Pediatric Hematopoietic Cell Transplantation.**	Human	THOR Model LX2M LED phototherapy LED cluster (69) Extraoral Pediatric patients	"The 10 trained nurses all reported that the device was accessible, maneuverable, and lightweight, and that training was effective. There was no reported toxicity attributed to the PBT."	PubMed
	Oral	Oral mucositis	Ferreira	Brazil (Recife)	2016	Support Care Cancer	**Low-level laser therapy prevents severe oral mucositis in patients submitted to hematopoietic stem cell transplantation: a randomized clinical trial.**	Human RCT	Patients undergoing HSCT	"Severe mucositis was found in 40% of the patients (14/35), 3 in the intervention group (17.65%) and 11 in the sham group (61.11%) (p = 0.015)."	PubMed
	Oral	Oral mucositis	Bezinelli	Brazil (São Paulo)	2016	Eur J Cancer Care (Engl)	**Quality of life related to oral mucositis of patients undergoing haematopoietic stem cell transplantation and receiving specialised oral care with low-level laser therapy: a prospective observational study.**	Human Observational	Patients undergoing HSCT	"A significant number of patients (46.38%) had grade 1 mucositis (indicating no ulcers in the oral cavity)." "The study showed that QoL improves over time in these patients undergoing LLLT therapy for prevention of mucositis."	PubMed
	Oral	Oral mucositis	Antunes	Brazil (Rio de Janeiro)	2016	Oral Oncol	**Cost-effectiveness of low-level laser therapy (LLLT) in head and neck cancer patients receiving concurrent chemoradiation.**	Human RCT	Cost-effectiveness calculation	"Our results indicate that morbidity was lower in the Laser Group and that LLLT was more cost-effective than placebo up to a threshold of at least US$ 5000 per mucositis case prevented." Jan Tuner has written: "PBM to prevent and reduce the incidence of oral mucositis has been well documented for 15 years and still not being widely accepted. Now that there is evidence of a cost saving method we might experience a renewed interest, because Money Talks."	PubMed
	Oral	Oral mucositis	Amadori	Italy (Brescia)	2016	Lasers Med Sci	**Low-level laser therapy for treatment of chemotherapy-induced oral mucositis in childhood: a randomized double-blind controlled study.**	Human RCT	Pediatric patients	"This study reported that there was no difference in the reduction of oral mucositis between the two groups, but only in the pain amelioration. The slight contrast with other studies [37] may be partially explained by the wavelengths used. In fact, we chose a high wavelength (830 nm) in order to verify if, exploiting the spectra absorption of cytochrome c oxidase, which is about 825 nm, and increasing the cellular metabolism and the oral mucosa healing process [35, 36], this type of wavelengths could be an alternative to 632–660 nm laser lights."	PubMed
★	Oral	Oral mucositis	Soto	Brazil (São Paulo)	2015	Photomed Laser Surg	**Pilot study on the efficacy of combined intraoral and extraoral low-level laser therapy for prevention of oral mucositis in pediatric patients undergoing hematopoietic stem cell transplantation.**	Human RCT	Intraoral + Extraoral Pediatric patients undergoing HSCT	"Clinical mucositis scores were significantly lower in the LLLT group than in the control group (p = 0.004). Incidence of ulcerative oral mucositis was also significantly lower in the LLLT group (p = 0.027). Functional limitation associated with diet/swallowing was less severe in the LLLT group; however, this was not statistically significant." Star: Nice study setting. A well-written paper.	PubMed
	Oral	Oral mucositis	Silva	Brazil (Goiás)	2015	Photomed Laser Surg	**The Impact of Low-Level Laser Therapy on Oral Mucositis and Quality of Life in Patients Undergoing Hematopoietic Stem Cell Transplantation Using the Oral Health Impact Profile and the Functional Assessment of Cancer Therapy-Bone Marrow Transplantation Questionnaires.**	Human RCT	Patients undergoing HSCT	"The laser group presented less severe OM than the control group (p<0.001)." "LLLT did not influence the oral and general health-related QoL of patients undergoing HSCT, although it was clinically effective in reducing the severity of chemotherapy-induced OM."	PubMed
★	Oral	Oral mucositis	Silva	Brazil (Goiás)	2015	Lasers Med Sci	**Effect of low-level laser therapy on inflammatory mediator release during chemotherapy-induced oral mucositis: a randomized preliminary study.**	Human RCT	Patients undergoing HSCT	"The study showed that 72.8 % (8 of 11) of patients treated with laser therapy were free of ulcers (grades 0 and 1); 27.2 % developed grade 2 mucositis, while none showed grades 3 or 4 mucositis". "On the other hand, in the control group, 57.1 % (8 out of 14) developed grades 2 and 3 mucositis, and 42.9 % of patients did not develop ulcerative OM." "its mechanism of action does not seem to be completely linked to the modulation of pro- or anti-inflammatory cytokines, growth factors or matrix metalloproteinases."	PubMed
	Oral	Oral mucositis	Oton-Leite	Brazil (Goiás)	2015	Lasers Surg Med	**Effect of low-level laser therapy on chemoradiotherapy-induced oral mucositis and salivary inflammatory mediators in head and neck cancer patients.**	Human RCT	Patients receiving chemoradiotherapy Head&neck cancer	"The laser group showed a reduction in the severity of OM, which coursed with significantly diminished salivary concentration of EGF and VEGF in the 7th radiotherapy session and of IL-6 and FGF in the 35th. There was a trend for reduced levels of IL-1β, TNF-α, IL-10, TGF-β, MMP2/TIMP2, MMP9/TIMP2 in the laser group compared to the control, however, no statistically significant differences were found." "These findings demonstrated that LLLT was effective in reducing the severity of chemoradiotherapy-induced OM and was associated with the reduction of inflammation and repair."	PubMed
	Oral	Oral mucositis	Gautam	India (Manipal)	2015	J Photochem Photobiol B	**Low level laser therapy against radiation induced oral mucositis in elderly head and neck cancer patients-a randomized placebo controlled trial.**	Human RCT	Elderly patients Head&neck cancer	"LLLT decreased the severity of OM and oral pain in elderly HNC patients. Also, lesser weight loss, morphine analgesic use and radiation break happened in laser group."	PubMed
	Oral	Oral mucositis	Eduardo Fde	Brazil (São Paulo)	2015	Pediatr Transplant	**Oral mucositis in pediatric patients undergoing hematopoietic stem cell transplantation: clinical outcomes in a context of specialized oral care using low-level laser therapy.**	Human Observational		"Specialized oral care, including LLLT, is feasible and affordable for HSCT pediatric patients, although some adaptation in the patient's oral hygiene routine must be adopted with help from parents/companions and clinical staff."	PubMed
	Oral	Oral mucositis	Curra	Brazil	2015	J Biomed Opt	**Photobiomodulation reduces oral mucositis by modulating NF-kB.**	Hamster		LLLT increased NF-kB and reduced the severity of oral mucositis.	PubMed
	Oral	Oral mucositis	Bensadoun & Nair	France (Nice) & Australia (Queensland)	2015	Photomed Laser Surg	**Low-Level Laser Therapy in the Management of Mucositis and Dermatitis Induced by Cancer Therapy.**	Letter			PubMed
	Oral	Oral mucositis	Basso	Brazil (Araraquara)	2015	Photochem Photobiol	**Biomodulation of Inflammatory Cytokines Related to Oral Mucositis by Low-Level Laser Therapy.**	In vitro	Gingival fibroblasts + LPS	"For LPS-treated groups, LLLT promoted significant decreases in the expression of TNF-α, IL-6, and IL-8 at 1.5 J cm(-2) and 3 J cm(-2)."	PubMed
☎	Oral	Oral mucositis	Freide Mdo	Brazil (Salvador, Bahia))	2014	Clin Oral Investig	**LED and laser photobiomodulation in the prevention and treatment of oral mucositis: experimental study in hamsters.**		LED phototherapy LED vs LLLT	"The best results were obtained from the preventive laser and LED photobiomodulation groups; both treatments were effective in diminishing the OM lesions." Comment: The laser parameters seem a little bit unlogical. If the radiation time is 30 seconds with the power output of 40mW, then total dose is 1.2J, not 16J.	PubMed
	Oral	Oral mucositis	Fekrazad & Chiniforush	Iran (Tehran)	2014	J Lasers Med Sci	**Oral mucositis prevention and management by therapeutic laser in head and neck cancers.**	Systematic review			PubMed

★	Oral	Oral mucositis	Oberoi	Canada (Toronto)	2014	PLoS One	**Effect of prophylactic low level laser therapy on oral mucositis: a systematic review and meta-analysis.**	Meta-analysis			PubMed
	Oral	Oral mucositis	Ottaviani	Italy (Trieste)	2013	Am J Pathol	**Effect of class IV laser therapy on chemotherapy-induced oral mucositis: a clinical and experimental study.**	Human Comparison trial		"We show that high-power laser therapy is more effective than low-power laser therapy in improving OM lesion healing, reducing the inflammatory burden, and preserving tissue integrity." Tunér: "The authors claim to have been using a "standard low power laser protocol" for comparison. In fact, they have not. The "standard" laser used is a 635 nm diode of 2.5 mW (standard laser pointer), delivering 0.45 J per point and delivered from a distance of 1 - 3 cm, further reducing the power density and for some reason pulsed." Note: Jan Bjordal wrote a comment to this article. The authors have replied to the comment.	PubMed
	Oral	Oral mucositis	Oton-Leite	Brazil (Goiás)	2013	Spec Care Dentist	**Effect of low level laser therapy in the reduction of oral complications in patients with cancer of the head and neck submitted to radiotherapy.**	Human RCT	Patients with head/neck cancer	"Better outcomes were observed in the laser group when compared with the control in the follow-up sessions, indicating lower degrees of oral mucositis, pain and higher salivary flow (p < .05)."	PubMed
	Oral	Oral mucositis	Migliorati	USA (Memphis, TN)	2013	Support Care Cancer	**Systematic review of laser and other light therapy for the management of oral mucositis in cancer patients.**	Systematic review			PubMed
	Oral	Oral mucositis	Lopez	Brazil (São Paulo)	2013	Braz Oral Res	**Effect of laser phototherapy in the prevention and treatment of chemo-induced mucositis in hamsters.**	Hamster	Chemo-induced oral mucositis Prevention vs therapy	"The therapeutic group had significantly lower clinical and histological scores than the other groups at Day 10." "This study showed that positive effects on oral mucositis management were obtained only when LPT was applied in the therapeutic protocol (from D+5 to D+15 after chemotherapy)."	PubMed
	Oral	Oral mucositis	Gautam	India (Manipal)	2013	Support Care Cancer	**Effect of low-level laser therapy on patient reported measures of oral mucositis and quality of life in head and neck cancer patients receiving chemoradiotherapy--a randomized controlled trial.**	Human RCT/DB	Patients with head/neck cancer (chemoradiotherapy)	"LLLT was effective in improving the patient's subjective experience of OM and QOL in HNC patients receiving CRT."	PubMed
	Oral	Oral mucositis	Figueiredo	Brazil (Salvador, BA)	2013	Rev Assoc Med Bras (1992)	**Laser therapy in the control of oral mucositis: a meta-analysis.**	Meta-analysis			PubMed
	Oral	Oral mucositis	de Castro	Brazil (Recife)	2013	Photomed Laser Surg	**Low-level laser in prevention and treatment of oral mucositis in pediatric patients with acute lymphoblastic leukemia.**	Human (control group)	Patients with lymphoblastic leukemia A: prevention of OM B: treatment of OM Red vs NIR	"Prophylactic laser produced a better outcome than when patients did not receive any preventive intervention" "red laser (660 nm) was better than infrared (830 nm)"	PubMed
☹	Oral	Oral mucositis	Arbabi-Kalati	Iran (Tehran)	2013	Acta Med Iran	**Evaluation of the effect of low level laser on prevention of chemotherapy-induced mucositis.**	Human RCT/DB	Chemo-induced oral mucositis	"The results showed that low-power laser was able to decrease the effect of chemotherapy on oral mucositis, xerostomia and pain in a variety of malignancies" Comment: Results are interesting, but the parameters are poorly reported.	PubMed
★	Oral	Oral mucositis	Antunes	Brazil (Rio de Janeiro)	2013	Radiother Oncol	**Phase III trial of low-level laser therapy to prevent oral mucositis in head and neck cancer patients treated with concurrent chemoradiation.**	Human RCT/DB	Patients with head/neck cancer (chemoradiotherapy)	"Preventive LLLT in HNSCC patients receiving chemoradiotherapy is an effective tool for reducing the incidence of grade 3-4 OM. Efficacy data were corroborated by improvements seen in quality of life." "At a median follow-up of 18 months (10–48 months) differences favoring the LLLT patients were observed in locoregional disease control, progression-free (P = 0.097) or overall survival (P = 0.147; Fig. 3 and 4 of the Supplementary Data)." Star: The 18-month follow-up data was supplied.	PubMed
☹	Oral	Oral mucositis	Oton-Leite	Brazil (Goiás)	2012	Head Neck	**Effect of intraoral low-level laser therapy on quality of life of patients with head and neck cancer undergoing radiotherapy.**	Human RCT		"Laser therapy reduces the impact of radiotherapy on the QOL of patients with head and neck cancer." Comment: The parameters were poorly reported.	PubMed
	Oral	Oral mucositis	Hodgson	USA (Milwaukee, WI)	2012	Support Care Cancer	**Amelioration of oral mucositis pain by NASA near-infrared light-emitting diodes in bone marrow transplant patients.**	Human RCT & DB?	LED phototherapy	"Phototherapy demonstrated a significant reduction in patient-reported pain as measured by the WHO criteria in this patient population included in this study. Improvement trends were noted in most other assessment measurements."	PubMed
	Oral	Oral mucositis	Gouvêa de Lima	Brazil (São Paulo)	2012	Int J Radiat Oncol Biol Phys	**Oral mucositis prevention by low-level laser therapy in head-and-neck cancer patients undergoing concurrent chemoradiotherapy: a phase III randomized study.**	Human RCT/DB	Patients with head/neck cancer (chemoradiotherapy)	"LLL therapy was not effective in reducing severe oral mucositis, although a marginal benefit could not be excluded. It reduced RT interruptions in these head-and-neck cancer patients, which might translate into improved CRT efficacy."	PubMed
	Oral	Oral mucositis	Gautam	India (Manipal)	2012	Radiother Oncol	**Low level laser therapy for concurrent chemoradiotherapy induced oral mucositis in head and neck cancer patients - a triple blinded randomized controlled trial.**	Human RCT/DB		"LLLT decreased the incidence of CCRT induced severe OM and its associated pain, dysphagia and opioid analgesics use."	PubMed
	Oral	Oral mucositis	Bensadoun & Nair	France (Nice) & Australia (Queensland)	2012	Photomed Laser Surg	**Efficacy of low-level laser therapy (LLLT) in oral mucositis: what have we learned from randomized studies and meta-analyses?**	Letter			PubMed
	Oral	Oral mucositis	Bensadoun & Nair	France (Nice) & Australia (Queensland)	2012	Curr Opin Oncol	**Low-level laser therapy in the prevention and treatment of cancer therapy-induced mucositis: 2012 state of the art based on literature review and meta-analysis.**	Review Meta-analysis			PubMed
	Oral	Oral mucositis	Silva	Brazil (Goiás)	2011	Photomed Laser Surg	**The prevention of induced oral mucositis with low-level laser therapy in bone marrow transplantation patients: a randomized clinical trial.**	Human RCT	HSCT patients	"In the LLLT group, 57.1% of patients had an OM grade 0, 9.6% had grade 1, and 33.3% had grade 2, whereas in the control group, only 4.8% of patients were free of OM (grade 0)."	PubMed
	Oral	Oral mucositis	Cauwels & Martens	Belgium (Ghent)	2011	Eur Arch Paediatr Dent	**Low level laser therapy in oral mucositis: a pilot study.**	Human Pilot study	Pediatric patients	"Immediately after beaming the OM, pain relief was noticed. Depending on the severity of OM, on average, 2.5 treatments per lesion in a period of 1 week were sufficient to heal a mucositis lesion."	PubMed
	Oral	Oral mucositis	Carvalho	Brazil (São Paulo)	2011	Oral Oncol	**Evaluation of low-level laser therapy in the prevention and treatment of radiation-induced mucositis: a double-blind randomized study in head and neck cancer patients.**	Human RCT/DB	Dose response	"Low-level laser therapy during radiotherapy was found to be effective in controlling the intensity of mucositis and pain."	PubMed

	Oral	Oral mucositis	Bjordal	Norway (Bergen)	2011	Support Care Cancer	**A systematic review with meta-analysis of the effect of low-level laser therapy (LLLT) in cancer therapy-induced oral mucositis.**	Meta-analysis			PubMed
	Oral	Oral mucositis	Ramalho	Brazil (São Paulo)	2011	Int Wound J	**Use of laser phototherapy on a delayed wound healing of oral mucosa previously submitted to radiotherapy: case report.**	Human Case report		"The wound healed completely after ten sessions. This treatment proved to be conservative and effective, inducing healing of a chronic wound in a tissue previously submitted to radiotherapy.2	PubMed
	Oral	Oral mucositis	Lino	Brazil (Salvador, Bahia)	2011	Braz Dent J	**Laser phototherapy as a treatment for radiotherapy-induced oral mucositis.**	Human Case report		"Treatment results indicate that the use of LPT on oral mucositis was effective and allowed the patient to carry on the RT without interruption.	PubMed
	Oral	Oral mucositis	Zanin	Brazil (São Paulo)	2010	Photomed Laser Surg	**Use of 660-nm diode laser in the prevention and treatment of human oral mucositis induced by radiotherapy and chemotherapy.**	Human		"Patients in group L usually did not present with OM or pain, but all patients in group C presented with OM ranging from Level I to III associated with pain." Comment: Cool results, but parameters aren't very well reported.	PubMed
	Oral	Oral mucositis	Lopes	Brazil (São Paulo)	2010	Lasers Surg Med	**Effects of low-level laser therapy on collagen expression and neutrophil infiltrate in 5-fluorouracil-induced oral mucositis in hamsters.**	Hamster		"This study supports two mechanisms of action for LLLT in reducing mucositis severity. The increase in collagen organization in response to the 35 mW laser indicates that LLLT promotes wound healing. In addition, LLLT also appears to have an anti-inflammatory effect, as evidenced by the reduction in neutrophil infiltrate."	PubMed
	Oral	Oral mucositis	Lima	Brazil (São Paulo)	2010	Braz Dent J	**Efficacy of low-level laser therapy and aluminum hydroxide in patients with chemotherapy and radiotherapy-induced oral mucositis.**	Human (not RCT)	LLLT vs aluminum hydroxide	"The prophylactic use of both treatments proposed in this study seems to reduce the incidence of severe OM lesions. However, the LLLT was more effective in delaying the appearance of severe OM."	PubMed
☹	Oral	Oral mucositis	Chor	Brazil (Rio de Janeiro)	2010	Eur J Haematol	**Low-power laser to prevent oral mucositis in autologous hematopoietic stem cell transplantation.**	Letter		"The cumulative probability to develop oral mucositis was 47% in the laser group and 69% in the placebo group (P = 0.27)." Comment: Parameters were poorly reported. Control group received LED light...	PubMed
	Oral	Oral mucositis	Simões	Brazil (São Paulo)	2009	Lasers Surg Med	**Laser phototherapy as topical prophylaxis against head and neck cancer radiotherapy-induced oral mucositis: comparison between low and high/low power lasers.**	Human Observational	Dose comparison No control group	"All protocols of LPT led to the maintenance of oral mucositis scores in the same levels until the last RT session. Moreover, LPT three times a week also maintained the pain levels. However, the patients submitted to the once a week LPT had significant pain increase; and the association of low/high LPT led to increased healing time."	PubMed
	Oral	Oral mucositis	Lopes	Brazil (São Paulo)	2009	Support Care Cancer	**Cyclooxygenase-2 and vascular endothelial growth factor expression in 5-fluorouracil-induced oral mucositis in hamsters: evaluation of two low-intensity laser protocols.**	Hamster		"Peak severity of mucositis was reduced in the 35 mW laser group as compared to the 100 mW laser and control groups. This reduced peak clinical severity of mucositis in the 35 mW laser group was accompanied by a significantly lower level of COX-2 staining. The 100 mW laser did not have an effect on the severity of clinical mucositis, but was associated with a decrease in VEGF levels at the later time-points, as compared to the other groups."	PubMed
	Oral	Oral mucositis	Kuhn	Brazil (Porto Alegre)	2009	J Pediatr Hematol Oncol	**Low-level infrared laser therapy in chemotherapy-induced oral mucositis: a randomized placebo-controlled trial in children.**	Human RCT	Pediatric patients undergoing chemo/HSCT	"In the laser group, the mean of OM duration was 5.8±2 days and in the placebo group was 8.9±2.4 days (P=0.004)."	PubMed
	Oral	Oral mucositis	Khouri	Brazil (Ribeirão Preto, SP)	2009	Braz Dent J	**Use of therapeutic laser for prevention and treatment of oral mucositis.**	Human		"In conclusion, laser reduced the frequency and severity of OM, suggesting that therapeutic laser can be used both as a new form of prevention and treatment of OM."	PubMed
	Oral	Oral mucositis	França	Brazil (São Paulo)	2009	J Photochem Photobiol B	**Low-intensity red laser on the prevention and treatment of induced-oral mucositis in hamsters.**	Hamster		"The results suggest that laser phototherapy had a positive effect in reducing mucositis severity, and a more pronounced effect in treating established mucositis."	PubMed
	Oral	Oral mucositis	Eduardo	Brazil (São Paulo)	2009	Photomed Laser Surg	**Severity of oral mucositis in patients undergoing hematopoietic cell transplantation and an oral laser phototherapy protocol: a survey of 30 patients.**	Human Observational / Case series		"The low grades of OM observed in this survey show the beneficial effects of laser phototherapy, but randomized clinical trials are necessary to confirm these findings."	PubMed
	Oral	Oral mucositis	Campos	Brazil (São Paulo)	2009	Photomed Laser Surg	**Improvement in quality of life of an oncological patient by laser phototherapy.**	Human Case report		"Normal oral function and consequent improvements in the quality of life of this oncologic patient were observed with LPT."	PubMed
☹	Oral	Oral mucositis	Genot-Klastersky	Belgium (Brussels)	2008	Support Care Cancer	**The use of low-energy laser (LEL) for the prevention of chemotherapy- and/or radiotherapy-induced oral mucositis in cancer patients: results from two prospective studies.**	Human RCT		"Our results strongly support the already available literature, suggesting that LEL is an effective and safe approach to prevent or treat oral mucositis resulting from cancer chemotherapy." Comment: Wavelength was not reported.	PubMed
	Oral	Oral mucositis	Arora	India (Manipal)	2008	Oral Surg Oral Med Oral Pathol Oral Radiol Endod	**Efficacy of He-Ne Laser in the prevention and treatment of radiotherapy-induced oral mucositis in oral cancer patients.**	Human		"Laser therapy applied prophylactically during radiotherapy can reduce the severity of oral mucositis, severity of pain, and functional impairment."	PubMed
	Oral	Oral mucositis	Antunes	Brazil (Rio de Janeiro)	2008	Med Oral Patol Oral Cir Bucal	**The Impact of low power laser in the treatment of conditioning-induced oral mucositis: a report of 11 clinical cases and their review.**	Case series		"Our results have indicated that the use of LPLT in HSCT patients is a powerful instrument in the treatment of overt OM and is now a standard procedure in this group of patients in our hospital."	PubMed
	Oral	Oral mucositis	Abramoff	Brazil (São Paulo)	2008	Photomed Laser Surg	**Low-level laser therapy in the prevention and treatment of chemotherapy-induced oral mucositis in young patients.**	Human RCT		"The ease of use of LLLT, high patient acceptance, and the positive results achieved, make this therapy feasible for the prevention and treatment of OM in young patients."	PubMed
	Oral	Oral mucositis	Schubert	USA (Seattle, WA)	2007	Support Care Cancer	**A phase III randomized double-blind placebo-controlled clinical trial to determine the efficacy of low level laser therapy for the prevention of oral mucositis in patients undergoing hematopoietic cell transplantation.**	Human RCT/DB		"The 650 nm wavelength reduced the severity of oral mucositis and pain scores. Low level laser therapy was well-tolerated and no adverse events were noted." Comment 1: On the other hand, the 780 nm wavelength appeared to make things even worse... Comment 2: The Discussion part seems lengthy. Maybe worth reading.	PubMed
☹	Oral	Oral mucositis	Jaguar	Brazil (São Paulo)	2007	Oral Dis	**Low-energy laser therapy for prevention of oral mucositis in hematopoietic stem cell transplantation.**	Human Observational		"All patients developed some grade of mucositis. However, the L- group presented initial mucositis by 4.36 days, whereas the L+ group presented it in 6.12 days (P = 0.01). The maximum mucositis occurred between day +2 and day +6 with healing by day +25 in the L- group and between day +2 and day +7 with healing by day +14 for the L+ group (P = 0.84). Laser therapy also reduced the time of oral pain from 5.64 to 2.45 days (P = 0.04), and decreased the consumption of morphine (P = 0.07)."	PubMed

☹	Oral	Oral mucositis	Cruz	Brazil (Porto Alegre)	2007	Pediatr Blood Cancer	**Influence of low-energy laser in the prevention of oral mucositis in children with cancer receiving chemotherapy.**	Human RCT		"This study showed no evidence of benefit from the prophylactic use of low-energy laser in children and adolescents with cancer treated with chemotherapy when optimal dental and oral care was provided." Comment: The parameters were poorly reported.	PubMed
	Oral	Oral mucositis	Antunes	Brazil (Rio de Janeiro)	2007	Blood	**Low-power laser in the prevention of induced oral mucositis in bone marrow transplantation patients: a randomized trial.**	Human RCT		"5.3% of the laser group presented with ulcers of 9.1 cm2 to 18 cm2, whereas 73.6% of the control group presented with ulcers from 9.1 cm2 to 18 cm2 (P = .003). Our results indicate that the use of upfront LPLT in patients who have undergone HSCT is a powerful instrument in reducing the incidence of OM and is now standard in our center."	PubMed
	Oral	Oral mucositis	Migliorati	USA (Fort Lauderdale, FL)	2006	Support Care Cancer	**The role of alternative and natural agents, cryotherapy, and/or laser for management of alimentary mucositis.**	Review			PubMed
	Oral	Oral mucositis	Arun Maiya	India (Manipal)	2006	Indian J Med Res	**Effect of low level helium-neon (He-Ne) laser therapy in the prevention & treatment of radiation induced mucositis in head & neck cancer patients.**	Human RCT		"The low-level He-Ne laser therapy during the radiotherapy treatment was found to be effective in preventing and treating the mucositis in head and neck cancer patients."	PubMed
	Oral	Oral mucositis	Nes & Posso	Norway (Drammen)	2005	Int Nurs Rev	**Patients with moderate chemotherapy-induced mucositis: pain therapy using low intensity lasers.**	Human		"There was a significant (P = 0.007) 67% decrease in the daily average experience of pain felt before and after each treatment, confirming that LLLT can relieve pain among patients who have developed COM." [See additional info. for information about the device.]	PubMed
	Oral	Oral mucositis	Genot & Klastersky	Belgium (Brussels)	2005	Curr Opin Oncol	**Low-level laser for prevention and therapy of oral mucositis induced by chemotherapy or radiotherapy.**	Review			PubMed
	Oral	Oral mucositis	Wong & Wilder-Smith	USA (Pomona, CA)	2002	Cancer J	**Pilot study of laser effects on oral mucositis in patients receiving chemotherapy.**	Human Pilot study		"Eleven of 15 patients experienced grade 0 mucositis, three patients experienced grade 1 to 2 mucositis, and one patient experienced grade 3 to 4 mucositis." "In this pilot study, laser therapy significantly reduced the incidence and the severity of mucositis in chemotherapy patients. The laser therapy does not appear to promote wound healing by affecting the intraoral perfusion, as assessed by Doppler measurements."	PubMed
	Oral	Oral mucositis	Whelan	USA (Milwaukee, WI)	2002	J Clin Laser Med Surg	**NASA light-emitting diodes for the prevention of oral mucositis in pediatric bone marrow transplant patients.**	Human	LED phototherapy	"The incidence of UOM was 53%, compared to an expected rate of 70-90%. There was also a 48% and 39% reduction of treated left and right buccal pain, respectively, compared to untreated throat pain at about posttransplant day 7 ($p < 0.05$). There were no significant differences between sides in OMI or pain." "Although more studies are needed, LED therapy appears useful in the prevention of OM in pediatric BMT patients."	PubMed
	Oral	Oral mucositis	Whelan	USA (Milwaukee, WI)	2001	J Clin Laser Med Surg	**Effect of NASA light-emitting diode irradiation on wound healing.**	Human	LED phototherapy	"LED produced a 47% reduction in pain of children suffering from oral mucositis."	PubMed
	Oral	Oral mucositis	Bensadoun	France (Nice)	1999	Support Care Cancer	**Low-energy He/Ne laser in the prevention of radiation-induced mucositis. A multicenter phase III randomized study in patients with head and neck cancer.**	Human RCT/DB		"Grade 3 mucositis occured with a frequency of 35.2% without LEL and of 7.6% with LEL ($P<0.01$). The frequency of "severe pain" (grade 3) was 23.8% without LEL, falling to 1.9% with LEL ($P<0.05$). Pain relief was significantly reduced throughout the treatment period (weeks 2-7). LEL therapy is capable of reducing the severity and duration of oral mucositis associated with radiation therapy. In addition, there is a tremendous potential for using LEL in combined treatment protocols utilizing concomitant chemotherapy and radiotherapy."	PubMed
	Oral	Oral mucositis	Cowen	France (Marseilles)	1997	Int J Radiat Oncol Biol Phys	**Low energy Helium-Neon laser in the prevention of oral mucositis in patients undergoing bone marrow transplant: results of a double blind randomized trial.**	Human RCT/DB		"Helium-Neon laser treatment was well tolerated, feasible in all cases, and reduced high dose chemoradiotherapy-induced oral mucositis. Optimal laser treatment schedules still needs to be defined."	PubMed
	Oral	Oral mucositis	Barasch	USA (Farmington)	1995	Cancer	**Helium-neon laser effects on conditioning-induced oral mucositis in bone marrow transplantation patients.**	Human		"Helium-neon laser treatment was well-tolerated and reduced the severity of conditioning-induced oral mucositis in BMT patients."	PubMed
	Oral	Oral surgery	Ustaoglu	Turkey (Trabzon)	2017 epub	Photomed Laser Surg	**Low-Level Laser Therapy in Enhancing Wound Healing and Preserving Tissue Thickness at Free Gingival Graft Donor Sites: A Randomized, Controlled Clinical Study.**	Human RCT		"The prevalence of Complete Wound Epithelization was higher in the LLLT group than in the control group on the 14th day ($p < 0.001$). The bleeding was lower in the test group than in the control group during the first 2 days ($p \leq 0.001$). Higher WHI Scores were observed in the test group relative to the control group at all visits ($p \leq 0.001$). Color match scores were higher in the test group than in the control group at the first 3 visits ($p < 0.05$). The TT changed from 4.62 ± 0.79 to 4.71 ± 0.82 mm in the LLLT group and from 4.23 ± 0.62 to 4.01 ± 0.68 mm in the control group." "It can be concluded that LLLT enhances FGG donor site wound healing and preserves TT at palatinal donor sites."	PubMed
	Oral	Oral surgery	Sanz-Moliner	Spain	2013	J Periodontol	**The effect of an 810-nm diode laser on postoperative pain and tissue response after modified Widman flap surgery: a pilot study in humans.**	Human Pilot study	Widman flap	LLLT seemed to decrease pain and edema.	PubMed
	Oral	Orofacial pain	Amanat	Iran (Shiraz)	2013	Photomed Laser Surg	**The adjunct therapeutic effect of lasers with medication in the management of orofacial pain: double blind randomized controlled trial.**	Human RCT/DB		"We found no significant level of efficacy for the GaAs laser in the management of common orofacial pain. Further studies are suggested to evaluate the efficacy of other types of lasers with different parameters in the management of orofacial pains."	PubMed
	Oral	Orofacial pain	Hansen & Thorøe	Denmark (Copenhagen)	1990	Pain	**Low power laser biostimulation of chronic oro-facial pain. A double-blind placebo controlled cross-over study in 40 patients.**	Human Crossover/DB		"No statistically significant difference between the analgesic effect of the laser and placebo irradiation was found on VAS-scales." Jan Tuner: "It is interesting to note that the authors themselves state the origin of "burning mouth" as multifactor, psychosomatic or psychogenic. Thus, there would be no actual injury to the tissue, and laser, like any other modality, would have no effect. The negative 5-HIAA measurement in the laser group may indeed confirm the inappropriate inclusion parameters and laser energies in this study."	PubMed
	Oral	Orthodontics	Meng	China (Chengdu)	2017	Photomed Laser Surg	**Effect of Low-Level Laser Therapy on Relapse of Rotated Teeth: A Systematic Review of Human and Animal Study.**	Systematic review			PubMed
	Oral	Orthodontics	Almallah	Syria (Damascus)	2016	J Clin Diagn Res	**Evaluation of Low Level Laser Therapy on Pain Perception Following Orthodontic Elastomeric Separation: A Randomized Controlled Trial.**	Human RCT	Pain	"LLLT was successful in reducing post-separation pain when the experimental side was compared to the placebo side at all assessment times in each group ($p<0.05$). There were no statistically significant differences between single and double irradiation groups in terms of pain reduction ($p>0.05$)."	PubMed

	Oral	Orthodontics	Gonçalves	Brazil (São Paulo)	2016	Lasers Med Sci	**Experimental tooth movement and photobiomodulation on bone remodeling in rats.**	Rat	Tooth movement	"PBM applied in one or three sessions increased the population of osteoblasts. Still, the application of three sessions of PBM increased the density of collagen fibers and new bone formation compared to the controls. An increase was observed in the interincisal distance in irradiated groups with three PBM sessions and the application of force for both 7 or 14 days." "These findings suggest that PBM can contribute positively to the orthodontic	PubMed
	Oral	Orthodontics	Lee	Korea (Seoul)	2016	Angle Orthod	**Combined effect of photobiomodulation with a matrix metalloproteinase inhibitor on the rate of relapse in rats.**	Rat		"In the present study, the combined effect of LLLT with doxycycline on both relapse rate and MMP expression in the PDL was proved to be antagonistic, although the stimulatory effect of LLLT and inhibitory effect of doxycycline were separately verified."	PubMed
	Oral	Orthodontics	Yanaguizawa	Brazil (Campinas)	2016 epub	Photomed Laser Surg	**Effects of Low-Level Laser Therapy in Orthodontic Patients on Immediate Inflammatory Response After Mini-Implants Insertion: A Preliminary Report.**	Human	Inflammatory response	"PGF around nonirradiated mini-implants showed higher levels of IL-8. Levels of IL-6 24 h after mini-implant insertion were higher for laser group." "LLLT modulates the initial inflammation after the insertion of mini-implant, possibly increasing the mini-implant success prognostic and decreasing patient discomfort."	PubMed
	Oral	Orthodontics	AlSayed Hasan	Syria (Damascus)	2016 epub	Angle Orthod	**Low-level laser therapy effectiveness in accelerating orthodontic tooth movement: A randomized controlled clinical trial.**	Human RCT	Tooth movement	"A statistically significant difference was found between the two groups in the overall treatment time (P < .001) and the leveling and alignment improvement percentage at T1 (P = .004) and T2; (P = .001)."	PubMed
	Oral	Orthodontics	Yassaei	Iran (Yazd & Mashdad)	2016	Lasers Med Sci	**Effects of diode laser (980 nm) on orthodontic tooth movement and interleukin 6 levels in gingival crevicular fluid in female subjects.**	Human RCT/DB split-mouth	Tooth movement	"Although the mean rate of canine retraction was higher in the LG (0.013) than the CG (0.012) and there was definitely a tendency for more canine retraction in the LLLI, but the results failed to show any significant difference between the mean rate of canine retraction of both groups (P = 0.068)." "A paired t test showed that there was no significant difference in the mean concentration of IL-6 at various stages of the treatment between the groups during canine distalization (P > 0.05)."	PubMed
	Oral	Orthodontics	Shaughnessy, et al.	USA&Canada	2016	BMC Oral Health	**Intraoral photobiomodulation-induced orthodontic tooth alignment: a preliminary study.**	Human RCT Pilot study	Tooth alignment	Alignment rate was significantly higher in LLLT group (1.27mm/week versus 0.44mm/week)	PubMed
	Oral	Orthodontics	Nahas	United Arab Emirates (Dubai)	2016	Lasers Med Sci	**Decrowding of lower anterior segment with and without photobiomodulation: a single center, randomized clinical trial.**	Human RCT	Tooth movement Extraoral LLLT	"The time between T1 and T2 was significantly reduced by 22 % in the test group compared to the control group (68.3 vs. 87.8 days, respectively, p < 0.043). The use of photobiomodulation for 20 min daily at a wavelength of 850 nm might reduce the time required to resolve lower anterior crowding. This trial and its protocol were not registered on a publicly accessible registry."	PubMed
	Oral	Orthodontics	Ekizer	Turkey (Kayseri)	2016	Lasers Surg Med	**Light emitting diode mediated photobiomodulation therapy improves orthodontic tooth movement and miniscrew stability: A randomized controlled clinical trial.**	Human RCT/DB split-mouth	Tooth movement Miniscrew stability	"Miniscrew stability was similar between control and LPT groups at baseline (T0) and the 1st month (T1). However, miniscrew stability was significantly increased in the LPT group in 2nd (T2) and 3rd (T3) months. Comparison of tooth movement during three different time intervals (T1-T0, T2-T1, and T3-T2) revealed that statistically significantly increased in every time intervals after LPT. No statistically significant change was detected in the IL-1β levels between groups." Comment: Parameters were poorly reported.	PubMed
	Oral	Orthodontics	Marini	Italy	2015	Lasers Med Sci	**The effect of diode superpulsed low-level laser therapy on experimental orthodontic pain caused by elastomeric separators: a randomized controlled clinical trial.**	Human RCT	Pain	A single LLLT treatment was effective in reducing pain.	PubMed
	Oral	Orthodontics	Ekizer	Turkey (Kayseri)	2015	Lasers Med Sci	**Effect of LED-mediated-photobiomodulation therapy on orthodontic tooth movement and root resorption in rats.**	Rat	Root resorption	"The magnitude of movement in the treatment group was higher (1.55 ± 0.33 mm) compared to the control group (1.06 ± 0.35 mm). Histomorphometric analysis of root resorption, expressed as a percentage, showed that the average relative root resorption affecting the maxillary molars on the TM side was 0.098 ± 0.066 in the LPT group and 0.494 ± 0.224 in the control group."	PubMed
	Oral	Orthodontics	Domínguez	Spain	2015	Lasers Med Sci	**Effects of low-level laser therapy on orthodontics: rate of tooth movement, pain, and release of RANKL and OPG in GCF.**	Human Volunteers Controlled	Tooth movement Pain	LLLT seemed to have some beneficial effects, but most of the positive effects weren't statistically significant.	PubMed
	Oral	Orthodontics	Long	China (Sichuan)	2015	Lasers Med Sci	**The effectiveness of low-level laser therapy in accelerating orthodontic tooth movement: a meta-analysis.**	Meta-analysis	Tooth movement		PubMed
	Oral	Orthodontics	Ge	China (Chengdu)	2015	Lasers Med Sci	**Efficacy of low-level laser therapy for accelerating tooth movement during orthodontic treatment: a systematic review and meta-analysis.**	Meta-analysis	Tooth movement Biphasic dose response		PubMed
	Oral	Orthodontics	Li	China (Wuhan)	2015	Lasers Med Sci	**Low-level laser therapy for orthodontic pain: a systematic review.**	Meta-analysis	Pain		PubMed
	Oral	Orthodontics	Shi	China (Beijing)	2015	Head Face Med	**Does low level laser therapy relieve the pain caused by the placement of the orthodontic separators?--A meta-analysis.**	Meta-analysis	Pain		PubMed
	Oral	Orthodontics	Nimeri	USA (Birmingham, AL)	2014	Clin Cosmet Investig Dent	**The effect of photobiomodulation on root resorption during orthodontic treatment.**	Human		"Our results showed that photobiomodulation did not cause root resorption greater than the normal range that is commonly detected in orthodontic treatments."	PubMed
	Oral	Orthodontics	Gkantidis	Switzerland (Bern)	2014	J Dent	**Effectiveness of non-conventional methods for accelerated orthodontic tooth movement: a systematic review and meta-analysis.**	Meta-analysis	Tooth movement		PubMed
	Oral	Orthodontics	Carvalho-Lobato	Spain	2014	Photomed Laser Surg	**Tooth movement in orthodontic treatment with low-level laser therapy: a systematic review of human and animal studies.**	Systematic review	Tooth movement		PubMed
	Oral	Orthodontics	Torri & Weber	Brazil (Porto Alegre)	2013	Photomed Laser Surg	**Influence of low-level laser therapy on the rate of orthodontic movement: a literature review.**	Review	Tooth movement		PubMed
	Oral	Orthodontics	He	China (Chengdu)	2013	Lasers Med Sci	**Efficacy of low-level laser therapy in the management of orthodontic pain: a systematic review and meta-analysis.**	Meta-analysis			PubMed
	Oral	Orthodontics	Kau	USA (Birmingham, AL)	2013	Prog Orthod	**Photobiomodulation accelerates orthodontic alignment in the early phase of treatment.**	Human Multicenter		"Multi-level mixed effect regression analysis was performed on the data, and the mean rate of change in LII was 0.49 and 1.12 mm/week for the control and test groups, respectively."	PubMed

	Oral	Orthodontics	Artés-Ribas	Spain	2013	Lasers Med Sci	**Analgesic effect of a low-level laser therapy (830 nm) in early orthodontic treatment.**	Human RCT	Pain	LLLT decreased pain, compared to placebo.	PubMed
	Oral	Orthodontics	Doshi-Mehta & Bhad-Patil	India (Nagpur)	2012	Am J Orthod Dentofacial Orthop	**Efficacy of low-intensity laser therapy in reducing treatment time and orthodontic pain: a clinical investigation.**	Human		"An average increase of 30% in the rate of tooth movement was observed with the low-intensity laser therapy. Pain scores on the experimental sides were significantly lower compared with the control sides." Comment: An extremely low dose was used according to this paper. In my opinion, that low dose is unlikely to have biological effects. Note: A comment to this paper was published	PubMed
	Oral	Orthodontics	Uysal	Turkey (Kayseri)	2012	Eur J Orthod	**Resonance frequency analysis of orthodontic miniscrews subjected to light-emitting diode photobiomodulation therapy.**	Rabbit	Orthodontic miniscrews to rabbit tibia	"Within the limits of this in vivo study, the present RFA findings suggest that LPT might have a favourable effect on healing and attachment of titanium orthodontic miniscrews."	PubMed
	Oral	Orthodontics	Altan	Turkey (Sivas)	2012	Lasers Med Sci	**Metrical and histological investigation of the effects of low-level laser therapy on orthodontic tooth movement.**	Rat		"No statistical difference was found for the amount of tooth movement in between the control and study groups ($p > 0.05$). The number of osteoclasts, osteoblasts, inflammatory cells, capillary vascularization, and new bone formation were found to be increased significantly in group II ($p < 0.05$). Immunohistochemical staining findings showed that RANKL immunoreactivity was stronger in group II than in the other groups." Group III (the lower-dose LLLT group) didn't seem to have any important benefits.	PubMed
	Oral	Orthodontics	Sousa	Brazil (São Paulo)	2011	Photomed Laser Surg	**Influence of low-level laser on the speed of orthodontic movement.**	Human	Tooth movement	"The diode laser used within the protocol guidelines increased the speed of tooth movement. This might reduce orthodontic treatment time."	PubMed
	Oral	Orthodontics	Gama	Brazil (Salvador, Bahia)	2010	Photomed Laser Surg	**Tooth movement after infrared laser phototherapy: clinical study in rodents.**	Rat		"The results showed no statistically significant difference, $p = 0.079$ (T0-T7), $p = 0.597$ (T7-T13), and $p = 0.550$ (T13-T19) between the laser and control groups on the amount of tooth movement in the different times evaluated. It may be concluded that laser phototherapy, with the parameters in the present study, did not significantly increase the amount of tooth displacement during induced orthodontic movement in rodents."	PubMed
	Oral	Orthodontics	Youssef	Syria (Damascus)	2008	Lasers Med Sci	**The effect of low-level laser therapy during orthodontic movement: a preliminary study.**	Human	Tooth movement Pain	"The velocity of canine movement was significantly greater in the lased group than in the control group. The pain intensity was also at lower level in the lased group than in the control group throughout the retraction period."	PubMed
	Oral	Orthodontics	Limpanichkul	Thailand (Songkhla)	2006	Orthod Craniofac Res	**Effects of low-level laser therapy on the rate of orthodontic tooth movement.**	Human	Tooth movement	"There was no significant difference of means of the canine distal movement between the LLLT side and the placebo side for any time periods (p-value = 0.77)." "The energy density of LLLT (GaAlAs) at the surface level in this study (25 J/cm(2)) was probably too low to express either stimulatory effect or inhibitory effect on the rate of orthodontic tooth movement."	PubMed
	Oral	Orthodontics	Cruz	Brazil (São Paulo)	2004	Lasers Surg Med	**Effects of low-intensity laser therapy on the orthodontic movement velocity of human teeth: a preliminary study.**	Human	Tooth movement	"Our findings suggest that LILT does accelerate human teeth movement and could therefore considerably shorten the whole treatment duration."	PubMed
	Oral	Osteonecrosis	Martins	Brazil (São Paulo)	2012	Oral Oncol	**Association of laser phototherapy with PRP improves healing of bisphosphonate-related osteonecrosis of the jaws in cancer patients: a preliminary study.**	Human		"These results suggest that the association of pharmacological therapy and surgical therapy with PRP plus LPT significantly improves BRONJ healing in oncologic patients. Although prospective studies with larger sample sizes are still needed, this preliminary study may be used to inform a better-designed future study."	PubMed
	Oral	Osteonecrosis	Vescovi	Italy (Parma)	2012	Photomed Laser Surg	**Early surgical laser-assisted management of bisphosphonate-related osteonecrosis of the jaws (BRONJ): a retrospective analysis of 101 treated sites with long-term follow-up.**	Human Retrospective		"Clinical improvement was achieved in 3 out of 12 (25%) BRONJ sites in G1. Sites if G2 with an improvement were 18 out of 27 (66%). (...) For sites in G4, a clinical improvement was recorded in 40 out of 45 cases (89%)." G1 = medical therapy G2 = LLLT G3 = medical + surgical + LLLT	PubMed
	Oral	Osteonecrosis	da Guarda	Brazil (Salvador, Bahia)	2012	Photomed Laser Surg	**Laser GaAlAs (λ860 nm) photobiomodulation for the treatment of bisphosphonate-induced osteonecrosis of the jaw.**	Case report		"Reduction in painful symptoms was reported after the second irradiation session, and tissue healing was complete at the end of the third week following oral curettage. The patient was followed up for 12 months and exhibited good oral health and quality of life."	PubMed
	Oral	Osteonecrosis	Romeo	Italy (Rome)	2011	Photomed Laser Surg	**Observation of pain control in patients with bisphosphonate-induced osteonecrosis using low level laser therapy: preliminary results.**	Human	Pain	"This pilot study suggests that LLLT may be a valid technique to support the treatment of BRONJ-related pain, even though the low number of cases in this study does not permit any conclusive consideration."	PubMed
	Oral	Osteonecrosis	Scoletta	Italy (Turin)	2010	Photomed Laser Surg	**Effect of low-level laser irradiation on bisphosphonate-induced osteonecrosis of the jaws: preliminary results of a prospective study.**	Human		"Four weeks after LLLT, a statistically significant difference was observed for reported pain ($p = 0.0001$), clinical size ($p = 0.0034$), edema ($p = 0.0005$), and presence of pus and fistulas ($p = 0.0078$ and $p = 0.03$, respectively)." "Of course, this needs to be addressed further in larger and randomly controlled studies in different clinical settings."	PubMed
	Oral	Pericoronitis	Sezer	Turkey (Gaziantep)	2012	Photomed Laser Surg	**Effects of low-level laser therapy as an adjunct to standard therapy in acute pericoronitis, and its impact on oral health-related quality of life.**	Human RCT		"The results demonstrate that both the 1064-nm Nd:YAG and the 808-nm diode lasers were effective in improving trismus and OHRQoL in acute pericoronitis. Taking into account the limitations of this study, we conclude that the 1064-nm Nd:YAG laser has biostimulatory effects and improves OHRQoL, making it suitable for LLLT." Note: In this study, 660nm didnt have a beneficial effect.	PubMed
	Oral	Periodontium	Pansani	Brazil (Araraquara)	2017	Lasers Med Sci	**Effects of low-level laser therapy and epidermal growth factor on the activities of gingival fibroblasts obtained from young or elderly individuals.**	In vitro		"Y and E fibroblasts irradiated with laser or exposed to EGF showed increased viability and collagen synthesis. Enhanced cell migration was observed for Y fibroblasts after both treatments, whereas only the LLLT stimulated migration of E cells. VEGF synthesis was higher for Y and E cells exposed to EGF, while this synthesis was reduced when E fibroblasts were irradiated. Increased gene expression of VEGF was observed only for Y and E fibroblasts treated with LLLT." "Regardless of a patient's age, the LLLT and EGF applications can biostimulate gingival fibroblast functions involved in tissue repair."	PubMed

Oral	Periodontium	Alzoman & Diab	Saudi Arabia (Riyadh)	2016	Int J Dent Hyg	**Effect of gallium aluminium arsenide diode laser therapy on Porphyromonas gingivalis in chronic periodontitis: a randomized controlled trial.**	Human RCT		"There were statistically significant improvements in GI, PD, CAL and GBI for the SRP + DL group compared to SRP group but no significant difference in PI between the groups." "Additionally, the percentage of P. gingivalis-positive sites in the SRP + DL group decreased from 80% (12/15) to 20% (3/15) after laser irradiation (P < 0.05). No significant changes were noted in the SRP group."	PubMed
Oral	Periodontium	Kumaresan	India (Chennai)	2016	Eur J Dent	**Gingival crevicular fluid periostin levels in chronic periodontitis patients following nonsurgical periodontal treatment with low-level laser therapy.**	Human Controlled		"Comparison of mean periostin levels between both the treatment groups showed a significant increase in LLLT group than RSD at the 3rd month (P < 0.05)." "Within the limitations of the present study, LLLT application was found to have additional benefits over RSD with respect to clinical periodontal parameters and GCF periostin levels. Moreover, periostin may be used as a possible biomarker to evaluate the outcome following NSPT."	PubMed
Oral	Periodontium	Demirturk-Gocgun	Turkey (Istanbul)	2016 epub	Photomed Laser Surg	**Role of Low-Level Laser Therapy as an Adjunct to Initial Periodontal Treatment in Type 2 Diabetic Patients: A Split-Mouth, Randomized, Controlled Clinical Trial.**	Human split-mouth	Diabetes + chronic periodontitis	"Test sites showed significant improvement in PI and BOP in deep pockets at the 1-month follow-up period (p < 0.001 and <0.001, respectively), whereas no difference was found between the control and the test sites in other periodontal parameters." "LLLT during periodontal treatment offered minimal short-term additional benefit in deep pocket healing in patients with type 2 DM."	PubMed
Oral	Periodontium	Sobouti	Iran (Mazandaran)	2015	J Lasers Med Sci	**The role of low-level laser in periodontal surgeries.**	Review			PubMed
Oral	Periodontium	Qadri	Sweden (Huddinge)	2015	Photomed Laser Surg	**Role of diode lasers (800-980 nm) as adjuncts to scaling and root planing in the treatment of chronic periodontitis: a systematic review.**	Systematic review			PubMed
Oral	Periodontium	Chang	Taiwan (Taipei)	2015	Lasers Med Sci	**Controlling periodontal bone levels with multiple LED irradiations.**	Rat	LED phototherapy	"By day 7, PBL was significantly reduced (p < 0.05), with significantly reduced inflammation (p < 0.05) and gingival hyperplasia (p < 0.001), in the animals receiving three irradiations per week. At day 14, the reduction in gingival hyperplasia was still significant (p < 0.05), and collagen matrix deposition and realignment appeared to be accelerated in the animals receiving three irradiations per week, despite a lack of significant difference in PBL. The treatment regimen receiving three LED light irradiations per week apparently extended the effects in reducing PBL and inflammation to 7 days."	PubMed
Oral	Periodontium	Dukić	Croatia	2013	J Periodontol	**Clinical effectiveness of diode laser therapy as an adjunct to non-surgical periodontal treatment: a randomized clinical study.**	Human split-mouth study	Periodontitis	LLLT provided minimal additional benefits to normal periodontal treatment.	PubMed
Oral	Periodontium	Chang	Singapore	2013	J Periodontal Res	**Irradiation by light-emitting diode light as an adjunct to facilitate healing of experimental periodontitis in vivo.**	Rat	Experimental periodontitis	"Reduction of inflammation, accelerated collagen deposition and realignment was noted following irradiation with LED light at densities of 10 and 15 J/cm2, and temporary reduction of periodontal bone loss, as well as bundle bone apposition, was noted at day 3 in rats treated with 10 J/cm2 light."	PubMed
Oral	Periodontium	Calderin	Spain	2013	Lasers Med Sci	**Short-term clinical and osteoimmunological effects of scaling and root planing complemented by simple or repeated laser phototherapy in chronic periodontitis.**	Human	LED phototherapy Periodontitis	Multiple sessions of LLLT reduced pro-inflammatory mediators and RANKL/OPG ratio.	PubMed
Oral	Periodontium	Makhlouf	Egypt (Cairo)	2012	Photomed Laser Surg	**Effect of adjunctive low level laser therapy (LLLT) on nonsurgical treatment of chronic periodontitis.**	Human Split-mouth DB		"SRP combined with LLLT improved radiographic bone density and short-term PPD reduction in patients with chronic periodontitis, but did not significantly affect either the gingival crevicular fluid of IL-1β or the gingival or plaque index."	PubMed
Oral	Periodontium	Choi	Korea (Gwangju)	2012	Lasers Med Sci	**Inflammatory cytokines are suppressed by light-emitting diode irradiation of P. gingivalis LPS-treated human gingival fibroblasts: inflammatory cytokine changes by LED irradiation.**	In vitro	Inflammation LED phototherapy	"LPS treatment of gingival fibroblasts led to the increased release of the pro-inflammatory-related cytokines interleukin-6 (IL-6) and IL-8, whereas LED irradiation inhibited their release. Analysis of MAPK signal transduction revealed a considerable decrease in p38 phosphorylation in response to 635-nm radiation either in the presence or absence of LPS. In addition, 635-nm LED irradiation significantly promoted JNK phosphorylation in the presence of LPS. LED irradiation can inhibit activation of pro-inflammatory cytokines, mediate the MAPK signaling pathway, and may be clinically useful as an anti-inflammatory tool."	PubMed
Oral	Periodontium	de Paula Eduardo	Brazil (São Paulo)	2010	Lasers Med Sci	**Laser phototherapy in the treatment of periodontal disease. A review.**	Review			PubMed
Oral	Periodontium	Pejcic	Serbia (Nis)	2010	Photomed Laser Surg	**The effects of low level laser irradiation on gingival inflammation.**	Human		"A general conclusion can be drawn that low level laser irradiation (semiconductor, 670 nm) can be used as a successful physical adjuvant method of treatment, which, together with traditional periodontal therapy, leads to better and longer-lasting therapeutic results."	PubMed
Oral	Periodontium	Angelov	USA (CA)	2009	Gen Dent	**Periodontal treatment with a low-level diode laser: clinical findings.**	Human RCT		"These findings suggest that a low-level diode laser can have a beneficial effect for treating inflammatory chronic advanced periodontitis."	PubMed
Oral	Periodontium	Qadri	Sweden (Huddinge)	2007	Lasers Med Sci	**The importance of coherence length in laser phototherapy of gingival inflammation: a pilot study.**	Human Pilot study		"At the follow up examination, all clinical parameters had improved significantly in both groups. A more pronounced decrease of clinical inflammation was observed after HeNe treatment."	PubMed
Oral	Periodontium	Qadri	Sweden (Huddinge)	2005	J Clin Periodontol	**The short-term effects of low-level lasers as adjunct therapy in the treatment of periodontal inflammation.**	Human Split-face		"The clinical variables i.e. probing pocket depth, plaque and gingival indices were reduced more on the laser side than on the placebo one (p<0.01)."	PubMed
Oral	Periodontium	Neiburger EJ	?	1999	J Mass Dent Soc	**Rapid healing of gingival incisions by the helium-neon diode laser.**	Human		"This study concludes that helium-neon diode lasers, at the previously mentioned energy level, increase the rate of gingival wound healing in 69 percent of patients, without any side effects."	PubMed
Oral	Periodontium	Masse	Canada (Québec)	1993	Int Dent J	**Effectiveness of soft laser treatment in periodontal surgery.**	Human placebo controlled		"The results showed no significant differences in the gingival index, healing index and pain reduction when the soft laser treatment was compared to the placebo operation. These results suggest that soft laser (As-Ga and He-Ne) treatments may not be a useful adjunct after certain periodontal surgical procedures." Comment: Tuner&Hode (1998) mention that in this study, the dose was 0.06J/cm2.	PubMed
Oral	Root resorption	Higashi	Brazil (Londrina)	2016	Lasers Med Sci	**Three consecutive days of application of LED therapy is necessary to inhibit experimentally induced root resorption in rats: a microtomographic study.**	Rat		"In conclusion, three daily LED therapy doses are required to inhibit root resorption after appliance of orthodontic forces."	PubMed

	Oral	Safety	Chan	Australia (Sydney)	2014	Laser Ther	**Low-power pulsed Nd:YAG laser irradiation for pre-emptive anaesthesia: A morphological and histological study.**	Human		"Low-power pulsed Nd:YAG laser dose, as used in the clinical trial to induce anaesthesia, does not cause morphological damage to the mineralized tooth structure. Both Laser and EMLA groups showed minor superficial pulpal change following cavity preparation which was not statistically significant. Laser and Control groups minus preparation had no pulpal changes."	PubMed
	Oral	Salivary glands	de Jesus	Brazil (Salvador, Bahia)	2015	Lasers Med Sci	**Influence of laser photobiomodulation (GaAlAs) on salivary flow rate and histomorphometry of the submandibular glands of hypothyroid rats.**	Rat	Hypothyroid rats	"No significant difference was found in the salivary flow of rats that received laser photobiomodulation compared with their control groups. Histological analysis revealed a decrease in the parenchyma of the salivary glands of hypothyroid rats, but the laser was not able to reverse this process. Hypothyroid rats irradiated or not with laser showed acini and acinar cells with significantly smaller areas than euthyroid groups. The laser photobiomodulation protocol used was not able to change salivary flow or reverse the acinar atrophy process in the submandibular glands of hypothyroid rats."	PubMed
	Oral	Salivary glands	Ibuki	Brazil (São Paulo)	2013	Lasers Med Sci	**Laser irradiation affects enzymatic antioxidant system of streptozotocin-induced diabetic rats.**	Rat	Diabetes Antioxidant system	"SOD and CAT activities, as well as [total antioxidant value] were higher in SMG of irradiated diabetic rats. However, in [submandibular salivary gland] of non-diabetic rats, laser irradiation decreased [total antioxidant] values and led to an increase in the CAT activity. In addition, there was a decrease in the activity of CAT in [parotid gland] of diabetic and non-diabetic animals after laser irradiation."	PubMed
	Oral	Stem cells	Marques	Brazil (São Paulo)	2016	Photomed Laser Surg	**Photobiomodulation of Dental Derived Mesenchymal Stem Cells: A Systematic Review.**	Systematic review			PubMed
	Oral	Stem cells	Borzabadi-Farahani A	Italy/UK	2016	J Photochem Photobiol B	**Effect of low-level laser irradiation on proliferation of human dental mesenchymal stem cells; a systemic review.**	Systematic review			PubMed
	Oral	Surgery	Doeuk	France (Créteil)	2015	Br J Oral Maxillofac Surg	**Current indications for low level laser treatment in maxillofacial surgery: a review.**	Review			PubMed
	Oral	Tooth replantation	de Carvalho	Brazil (Salvador, Bahia)	2016	Dent Traumatol	**Evaluation of laser phototherapy (λ 780 nm) after dental replantation in rats.**	Rat		"The use of laser phototherapy on the root surface and at the entrance of the alveolus prior to replantation had a positive biomodulative effect on alveolar repair after tooth replantation in rats."	PubMed
	Oral	Tooth replantation	Matos Fde	Brazil (Aracaju)	2016	Dent Traumatol	**Effect of laser photobiomodulation on the periodontal repair process of replanted teeth.**	Rat		"The LPBM protocol at λ808 nm and λ660 nm as well as whole milk and soy milk favored the periodontal repair process of replanted teeth in rats."	PubMed
	Oral	Tooth replantation	Carvalho	Brazil (Salvador, Bahia)	2016	Dent Traumatol	**Effects of diode laser irradiation and fibroblast growth factor on periodontal healing of replanted teeth after extended extra-oral dry time.**	Rat		"DL, with or without FGF, reduced the occurrence of external root resorption and ankylosis. Periodontal healing was favored and some fiber reinsertion occurred only when FGF was used."	PubMed
	Oral	Tooth replantation	Vilela	Brazil (São Paulo)	2012	Lasers Med Sci	**Histomorphometric analysis of inflammatory response and necrosis in re-implanted central incisor of rats treated with low-level laser therapy.**	Rat		"These results showed that the laser groups developed less root resorption areas than the control group in all experimental periods. Additionally, histological analysis revealed less inflammatory cells and necrotic areas in laser groups."	PubMed
	Oral	Tooth replantation	Carvalho Edos	Brazil (Taubaté)	2012	Dent Traumatol	**Root surface treatment using diode laser in delayed tooth replantation: radiographic and histomorphometric analyses in rats.**	Rat		"Root surface treatments with high-powered diode laser irradiation prior to delayed replantation reduced the occurrence of external root resorption compared to no treatment or sodium fluoride treatment at up to 60 days."	PubMed
★	Oral	Teeth	Arany	USA (Cambridge and Boston, MA)	2014	Sci Transl Med	**Photoactivation of endogenous latent transforming growth factor-β1 directs dental stem cell differentiation for regeneration.**	Mouse	Dentin regeneration Mechanisms Stem cells	"Further, an in vivo pulp capping model in rat teeth demonstrated significant increase in dentin regeneration after LPL treatment. " "These findings indicate a pivotal role for TGF-β in mediating LPL-induced dental tissue regeneration. More broadly, this work outlines a mechanistic basis for harnessing resident stem cells with a light-activated endogenous cue for clinical regenerative applications."	PubMed
	Oral	Tissue engineering	Theocharidou	Greece (Thessaloniki)	2016	Lasers Med Sci	**Odontogenic differentiation and biomineralization potential of dental pulp stem cells inside Mg-based bioceramic scaffolds under low-level laser treatment.**	In vitro	Pulp stem cells Bioceramic scaffolds	"LLLI treatment proved to be beneficial for odontogenic differentiation and biomineralization of DPSCs inside the bioceramic scaffolds, making this therapeutic modality promising for targeted dentin engineering."	PubMed
	Oral	TMJ	Cavalcanti	Brazil (São Paulo)	2016 epub	Photomed Laser Surg	**Comparative Study of the Physiotherapeutic and Drug Protocol and Low-Level Laser Irradiation in the Treatment of Pain Associated With Temporomandibular Dysfunction.**			"Based on obtained data, we concluded that, compared to PDP, LLL treatment is effective to control pain associated with TMD."	PubMed
	Oral	TMJ	Machado	Brazil (Ribeirão Preto)	2016	Lasers Med Sci	**Effects of oral motor exercises and laser therapy on chronic temporomandibular disorders: a randomized study with follow-up.**	Human RCT/SB		"However, LLLT alone was not sufficient for TMD rehabilitation" Seems that LLLT alone didn't outdo placebo treatment. Comment: Parameters were limitedly reported	PubMed
	Oral	TMJ	Chen	China (Chengdu)	2015	J Oral Rehabil	**Efficacy of low-level laser therapy in the treatment of TMDs: a meta-analysis of 14 randomised controlled trials.**	Meta-analysis			PubMed
	Oral	TMJ	Leal de Godoy	Brazil (São Paulo)	2015	J Oral Maxillofac Surg	**Effect of low-level laser therapy on adolescents with temporomandibular disorder: a blind randomized controlled pilot study.**	Human RCT	Insufficient dosage	"No statistically significant differences were found regarding pain, mandibular range of motion, or the distribution of occlusal contacts after treatment with low-level laser therapy." Tuner: "The energy used here is 1 J per point (50 mW x 20 s = 1000 mJ = 1 J). For a muscle, this is far from the therapeutic window and a failure is to be expected. We found 6 J per point effective, but not necessarily optimal(Ahrari et al. 2013), even higher energies are sometimes clincally needed for reasonable results. Muscles are thick and contain a lot of hemoglobin, a major absorber of the light. Irradiation with or without pressure also changes to energy at target. The laser parameters here are well	
	Oral	TMJ	Fornaini	Italy	2015	Laser Ther	**The "at-home LLLT" in temporo-mandibular disorders pain control: a pilot study.**	Human Pilot study		LLLT was more effective than placebo.	PubMed
	Oral	TMJ	Peimani & Sardary	Iran (Rafsanjan)	2014	J Dent (Tehran)	**Effect of low-level laser on healing of temporomandibular joint osteoarthritis in rats.**	Rat		"After three days of treatment the grade of cartilage defects, number of inflammatory cells, angiogenesis, number of cell layers and arthritis in rats in the case group were not significantly different compared with controls (P>0.05). After seven days, the grade of cartilage defects, number of inflammatory cells, number of cell layers, and arthritis in the case group improved compared to controls (P<0.05); angiogenesis in both groups was similar."	PubMed
	Oral	TMJ	Salmos-Brito	Brazil (Recife)	2013	Lasers Med Sci	**Evaluation of low-level laser therapy in patients with acute and chronic temporomandibular disorders.**	Human		"In summary, considering the non-invasive and harmless characteristics of this modality, and the significant improvement obtained in both groups (acute and chronic TMD) in subjective parameters (e.g., pain), as well as, in objective functional parameters (e.g., maximal mouth opening), LLLT may promote some anti-inflammatory effect and pain relief in painful and dysfunctional temporomandibular muscles."	PubMed

	Oral	TMJ	Herranz-Aparicio	Spain	2013	Med Oral Patol Oral Cir Bucal	**The use of low level laser therapy in the treatment of temporomandibular joint disorders. Review of the literature**	Systematic review			PubMed
	Oral	TMJ	Maia	Brazil (Aracaju)	2012	J Appl Oral Sci	**Effect of low-level laser therapy on pain levels in patients with temporomandibular disorders: a systematic review.**	Systematic review			PubMed
	Oral	TMJ	Dostalová	Czech	2012	Photomed Laser Surg	**Effectiveness of physiotherapy and GaAlAs laser in the management of temporomandibular joint disorders.**	Human non-controlled		LLLT appeared to reduce pain a lot, and improve mouth opening. Comment: Interesting results.	PubMed
	Oral	TMJ	Petrucci	Italy (L'Aquila)	2011	J Orofac Pain	**Effectiveness of low-level laser therapy in temporomandibular disorders: a systematic review and meta-analysis.**	Meta-analysis			PubMed
	Oral	TMJ	Carvalho	Brazil (Salvador, Bahia)	2010	Lasers Med Sci	**Wavelength effect in temporomandibular joint pain: a clinical experience.**	Human Retrospective		"At the end of the 12 sessions the patients were again examined, and they scored their pain using the VAS. The results were statistically analyzed and showed that 64% of the patients were asymptomatic or had improved after treatment and that the association of both wavelengths was statistically significant (P = 0.02) in the asymptomatic group. It was concluded that the association of red and infrared (IR) laser light was effective in pain reduction on TMJ disorders of several origins."	PubMed
	Oral	TMJ	Kucuk	Turkey (Istanbul)	2010	J Orofac Pain	**The anti-inflammatory effect of low-level laser therapy on experimentally induced inflammation of rabbit temporomandibular joint retrodiscal tissues.**	Rabbit		"Under the conditions used in this study, quantitative scintigraphic measurements of TMJ inflammation of the treated TMJ group decreased but did not differ significantly from those of the control TMJ group." Jan Tuner: "It is suggested that the lack of effect in the Kucuk paper is due to gross over dosage and subsequent inhibition."	PubMed
	Oral	TMJ	Emshoff	Austria (Innsbruck)	2008	Oral Surg Oral Med Oral Pathol Oral Radiol Endod	**Low-level laser therapy for treatment of temporomandibular joint pain: a double-blind and placebo-controlled trial.**	Human RCT/DB		"The study suggests that LLLT is not better than placebo at reducing TMJ pain during function."	PubMed
	Oral	TMJ	Fikácková	Czech	2007	Photomed Laser Surg	**Effectiveness of low-level laser therapy in temporomandibular joint disorders: a placebo-controlled study.**	Human RCT		LLLT was effective for the pain related to TMD.	PubMed
	Oral	TMJ	Fikácková	Czech	2006	Photomed Laser Surg	**Arthralgia of the temporomandibular joint and low-level laser therapy.**	Human non-controlled		LLLT reduced pain and inflammation (according to tissue temperature).	PubMed
	Oral	Tooth extraction	Pedreira	Brazil (Salvador, Bahia)	2016	Minerva Stomatol	**Thermographic and clinical evaluation of 808-nm laser photobiomodulation effects after third molar extraction.**	Human		"A slight improvement was observed for swelling, pain and trismus in patients who received laser irradiation, although the differences were not statistically significant (P>0.05). Laser therapy had a significant influence on the local circulation in the area near the temporomandibular joint, as determined by infrared thermography (P<0.05)."	PubMed
	Oral	Tooth extraction	Sierra	Brazil (São Paulo)	2016	Lasers Surg Med	**Choosing between intraoral or extraoral, red or infrared laser irradiation after impacted third molar extraction.**	Human	Wisdom tooth	"The intra-group analyses showed that 808 nm laser applied extra-orally favored reductions in postoperative facial swelling and trismus, although the inter-group comparisons revealed no statistically significant differences."	PubMed
	Oral	Tooth extraction	Ribeiro	Brazil (São Paulo)	2016	Oral Surg	**The effect of the low-level laser therapy on healing and pain after tooth extraction: a systematic review**	Systematic review			(Not in Pubmed yet)
	Oral	Tooth extraction	Pol	Italy (Novara)	2016	J Craniofac Surg	**Efficacy of Anti-Inflammatory and Analgesic of Superpulsed Low Level Laser Therapy After Impacted Mandibular Third Molars Extractions.**	Human		"Results indicate that in the treated site SLLLT determines a reduction in pain and swelling statistically significant compared with the control site (P < 0.05). The authors found that the effectiveness of laser therapy is in the first 5 days after surgery, showing a significant reduction of pain and swelling in the treated site than the control site."	PubMed
	Oral	Tooth extraction	Hamad	Iraq (Kurdistan)	2016	J Maxillofac Oral Surg	**Effect of Diode Laser on Healing of Tooth Extraction Socket: An Experimental Study in Rabbits.**	Rabbit		"Diode laser application to tooth extraction socket has a positive effect on bone formation."	PubMed
	Oral	Tooth extraction	Eshghpour	Iran (Mashhad)	2016	J Oral Maxillofac Surg	**Is Low-Level Laser Therapy Effective in the Management of Pain and Swelling After Mandibular Third Molar Surgery?**	Human RCT/DB	Wisdom tooth Combined wavelengths	"Pain level was significantly lower in the laser than in the placebo side at all time points during the experiment (P < .05). Swelling was significantly lower in the laser than in the placebo group on days 2, 4, and 7 after surgery (P < .05)."	PubMed
	Oral	Tooth extraction	Eroglu & Keskin Tunc	Turkey (Van)	2016	Photomed Laser Surg	**Effectiveness of Single Session of Low-Level Laser Therapy with a 940 nm Wavelength Diode Laser on Pain, Swelling, and Trismus After Impacted Third Molar Surgery.**	Human	Wisdom tooth	"There was no statistically significant difference in pain, swelling, or trismus between the sides (Mann-Whitney U test p > 0.05). However, according to the clinical outcomes, swelling and trismus were less in the laser-treated side than in the placebo side."	PubMed
	Oral	Tooth extraction	Elbay	Turkey (Kocaeli)	2016	Photomed Laser Surg	**Efficacy of Low-Level Laser Therapy in the Management of Postoperative Pain in Children After Primary Teeth Extraction: A Randomized Clinical Trial.**	Human RCT/DB	Primary teeth	"Within the limitations of this study, LLLT application following primary molar extraction was not found to affect postoperative pain in children."	PubMed
	Oral	Tooth extraction	Alan	Turkey (Malatya)	2016	Head Face Med	**Evaluation of the effects of the low-level laser therapy on swelling, pain, and trismus after removal of impacted lower third molar.**		Wisdom tooth	"Although there were decreasing trismus, swelling, and pain level, with this LLLT, there was significant difference only in the 7th day pain level in the laser group compared with the control group."	PubMed
	Oral	Tooth extraction	Sierra	Brazil (Bauru)	2015	Br J Oral Maxillofac Surg	**Effect of low-intensity laser treatment on pain after extraction of impacted mandibular third molars: a randomised, controlled, clinical trial.**	Human RCT	Wisdom tooth intraoral vs extraoral	"We conclude that a single session of low intensity laser had no significant effect on the amount of pain under the conditions investigated." Note: Even control group had very low pain levels to begin with, which might explain the lack of success in this study. Comment: Parameters are very nicely reported in a table.	PubMed
☹	Oral	Tooth extraction	Monea	Romania (Târgu Mureș)	2015	BMC Oral Health	**Bone healing after low-level laser application in extraction sockets grafted with allograft material and covered with a resorbable collagen dressing: a pilot histological evaluation.**	Human RCT		"The histological results of the site treated with LLLT for 21 days, harvested at 60 days after grafting showed abundant new bone formation without any sign of inflammation. The same results were obtained in the control group not before 120 days post-surgery." "It can be concluded that LLLT photobiomodulation can reduce the healing time after grafting the extraction socket." Comment: Parameters were poorly reported... Even wavelength was left unmentioned, but the device name (OsseoPulse) was mentioned.	PubMed

	Oral	Tooth extraction	Abdel-Alim	Saudi Arabia (Jeddah)	2015	Photomed Laser Surg	**A Comparative Study of the Effectiveness of Immediate Versus Delayed Photobiomodulation Therapy in Reducing the Severity of Postoperative Inflammatory Complications.**	Human	Immediate LLLT vs delayed LLLT (1 day after operation)	"Eighty patients with horizontally impacted mandibular third molars with no inferior alveolar canal approximation were recruited for this study. They were divided into two groups. The immediate group received PBM therapy immediately after surgery and on the 3rd day postoperatively. Subjects in the delayed group received PBM therapy on the 2nd and 4th days postoperatively. All subjects received 2 min of treatment using a 4 W laser beam, during which 171 J were delivered via a 2.8 cm(2) spot size." "Clinical and statistical results showed a significant reduction in pain, trismus, and swelling in the immediate PBM therapy group compared with the delayed PBM therapy group."	PubMed
	Oral	Tooth extraction	Merigo	Italy	2015	Laser Ther	**Efficacy of LLLT in swelling and pain control after the extraction of lower impacted third molars.**	Human RCT	Wisdom tooth	A strangely written paper, but they claim that LLLT was beneficial.	PubMed
	Oral	Tooth extraction	He	China (Guangzhou)	2015	Lasers Med Sci	**A systematic review and meta-analysis on the efficacy of low-level laser therapy in the management of complication after mandibular third molar surgery.**	Meta-analysis			PubMed
	Oral	Tooth extraction	Kazancioglu	Turkey (Istanbul)	2014	Lasers Med Sci	**Comparison of the influence of ozone and laser therapies on pain, swelling, and trismus following impacted third-molar surgery.**	Human RCT	Wisdom tooth	"The pain level and the number of analgesics tablets taken were lower in the ozonated and LLLT applied groups than in the control group. This study showed that ozone and low power laser therapies had a positive effect on the patients' quality of life. Trismus in the LLLT group was significantly less than in the ozonated and control groups (p = 0.033). Ozone application showed no superiority in regards of postoperative swelling; however, LLLT group had significantly lower postoperative swelling." Note: There seemed to be no placebo group. A comment was published, noting that this might affect the results.	PubMed
	Oral	Tooth extraction	Oliveira Sierra	Brazil (São Paulo)	2013	Trials	**Effect of low-level laser therapy on the post-surgical inflammatory process after third molar removal: study protocol for a double-blind randomized controlled trial.**	Study protocol	Wisdom tooth	"The present study aims to provide a randomized, controlled, double-blind trial to compare four different LLLT parameters in relation to the outcomes of pain, swelling and muscle spasm following surgery for the extraction of impacted third molars and evaluate the effects os surgery on patients' quality os life (QOL)."	PubMed
	Oral	Tooth extraction	Ferrante	Italy	2013	Lasers Med Sci	**Effect of low-level laser therapy after extraction of impacted lower third molars.**	Human RCT (no placebo)	Wisdom tooth	There was much less pain and swelling in LLLT group.	PubMed
	Oral	Tooth extraction	Batinjan	Croatia	2013	J Lasers Med Sci	**Assessing Health-Related Quality of Life with Antimicrobial Photodynamic Therapy (APDT) and Low Level Laser Therapy (LLLT) after Third Molar Removal.**	Human	Wisdom tooth PDT + LLLT	PDT+LLLT seemed to have some mild beneficial effects.	PubMed
	Oral	Tooth extraction	López-Ramírez	Spain (Barcelona)	2012	Lasers Med Sci	**Efficacy of low-level laser therapy in the management of pain, facial swelling, and postoperative trismus after a lower third molar extraction. A preliminary study.**	Human RCT/DB	Wisdom tooth	"The application of a low-level laser with the parameters used in this study did not show beneficial affects in reducing pain, swelling, and trismus after removal of impacted lower third molars."	PubMed
	Oral	Tooth extraction	Brignardello-Petersen	Canada (Toronto)	2012	J Oral Maxillofac Surg	**Is adjuvant laser therapy effective for preventing pain, swelling, and trismus after surgical removal of impacted mandibular third molars? A systematic review and meta-analysis.**	Meta-analysis			PubMed
	Oral	Tooth extraction	Park & Kang	Korea (Seoul)	2012	Lasers Med Sci	**Effect of 980-nm GaAlAs diode laser irradiation on healing of extraction sockets in streptozotocin-induced diabetic rats: a pilot study.**	Rat	Diabetic rats	"Histological observations and gene expression analyses revealed that groups 2 (normal rats with LLLT) and 4 (diabetic rats with LLLT) showed faster initial healing and more new alveolar bone formation than group 1 (normal rats without LLLT) and group 3 (diabetic rats without LLLT), respectively."	PubMed
	Oral	Tooth extraction	Aras & Güngörmüş	Turkey (Gaziantep)	2010	Lasers Med Sci	**Placebo-controlled randomized clinical trial of the effect two different low-level laser therapies (LLLT)--intraoral and extraoral--on trismus and facial swelling following surgical extraction of the lower third molar.**	Human RCT	Wisdom tooth	"This study demonstrates that extraoral LLLT is more effective than intraoral LLLT for the reduction of postoperative trismus and swelling after extraction of the lower third molar."	PubMed
☹	Oral	Tooth extraction	Amarillas-Escobar	Mexico (San Luis Potosí)	2010	J Oral Maxillofac Surg	**Use of therapeutic laser after surgical removal of impacted lower third molars.**	Human RCT/DB	Wisdom tooth Intraoral+Extraoral	"The experimental group exhibited a lower intensity of postoperative pain, swelling, and trismus than the control group, without significant statistical differences." Comment: Parameters were poorly reported.	PubMed
☎	Oral	Tooth extraction	Marković & Todorović	Serbia (Belgrade)	2007	Int J Oral Maxillofac Surg.	**Effectiveness of dexamethasone and low-power laser in minimizing oedema after third molar surgery: a clinical trial.**	Human	Wisdom tooth	"LPL irradiation with local use of dexamethasone (group 2) resulted in a statistically significant reduction of postoperative oedema in comparison to the other groups. No adverse effects of the procedure or medication were observed." Comment: A good photograph of the LLLT treatment was supplied. Comment: Parameters were quite poorly reported.	PubMed
	Oral	Tooth extraction	Marković & Todorović	Serbia (Belgrade)	2006	Oral Surg Oral Med Oral Pathol Oral Radiol Endod	**Postoperative analgesia after lower third molar surgery: contribution of the use of long-acting local anesthetics, low-power laser, and diclofenac.**	Human LLLT+diclo	Wisdom tooth Postoperative analgesia	"In the second part of the study, low-power laser irradiation significantly reduced postoperative pain intensity in patients premedicated with diclofenac, compared with the controls."	PubMed
	Oral	Tooth extraction	Freitas	Brazil (Porto Alegre)	2001	Braz Dent J	**Assessment of anti-inflammatory effect of 830nm laser light using C-reactive protein levels.**	Human		"CRP values were more symmetric and better distributed for the irradiated group (0.320 mg/dl) than for the control (0.862.mg/dl) 48 h after surgery, however there was no statistically significant difference. After 72 h, both groups had statistically similar CRP levels (0.272 and 0.608 mg/dl), because of the normal tendency of decreasing CRP levels."	PubMed
	Oral	Tooth extraction	Braams	Netherlands	1994	Ned Tijdschr Tandheelkd	**[Treatment with soft laser. The effect on complaints after the removal of wisdom teeth in the mandible]. [Article in Dutch]**	Human	Wisdom tooth	"The results of this study show that therapeutic low level laser treatment could not statistically reduce the postoperative pain, swelling, trismus and function impairment after extraction of lower third molars."	PubMed
	Oral	Tooth extraction	Røynesdal	Norway (Oslo)	1993	Int J Oral Maxillofac Surg	**The effect of soft-laser application on postoperative pain and swelling. A double-blind, crossover study.**	Human Crossover, DB	Wisdom tooth	"No statistically significant differences were observed in comparison of the experimental side with the placebo side."	PubMed
	Oral	Tooth extraction	Fernando	UK (Cardiff)	1993	Br J Oral Maxillofac Surg	**A randomised double blind comparative study of low level laser therapy following surgical extraction of lower third molar teeth.**	Human RCT/DB		"The results showed that there was no evidence of a difference in pain and swelling on the third day after operation between laser and placebo sides. There was no difference between the two sides when they were assessed for healing 7 days after surgery."	PubMed

Oral	Tooth extraction	Carrillo	Spain (Madrid)	1990	Int Dent J	**A randomized double-blind clinical trial on the effectiveness of helium-neon laser in the prevention of pain, swelling and trismus after removal of impacted third molars.**	Human RCT/DB	Wisdom tooth	"The effect of helium-neon (He-Ne) laser on the prevention of pain, swelling and trismus following the removal of an impacted third molar was studied in 100 patients randomly allocated to receive He-Ne laser, ibuprofen or placebo in a prospective double-blind parallel clinical trial. Trismus was significantly reduced in the He-Ne laser and ibuprofen treatment groups. Pain was significantly less in the ibuprofen group with regard to He-Ne laser and placebo groups. Swelling was the same in the three treatment groups."	PubMed
Oral	Ulcers	Cabras	Italy (Turin)	2016	Case Rep Dent	**Laser Photobiomodulation for a Complex Patient with Severe Hydroxyurea-Induced Oral Ulcerations.**	Human Case report		"In this case report laser photobiomodulation has achieved pain control and has contributed to the healing of oral ulcers without any adverse effect; this has permitted a reduction in the dose of systemic corticosteroids and the suspension of the use of the topic ones, due to the long-term stability of oral health, even after the interruption of LLLT sessions."	PubMed
Oral	Uncategorized (dental)	Ramalho	Brazil (São Paulo)	2014	Case Rep Dent	**Lasers in esthetic dentistry: soft tissue photobiomodulation, hard tissue decontamination, and ceramics conditioning.**	Human Case report		"Three different laser wavelengths were applied throughout the treatment with different purposes: Nd:YAG laser (1,064 nm) for dentin decontamination, diode (660 nm) for soft tissue biomodulation, and Er:YAG laser (2,940 nm) for inner ceramic surface conditioning. Lasers were successfully applied in the present case report as coadjutant in the treatment."	PubMed
Oral	Wound healing: palatal wounds	Keskiner	Turkey (Samsun)	2016	Photomed Laser Surg	**Effect of Photobiomodulation on Transforming Growth Factor-β1, Platelet-Derived Growth Factor-BB, and Interleukin-8 Release in Palatal Wounds After Free Gingival Graft Harvesting: A Randomized Clinical Studv.**	Human RCT		"Observed increases in PWF TGF-β1, PDGF-BB, and IL-8 levels suggest that PBM may accelerate wound healing by stimulating production of selected mediators."	PubMed
Oral	Wound healing	Wagner	Brazil (Porto Alegre)	2016	Lasers Med Sci	**Photobiomodulation regulates cytokine release and new blood vessel formation during oral wound healing in rats.**	Rat		"PBM increased the tissue levels of IL-1β at the early stage of oral wound healing ($p < 0.01$) and increased the tissue levels of TNF-α during all stages of oral wound healing ($p < 0.05$). PBM at a dose of 4 J/cm(2) produced more significant results regarding cytokine modulation and was associated with higher MVD at day 5. Collectively, these findings indicate that cytokine modulation and increased angiogenesis are among the basic mechanisms whereby PBM improves oral wound repair."	PubMed
Oral	Wound healing	Khan & Arany	USA (Bethesda, MD)	2015	Adv Wound Care (New Rochelle)	**Biophysical Approaches for Oral Wound Healing: Emphasis on Photobiomodulation.**	Review	Mechanisms		PubMed
Other	Editorial	Abrahamse H	South Africa (Johannesburg)	2016	Photomed Laser Surg	**Photobiomodulation: An Accepted Therapeutic Modality?**		Editorial		PubMed
Other	Editorial	Lanzafame RJ	USA (Rochester, NY)	2015	Photomed Laser Surg	**Janusian peregrinations and progress.**		Editorial		PubMed
Other	Editorial	Brugnera Junior & Bagnato	Brazil (São Paulo)	2015	Photomed Laser Surg	**Biophotonics and the life sciences.**		Guest Editorial		PubMed
Other	Editorial	Bjordal JM	Norway (Bergen)	2015	Photomed Laser Surg	**Evidence-Based Medicine Turned Upside Down.**		Guest Editorial		PubMed
Other	Editorial	Anders JJ	USA (Bethesda, MD)	2015	Photomed Laser Surg	**The International Year of Light: Celebrate and Educate.**		Guest Editorial		PubMed
Other	Editorial	Trelles MA	Spain (Tarragona)	2014	Photomed Laser Surg	**Scientific rigor and strategic vision are the key points for going forward in photomedicine.**	Guest Editorial			PubMed
Other	Editorial	Robinson NG	USA (Fort Collins, CO)	2014	Photomed Laser Surg	**Laser acupuncture: keep it scientific.**		Guest Editorial		PubMed
Other	Editorial	Liu & Kang	China (Guangzhou)	2014	Photomed Laser Surg	**Functional photobiomodulation.**		Guest Editorial		PubMed
Other	Editorial	Lanzafame RJ	USA (Rochester, NY)	2014	Photomed Laser Surg	**One man's light: mechanistic convergence of photobiomodulation and biological effects.**		Editorial		PubMed
Other	Editorial	Choy DS	USA (New York, NY)	2014	Photomed Laser Surg	**History of lasers in medicine.**		Editorial		PubMed
Other	Editorial	Karu TI	Russia (Troitsk)	2013	Photomed Laser Surg	**Is it time to consider photobiomodulation as a drug equivalent?**		Guest Editorial		PubMed
Other	Editorial	Lanzafame RJ	USA (Rochester, NY)	2013	Photomed Laser Surg	**Photobiomodulation: an enlightened path emerges.**	Editorial			PubMed
Other	Editorial	Lanzafame RJ	USA (Rochester, NY)	2012	Photomed Laser Surg	**Minding the mind in photobiomodulation: it matters!**	Editorial	Nocebo		PubMed
Other	Editorial	Lanzafame RJ	Brazil (São Paulo)	2011	Photomed Laser Surg	**Photobiomodulation, tissue effects and bystanders.**		Editorial		PubMed
Other	Editorial	Hamblin MR		2010	Lasers Surg Med	**Introduction to experimental and clinical studies using low-level laser (light) therapy (LLLT).**		Editorial		PubMed
Other	Hypothesis	Mathewson I	Australia (Brisbane)	2015	Med Hypotheses	**Did human hairlessness allow natural photobiomodulation 2 million years ago and enable photobiomodulation therapy today? This can explain the rapid expansion of our genus's brain.**				PubMed
Pancreas	Regeneration	Huang	China (Guangzhou)	2015	J Cell Biochem	**Photoactivation of Akt1/GSK3β Isoform-Specific Signaling Axis Promotes Pancreatic β-Cell Regeneration.**		Dose response	"In the present study, we showed that LPLI promoted β-cell replication and cell cycle progression through activation of Akt1/GSK3β isoform-specific signaling axis. Inhibition of PI3-K/Akt or GSK3 with specific inhibitors dramatically reduced or increased LPLI-induced β-cell replication, revealing Akt/GSK3 signaling axis was involved in β-cell replication and survival upon LPLI treatment."	PubMed
Pancreas	Function	Irani	Iran (Tehran)	2009	Transplant Proc	**Effect of low-level laser irradiation on in vitro function of pancreatic islets.**	In vitro		"These findings suggest that low-level laser irradiations improved islet cell function before transplantation."	PubMed
Pain	Acute	Bjordal	Norway (Bergen)	2006	Photomed Laser Surg	**Low-level laser therapy in acute pain: a systematic review of possible mechanisms of action and clinical effects in randomized placebo-controlled trials.**	Systematic review			PubMed

	Pain	Allodynia	Hsieh	Taiwan (Taichung)	2016	Support Care Cancer	**Low-level laser therapy alleviates mechanical and cold allodynia induced by oxaliplatin administration in rats.**	Rat		"LLLT relieved both cold and mechanical allodynia induced by oxaliplatin in rats. Oxaliplatin-related increases in protein levels of NGF and TRPM8 in DRG and SP in the dorsal horn were also reduced after LLLT." "The findings of this study support LLLT as a potential treatment for oxaliplatin-induced neuropathy. Moreover, our findings suggest that SP, TRPM8, and NGF proteins in the superficial dorsal horn and DRG may be involved in an antiallodynic effect for LLLT."	PubMed
	Pain	Analgesia	Meireles	Brazil (Cascavel)	2012	Rev Dor	**Role of endogenous opioids in 820 nm low power laser analgesia in the knees of Wistar rats**	Rat		"Our study has observed that low power 820 nm laser analgesic effect has suffered significant interference and was antagonized by naloxone. To justify such effect, it is inferred that the group receiving naloxone and low power laser association has maintained pain in intra-group comparison for the third evaluation moment. It is then believed that laser might have induced endogenous opioids production and release by blood cells15, thus explaining our results."	SciELO
	Pain	Analgesia	Hagiwara	Japan (Yufu)	2008	Anesth Analg	**Pre-Irradiation of blood by gallium aluminum arsenide (830 nm) low-level laser enhances peripheral endogenous opioid analgesia in rats.**	Rat	Endogenous opioids Systemic effects	"These findings suggest that that LLLT pretreatment of blood induces analgesia in rats by enhancing peripheral endogenous opioid production, in addition to previously reported mechanisms."	PubMed
	Pain	Analgesia	Hagiwara	Japan (Yufu)	2007	Lasers Surg Med	**GaAlAs (830 nm) low-level laser enhances peripheral endogenous opioid analgesia in rats.**	Rat	Endogenous opioids Systemic effects	"LLLT produced an analgesic effect in inflamed peripheral tissue which was transiently antagonized by naloxone. Beta-endorphin precursor mRNA expression increased with LLLT, both in vivo and in vitro."	PubMed
★	Pain	Back pain	Holanda	Brazil (São Paulo)	2016	Lasers Surg Med	**Photobiomodulation of the dorsal root ganglion for the treatment of low back pain: A pilot study.**	Human Comparison trial	LLLT vs lidocaine PBM of dorsal root ganglion (DRG) Photon Lase III® DCM, Brazil	"All patients in the local anesthetic and laser treatment groups reported a pain reduction of at least 50% immediately post-procedure and 10 out of 11 patients in the radiofrequency group reported a pain reduction of at least 50%. At 1 month post-treatment, the laser treatment group had the greatest number of patients who reported more than 50% pain relief based on PRS (7 out of 10 patients) while only 2 out of 7 patients and 3 out of 11 patients in the lidocaine and radiofrequency treatment groups respectively reported more than a 50% pain relief." "Laser irradiation caused an immediate decrease in low back pain post-procedure similar to pain reduction caused by lidocaine injection."	PubMed
	Pain	Back pain	Glazov	Australia	2016	Acupunct Med	**Low-level laser therapy for chronic non-specific low back pain: a meta-analysis of randomised controlled trials.**	Meta-analysis			PubMed
	Pain	Back pain	Huang	China (Chengdu)	2015	Arthritis Res Ther	**The effectiveness of low-level laser therapy for nonspecific chronic low back pain: a systematic review and meta-analysis.**	Meta-analysis			PubMed
	Pain	Back pain	Vallone	Italy (Genoa)	2014	Photomed Laser Surg	**Effect of diode laser in the treatment of patients with nonspecific chronic low back pain: a randomized controlled trial.**	Human RCT		"At the end of the 3 week period, the Laser+EX group showed a significantly greater decrease in pain than did the EX group. There was a significant difference between the two groups, with average Δ VAS scores of 3.96 (Laser+EX group) and 2.23 (EX group)." Comment: One of the rare studies with a large spot size!	PubMed
	Pain	Back pain	Glazov	Australia (Crawley)	2014	Acupunct Med	**Low-dose laser acupuncture for non-specific chronic low back pain: a double-blind randomised controlled trial.**	Human RCT/DB	Laser acupuncture	"The analysis showed no difference between sham and the laser groups at 6 weeks for pain or disability."	PubMed
	Pain	Back pain	Alayat	Egypt (Cairo)	2014	Lasers Med Sci	**Long-term effect of high-intensity laser therapy in the treatment of patients with chronic low back pain: a randomized blinded placebo-controlled trial.**	Human RCT/DB (?)		"HILT combined with exercise appears to be more effective in patients with CLBP than either HLLT alone or placebo laser with exercise."	PubMed
☹	Pain	Back pain	Lin	Taiwan (Taipei)	2012	Evid Based Complement Alternat Med	**Evaluation of the effect of laser acupuncture and cupping with ryodoraku and visual analog scale on low back pain.**	Human RCT/DB	Laser acupuncture	No difference between active laser and placebo. Note: The anatomical site of irradiation was leg, not back...	PubMed
	Pain	Back pain	Konstantinovic	Serbia (Belgrade)	2010	Photomed Laser Surg	**Acute low back pain with radiculopathy: a double-blind, randomized, placebo-controlled study.**	Human RCT/DB	Radiculopathy	"Statistically significant differences were found in all outcomes measured ($p < 0.001$), but were larger in [LLLT group] than in [nimesulide group] ($p < 0.0005$) and [nimesulide + sham-LLLT group] ($p < 0.0005$). The results in [nimesulide + sham-LLLT group] were better than in [nimesulide group] ($p <$ 0.0005)."	PubMed
	Pain	Back pain	Ay	Turkey (Ankara)	2010	Clin Rheumatol	**Is low-level laser therapy effective in acute or chronic low back pain?**	Human RCT/DB		"no significant differences were detected between four treatment groups with respect to all outcome parameters ($p > 0.05$)"	PubMed
	Pain	Back pain	Glazov	Australia (Perth)	2009	Acupunct Med	**Laser acupuncture for chronic non-specific low back pain: a controlled clinical trial.**	Human RCT/DB	Laser acupuncture	"This study did not show a specific effect for LA using infrared laser at 0.2 Joules per point for chronic low back pain."	PubMed
	Pain	Back pain	Yousefi-Nooraie	Iran (Tehran)	2008	Cochrane Database Syst Rev	**Low level laser therapy for nonspecific low-back pain.**	Meta-analysis			PubMed
	Pain	Back pain	Djavid	Iran	2007	Aust J Physiother	**In chronic low back pain, low level laser therapy combined with exercise is more beneficial than exercise alone in the long term: a randomised trial.**	Human RCT/DB (?)		"in the laser therapy plus exercise group pain had reduced by 1.8 cm (95% CI 0.1 to 3.3, $p = 0.03$), lumbar range of movement increased by 0.9 cm (95% CI 0.2 to 1.8, $p < 0.01$) on the Schober Test and by 15 deg (95% CI 5 to 25, $p < 0.01$) of active flexion, and disability reduced by 9.4 points (95% CI 2.7 to 16.0, $p = 0.03$) more than in the exercise group at 12 weeks."	PubMed
	Pain	Back pain	Gur	Turkey (Diyarbakir)	2003	Lasers Surg Med	**Efficacy of low power laser therapy and exercise on pain and functions in chronic low back pain.**	Human	(no control group)	"Low power laser therapy seemed to be an effective method in reducing pain and functional disability in the therapy of chronic LBP."	PubMed
	Pain	Back pain	Basford	USA (Rochester, MN)	1999	Arch Phys Med Rehabil	**Laser therapy: a randomized, controlled trial of the effects of low-intensity Nd:YAG laser irradiation on musculoskeletal back pain.**	Human RCT/DB		"Treatment with low-intensity 1.06 microm laser irradiation produced a moderate reduction in pain and improvement in function in patients with musculoskeletal low back pain. Benefits, however, were limited and decreased with time."	PubMed
	Pain	Back pain	Klein & Eek	USA (Santa Barbara, CA)	1990	Arch Phys Med Rehabil	**Low-energy laser treatment and exercise for chronic low back pain: double-blind controlled trial.**			"There were significant improvements in objective parameters in both the laser and placebo groups, but no relative advantage accrued to either group. Under the conditions of this study, low-energy laser stimulation plus exercise did not provide a significant advantage over exercise alone." Note: According to Tuner&Hode 1998, the power density was 0.1 J/cm2 instead of the stated 1-3 J/cm2	PubMed

Pain	Hyperalgesia	Martins	Brazil (Palhoça)	2016	Neuroscience	**Light-emitting diode therapy reduces persistent inflammatory pain: Role of interleukin 10 and antioxidant enzymes.**	Mouse	Chronic inflammatory hyperalgesia induced by Complete Freund's Adjuvant (CFA) LED phototherapy Dose response	"LEDT inhibited mechanical and thermal hyperalgesia induced by CFA injection. LEDT did not reduce paw edema, neither influenced the levels of TNF-α and IL1-β; although it increased the levels of IL-10. LEDT significantly prevented TBARS increase in both acute and chronic phases post-CFA injection; whereas protein carbonyl levels were reduced only in the acute phase. LEDT induced an increase in both SOD and CAT activity, with effects observable in the acute but not in the chronic. And finally, pre-administration of naloxone or fucoidin prevented LEDT analgesic effect."	PubMed
Pain	Hyperalgesia	Nadur-Andrade	Brazil (São Paulo)	2016	PLoS Negl Trop Dis	**Analgesic Effect of Photobiomodulation on Bothrops Moojeni Venom-Induced Hyperalgesia: A Mechanism Dependent on Neuronal Inhibition, Cytokines and Kinin Receptors Modulation.**	Mouse	Hyperalgesia induced by snake poison	"These data demonstrate that LLLT interferes with mechanisms involved in nociception and hyperalgesia and modulates Bmv-induced nociceptive signal. The use of photobiomodulation in reducing local pain induced by Bothropic venoms should be considered as a novel therapeutic tool for the treatment of local symptoms induced after bothropic snakebites."	PubMed
Pain	Hyperalgesia	Nadur-Andrade	Brazil (São Paulo)	2014	Photochem Photobiol	**Analgesic Effect of Light-Emitting Diode (LED) Therapy at Wavelengths of 635 and 945 nm on Bothrops moojeni Venom-Induced Hyperalgesia.**	Mouse		"Both 635 nm and 945 nm LED inhibited mechanical allodynia and hyperalgesia of mice alone or in combination with antivenom treatment, even when the symptoms were already present."	PubMed
Pain	Mechanisms	Chow & Armati	Australia (Sydney)	2016	Photomed Laser Surg	**Photobiomodulation: Implications for Anesthesia and Pain Relief.**	Review			PubMed
Pain	Mechanisms	Chow	Australia (Sydney)	2007	J Peripher Nerv Syst	**830 nm laser irradiation induces varicosity formation, reduces mitochondrial membrane potential and blocks fast axonal flow in small and medium diameter rat dorsal root ganglion neurons: implications for the analgesic effects of 830 nm laser.**	In vitro	Analgesia	"Photoacceptors in the mitochondrial membrane absorb laser and mediate the transduction of laser energy into electrochemical changes, initiating a secondary cascade of intracellular events. In neurons, this results in a decrease in MMP with a concurrent decrease in available ATP required for nerve function, including maintenance of microtubules and molecular motors, dyneins and kinesins, responsible for fast axonal flow. Laser-induced neural blockade is a consequence of such changes and provide a mechanism for a neural basis of laser-induced pain relief." "The repeated application of laser in a clinical setting modulates nociception and reduces pain. The application of laser therapy for chronic pain may provide a non-drug alternative for the management of chronic pain." [See additional info]	PubMed
Pain	Mechanisms	Bjordal	Norway (Bergen)	2006	Photomed Laser Surg	**Low-level laser therapy in acute pain: a systematic review of possible mechanisms of action and clinical effects in randomized placebo-controlled trials.**	Systematic review			PubMed
Pain	Myofascial	Hsieh	Taiwan (Taichung)	2015	Lasers Med Sci	**Fluence-dependent effects of low-level laser therapy in myofascial trigger spots on modulation of biochemicals associated with pain in a rabbit model.**	Rabbit		"LLLT irradiation with fluences of 4.5 and 27 J/cm(2) at [myofascial trigger points] can significantly reduce SP level in [dorsal root ganglion]. LLLT with lower fluence of 4.5 J/cm(2) exerted lower levels of TNF-α and COX-2 expression in laser-treated muscle, but LLLT with higher fluence of 27 J/cm(2) elevated the levels of [β-endorphin] in serum, [dorsal root ganglion], and muscle."	PubMed
Pain	Myofascial	Manca	Italy	2014	Physiother Res Int	**Ultrasound and laser as stand-alone therapies for myofascial trigger points: a randomized, double-blind, placebo-controlled study.**	Human RCT	Pain (trigger points)	LLLT+ultrasound was not better than placebo. LLLT and placebo were better than control (no treatment). Note: In the PubMed Commons, there is some discussion between Jan Tunér and the study author Andrea Manca	PubMed
Pain	Myofascial	Simunovic Z	Switzerland	1996	J Clin Laser Med Surg	**Low level laser therapy with trigger points technique: a clinical study on 243 patients.**	Human Retrospective	Biphasic dose response	"Results measured according to VAS/VRS/PTM: in acute pain, diminished more than 70%; in chronic pain more than 60%. Clinical effectiveness (success or failure) depends on the correctly applied energy dose--over/underdosage produces opposite, negative effects on cellular metabolism. We did not observe any negative effects on the human body and the use of analgesic drugs could be reduced or completely excluded. LLLT suggests that the laser beam can be used as monotherapy or as a supplementary treatment to other therapeutic procedures for pain treatment."	PubMed
Pain	Myofascial	Airaksinen	Finland	1989	Acupunct Electrother Res	**Effects of the infrared laser therapy at treated and non-treated trigger points**	Human RCT, crossover	Trigger point pain	"Our research study results suggest that infrared laser had an effect at the trigger points and that the treatment significantly increased the pain threshold."	IngentaConnect
Pain	Neck	Wong	Canada	2016	Spine J	**Are manual therapies, passive physical modalities, or acupuncture effective for the management of patients with whiplash-associated disorders or neck pain and associated disorders? An update of the Bone and Joint Decade Task Force on Neck Pain and Its Associated Disorders by the OPTIMa collaboration.**	Systematic review			PubMed
Pain	Neck	Kadhim-Saleh	Canada (Ottawa)	2013	Rheumatol Int	**Is low-level laser therapy in relieving neck pain effective? Systematic review and meta-analysis.**	Meta-analysis			PubMed
Pain	Neck	Swedish Council on Health Technology Assessment (SBU)	Sweden	2014	Swedish Council on Health Technology Assessment (SBU)	**Laser Treatment of Neck Pain [Internet].**	Systematic review			PubMed
Pain	Neck	Gross	Canada (Hamilton)	2013	Open Orthop J	**Low Level Laser Therapy (LLLT) for Neck Pain: A Systematic Review and Meta-Regression.**	Systematic review			PubMed
Pain	Neck	Konstantinovic	Serbia (Belgrade)	2010	Pain Med	**Low-level laser therapy for acute neck pain with radiculopathy: a double-blind placebo-controlled randomized study.**	Human RCT/DB		"LLLT gave more effective short-term relief of arm pain and increased range of neck extension in patients with acute neck pain with radiculopathy in comparison to the placebo procedure."	PubMed
Pain	Neck	Chow	Australia	2009	Lancet	**Efficacy of low-level laser therapy in the management of neck pain: a systematic review and meta-analysis of randomised placebo or active-treatment controlled trials.**	Meta-analysis	Chronic neck pain		PubMed

	Pain	Neck	Chow	Australia (Sydney)	2006	Pain	**The effect of 300 mW, 830 nm laser on chronic neck pain: a double-blind, randomized, placebo-controlled study.**	Human RCT/DB		"Low-level laser therapy (LLLT), at the parameters used in this study, was efficacious in providing pain relief for patients with chronic neck pain over a period of 3 months." Editorial notes: "Although patients were randomly assigned to the laser group and placebo group, there was a substantial imbalance of baseline pain scores between the groups (i.e. a difference of 1.9 on a 10-points scale)."	PubMed
	Pain	Neck	Chow & Barnsley	Australia (Sydney)	2005	Lasers Surg Med	**Systematic review of the literature of low-level laser therapy (LLLT) in the management of neck pain.**	Systematic review			PubMed
	Pain	Neuropathic	Holanda	Brazil (São Paulo)	2017 epub	Lasers Surg Med	**The mechanistic basis for photobiomodulation therapy of neuropathic pain by near infrared laser light.**	Rat + in vitro	Spared nerve injury surgery (SNI)	↓heat hyperalgesia, ↓cold allodynia, ↓mechanical hyperalgesia "Of clinical relevance is the duration of the effect. As demonstrated, even after 21 days, the laser treated group showed less sensitivity to the heat stimulus compared to control group. For cold allodynia and mechanical hyperalgesia, the duration of the effect was 5 days"	PubMed
★	Pain	Neuropathic	Kobiela Ketz	Germany (Landstuhl)	2016 epub	Pain Med	**Characterization of Macrophage/Microglial Activation and Effect of Photobiomodulation in the Spared Nerve Injury Model of Neuropathic Pain.**		Irradiation of affected hind paw + dorsal root ganglia + spinal cord regions Microglia (M2 activation by LLLT)	"Injured groups demonstrated mechanical hypersensitivity 1-30 days post-operatively. Photobiomodulation-treated animals began to recover after two treatments; at day 26, mechanical sensitivity reached baseline." "Peripheral nerve injury caused region-specific macrophages/microglia activation along spinothalamic and dorsal-column medial lemniscus pathways. A pro-inflammatory microglial marker was expressed in the spinal cord of injured rats compared to photobiomodulation-treated and sham group." "Photobiomodulation-treated dorsal root ganglion macrophages expressed anti-inflammatory markers." "Photobiomodulation effectively reduced mechanical hypersensitivity, potentially through modulating macrophage/microglial activation to an anti-inflammatory phenotype."	PubMed
★	Pain	Neuropathic	Oliveira	Brazil (São Paulo)	2016 epub	Photochem Photobiol Sci	**Low Level Laser Therapy alters satellite glial cell expression and reverses nociceptive behavior in rats with neuropathic pain**	Rat	Chronic constriction injury	↓IL-1β, ↓CX3CL1, ↓gliosis of DRG, ↓hyperalgesia "These data provide evidence that LLLT reverses CCI-induced behavioral hypersensitivity, reduces glial cell activation in the DRG and decrease pro-inflammatory cytokines; we suggest that this involvement of glial cells can be one potential mechanism in such effect."	RSC
	Pain	Neuropathic	Janzadeh	Iran (Tehran)	2016	Lasers Med Sci	**Photobiomodulation therapy reduces apoptotic factors and increases glutathione levels in a neuropathic pain model.**	Rat	Chronic constriction injury	"CCI decreased the pain threshold, 2-week photobiomodulation therapy significantly increased mechanical and thermal threshold, decreased P2X3 expression ($p < 0.001$), and increased bcl2 expression ($p < 0.01$), but it was not effective on the Bax expression. We speculated that although photobiomodulation therapy increased ROS generation, it increased antioxidants such as GSH."	PubMed
	Pain	Neuropathic	Masoumipoor	Iran (Tehran)	2014	Lasers Med Sci	**Effects of 660- and 980-nm low-level laser therapy on neuropathic pain relief following chronic constriction injury in rat sciatic nerve.**	Rat	Chronic constriction injury	"CCI decreased the pain threshold, whereas both wavelengths of LLLT for 2 weeks increased mechanical and thermal threshold significantly." "Based on our findings, the laser with a 660-nm wavelength had better therapeutic effects than the laser with a 980-nm wavelength, so the former one may be used for clinical application in neuropathic cases; however, it needs more future studies."	PubMed
	Pain	Nociception	Chow	Australia (Sydney)	2011	Photomed Laser Surg	**Inhibitory effects of laser irradiation on peripheral mammalian nerves and relevance to analgesic effects: a systematic review.**	Systematic review			PubMed
	Pain	Nociception	Laakso & Cabot	Australia (Gold Coast)	2005	Photomed Laser Surg	**Nociceptive scores and endorphin-containing cells reduced by low-level laser therapy (LLLT) in inflamed paws of Wistar rat.**	Rat	Dose response (?)	"A dose of 1 J/cm(2) had no statistically significant effect on antinociceptive responses. A dose of 2.5 J/cm(2) demonstrated a statistically significant effect on paw pressure threshold ($p < 0.029$) compared to controls. There was no difference in paw thermal threshold responses and paw volumes at either dose."	PubMed
★	Pain	Postoperative	Cidral-Filho	Brazil (Florianópolis)	2014	Lasers Med Sci	**Light-emitting diode therapy induces analgesia in a mouse model of postoperative pain through activation of peripheral opioid receptors and the L-arginine/nitric oxide pathway.**	Mouse	Dose response Biphasic dose response LED phototherapy	"In conclusion, our results demonstrate, for the first time, that LEDT (950 nm, 80 mW/cm2) induced a dose–response analgesic effect in the model of PI in mice. At the energy density of 9 J/cm2, LEDT presented the most significant results through (1) activation of peripheral opioid receptors which involve, at least in part, the recruitment of opioid-containing leukocytes to the PI site and (2) activation of the l-arginine/NO pathway."	PubMed
★	Pain	Review	Cotler	USA (Houston, TX)	2015	MOJ Orthop Rheumatol	**The Use of Low Level Laser Therapy (LLLT) For Musculoskeletal Pain.**	Review			PubMed
	Pain	Sciatica	Bertolini	Brazil (Cascavel)	2011	Arq Neuropsiquiatr	**Low-level laser therapy, at 830 nm, for pain reduction in experimental model of rats with sciatica.**	Rat	Biphasic dose response (?)	"Low-level laser was effective in reducing the painful condition."	PubMed
	Pain	Shoulder	Kibar	Turkey (Ankara)	2016	Pain Med	**Laser Acupuncture Treatment Improves Pain and Functional Status in Patients with Subacromial Impingement Syndrome: A Randomized, Double-Blind, Sham-Controlled Study.**	Human RCT/DB	Subacromial impingement syndrome	"All parameters of pain and functional status in the treatment group were significantly better than those in the control group at week 3."	PubMed
	Pain	Shoulder	Yavuz	Turkey (Ankara)	2014	J Back Musculoskelet Rehabil	**Low-level laser therapy versus ultrasound therapy in the treatment of subacromial impingement syndrome: a randomized clinical trial.**	Human Randomized Comparison trial	Subacromial impingement syndrome	"The results suggest that efficacy of both treatments were comparable to each other in regarding reducing pain severity and functional disability in patients with subacromial impingement syndrome. Based on our findings, we conclude that low-level laser therapy may be considered as an effective alternative to ultrasound based therapy in patients with subacromial impingement syndrome especially ultrasound based therapy is contraindicated."	PubMed
	Pain	Shoulder	Montes-Molina	Spain	2012	Physiotherapy	**Interferential laser therapy in the treatment of shoulder pain and disability from musculoskeletal pathologies: a randomised comparative study.**	Human Comparison trial		Interferential LLLT wasn't better than normal LLLT.	PubMed
	Pain	Shoulder	Dogan	Turkey (Ankara)	2010	Clinics (Sao Paulo)	**The effectiveness of low laser therapy in subacromial impingement syndrome: a randomized placebo controlled double-blind prospective study.**	Human RCT/DB	Subacromial impingement syndrome	"The Low level laser therapy seems to have no superiority over placebo laser therapy in reducing pain severity, range of motion and functional disability."	PubMed

★	Pain	Shoulder		Stergioulas A	Greece (Sparta)	2008	Photomed Laser Surg	**Low-power laser treatment in patients with frozen shoulder: preliminary results.**	Human RCT/SB		"Relative to the placebo group, the active laser group had: (1) a significant decrease in overall, night, and activity pain scores at the end of 4 wk and 8 wk of treatment, and at the end of 8 wk additional follow-up (16 wk post-randomization); (2) a significant decrease in shoulder pain and disability index (SPADI) scores and Croft shoulder disability questionnaire scores at those same intervals; (3) a significant decrease in disability of arm, shoulder, and hand questionnaire (DASH) scores at the end of 8 wk of treatment, and at 16 wk posttreatment; and (4) a significant decrease in health-assessment questionnaire (HAQ) scores at the end of 4 wk and 8 wk of treatment. There was some improvement in range of motion, but this did not reach statistical	PubMed
	Pain	Surgical		Alvarange	Brazil (São Paulo)	2016 epub	Lasers Surg Med	**Effect of low-level laser therapy on pain and perineal healing after episiotomy: A triple-blind randomized controlled trial.**	Human RCT/DB (TB)		"The use of LLLT does not provide any benefit for treating postpartum perineal trauma using these specific protocol and parameters." "Further research may be necessary to define an appropriate irradiation protocol to treat post-partum perineal pain."	PubMed
	Pain	Surgical		Santos Jde	Brazil (São Paulo)	2012	J Clin Nurs	**Low-level laser therapy for pain relief after episiotomy: a double-blind randomised clinical trial.**	Human RCT/DB		"The effect of laser in perineal pain relief was not demonstrated in this study. The dosage may not have been sufficient to provide relief from perineal pain after episiotomy during a vaginal birth."	PubMed
	Pain	Surgical		Santos Jde	Brazil (São Paulo)	2012	Midwifery	**A randomised clinical trial of the effect of low-level laser therapy for perineal pain and healing after episiotomy: a pilot study.**	Human RCT/DB Pilot study		"This pilot study showed that LLLT did not accelerate episiotomy healing. Although there was a reduction in perineal pain mean scores in the experimental group, we cannot conclude that the laser relieved perineal pain. This study led to the suggestion of a new research proposal involving another irradiation protocol to evaluate LLLT's effect on perineal pain relief." Comment: Quite a low dose was used	PubMed
	Pain	Trigeminal neuralgia		Falaki	Iran (Mashdad)	2014	J Dent Res Dent Clin Dent Prospects	**The Effect of Low-level Laser Therapy on Trigeminal Neuralgia: A Review of Literature.**	Review			PubMed
★ ☹	Pain	Trigeminal neuralgia		Aghamohammadi	Iran (Tabriz)	2012	Neurosurg Q	**Gasserian Ganglion Block With or Without Low-intensity Laser Therapy in Trigeminal Neuralgia: A Comparative Study**	Human RCT Comparison trial		"The severity of pain was significantly lower in group A, from day 7 until the end of the study period (month 6). The number of carbamazepine tablets taken was also significantly lower in group A compared with group B from the initial months until the end of the study period (month 6). The period of a pain-free state was significantly higher in group A than in group B (P<0.00l)."" Comment: LLLT was very clearly superior in this study. Comment: Parameters were poorly reported. According to the paper, they used "Mustang 026 Russia, and the probe type was LO3"". The following paper (http://proceedings.spiedigitallibrary.org/proceeding.aspx?articleid=887067) seems to have some data on these Russian lasers, but it seems impossible to retrieve the relevant parameters. Comment: This journal isn't indexed in PubMed, and its' ranking is surprisingly poor:	LWW
	Pain			Robinson NG	USA (Fort Collins, CO)	2016	Photomed Laser Surg	**Photomedicine, Not Opioids, for Chronic Pain.**	Guest Editorial			PubMed
	Pain			Zarković	Yugoslavia (Zagreb)	1989	Lasers Surg Med	**Effect of semiconductor GaAs laser irradiation on pain perception in mice.**	Mouse		"Laser treatment induced further shortening of latencies, suggesting its stimulatory influence on pain perception." Note: There is no reason to believe that this ultra-low dose of 0.41 mJ/cm2 would have had any biological effects	PubMed
	Parameters	Coherence		Hode L	Sweden (Stockholm)	2005	Photomed Laser Surg	**The importance of the coherency.**	Letter to the Editor			PubMed
	Parameters	Coherence		Smith KC	USA (Stanford, CA)	2005	Photomed Laser Surg	**Laser (and LED) therapy is phototherapy.**	Letter to the Editor			PubMed
	Parameters	Editorial		Tunér & Jenkins	Sweden & USA	2016	Photomed Laser Surg	**Parameter Reproducibility in Photobiomodulation.**	Guest Editorial			PubMed
	Parameters	Editorial		Bayat M	Iran (Tehran)	2014	Photomed Laser Surg	**The necessity for increased attention to pulsed low-level laser therapy.**	Guest Editorial			PubMed
	Parameters	Editorial		Bjordal JM	Norway (Bergen)	2012	Photomed Laser Surg	**Low level laser therapy (LLLT) and World Association for Laser Therapy (WALT) dosage recommendations.**	Guest Editorial			PubMed
	Parameters	Editorial		Enwemeka CS	USA (Milwaukee, WI)	2011	Photomed Laser Surg	**The relevance of accurate comprehensive treatment parameters in photobiomodulation.**	Editorial			PubMed
	Parameters	Original research		Giacci	Australia	2015	J Vis Exp	**Method for the assessment of effects of a range of wavelengths and intensities of red/near-infrared light therapy on oxidative stress in vitro.**	In vitro		"Non-coherent Xenon light was filtered through narrow-band interference filters to deliver varying wavelengths (center wavelengths of 440, 550, 670 and 810 nm) and fluences (8.5x10(-3) to 3.8x10(-1) J/cm2) of light to cultured cells." "While the fluences of R/NIR-LT used in the current study did not exert an effect on ROS generated by the cultured cells, the method of light delivery is applicable to other systems including isolated mitochondria or more physiologically relevant organotypic slice culture models, and could be used to assess effects on a range of outcome	PubMed
★	Parameters	Recommendation		Jenkins & Carroll	Australia (Oakbank, SA)	2011	Photomed Laser Surg	**How to report low-level laser therapy (LLLT)/photomedicine dose and beam parameters in clinical and laboratory studies.**	Recommendation			PubMed
★	Parameters	Review		Hadis	UK (Birmingham)	2016	Lasers Med Sci	**The dark art of light measurement: accurate radiometry for low-level light therapy.**	Review			PubMed
	Parameters	Review		Hashmi	USA (Boston, MA)	2010	Lasers Surg Med	**Effect of pulsing in low-level light therapy.**	Review	Pulsing		PubMed
★	Parameters	Review		Tunér & Hode	Sweden (Stockholm)	1998	J Clin Laser Med Surg	**It's all in the parameters: a critical analysis of some well-known negative studies on low-level laser therapy.**	Review	Negative results		PubMed

	Penetration		Hart & Fitzgerald	Australia (Perth)	2016	Discov Med	**A new perspective on delivery of red-near-infrared light therapy for disorders of the brain.**	Review	Brain	PubMed
	Penetration		Chen	China (Shanghai)	2016	Neural Regen Res	**Low-power laser therapy for carpal tunnel syndrome: effective optical power.**	Human		PubMed
	Penetration		Anders & Wu	USA (Bethesda, MD)	2016	Photomed Laser Surg	**Comparison of Light Penetration of Continuous Wave 810 nm and Superpulsed 904 nm Wavelength Light in Anesthetized Rats.**			PubMed "The percentages of light transmission (fluence rate) through muscle and skin were 7.42% (810 nm wavelength) and 4.01% (904 nm wavelength) and through skin were 24.63% (810 nm wavelength) and 19.94% (904 nm wavelength). These data prove that transmission of CW 810 nm wavelength light through muscle and skin and skin alone is greater than transmission of superpulsed 904 nm wavelength light."
	Penetration		Tedford	USA (Poulsbo, WA)	2015	Lasers Surg Med	**Quantitative analysis of transcranial and intraparenchymal light penetration in human cadaver brain tissue.**	Human cadaver		PubMed "The 808 nm wavelength light demonstrated superior CNS tissue penetration."
	Penetration		Pitzschke	Switzerland	2015	Phys Med Biol	**Red and NIR light dosimetry in the human deep brain.**	Human cadaver		PubMed "Our study demonstrates that it is possible to illuminate deep brain tissues transcranially, transsphenoidally and via different application routes. This opens therapeutic options for sufferers of PD or other cerebral diseases necessitating light therapy."
	Penetration		Henderson & Morries	USA (Lakewood, CO)	2015	Neuropsychiatr Dis Treat	**Near-infrared photonic energy penetration: can infrared phototherapy effectively reach the human brain?**	Review	Brain	PubMed
	Penetration		Hudson	USA (CT)	2013	Photomed Laser Surg	**Penetration of laser light at 808 and 980 nm in bovine tissue samples.**			PubMed "For 808 nm, 1 mW/cm(2) was achieved at 3.4 cm, but for 980 nm, 1 mW/cm(2) was achieved at only 2.2 cm depth of tissue." "It was determined that 808 nm of light penetrates as much as 54% deeper than 980 nm light in bovine tissue."
	Penetration		Joensen	Norway (Bergen)	2012	Photomed Laser Surg	**Skin penetration time-profiles for continuous 810 nm and Superpulsed 904 nm lasers in a rat model.**			
	Penetration		Neupane	Nepal	2010	Photodiagnosis Photodyn Ther	**Effect of light emitting diodes in the photodynamic therapy of rheumatoid arthritis.**			PubMed Red, white, yellow and infra-red (IR) LEDs were tested to measure the optical penetration for soft tissue and their scattering.
	Penetration		Esnouf	UK (London)	2007	Acupunct Electrother Res	**Depth of penetration of an 850nm wavelength low level laser in human skin.**	Human skin samples		PubMed "The intensity of laser radiation reduced by 66% after being transmitted through a 0.784mm sample of human abdominal tissue. In this study most laser radiation was absorbed within the first 1mm of skin."
	Penetration		Ryan & Smith	UK (Hatfield)	2007	Ir Vet J	**An investigation into the depth of penetration of low level laser therapy through the equine tendon in vivo.**	Equine tendon		PubMed "These results suggest that, when applying laser to a subcutaneous structure in the horse, the area should be clipped and cleaned beforehand."
	Penetration	Teeth	Turrioni	Brazil	2013	Am J Dent	**LED light attenuation through human dentin: a first step toward pulp photobiomodulation after cavity preparation.**	Human dentin samples		PubMed "In terms of minimum (0.2 mm) and maximum (1.0 mm) dentin thicknesses, the percentage of light attenuation varied from 49.3% to 69.9% for blue light, 42.9% to 58.5% for red light and 39.3% to 46.8% for infrared."
	Penetration	Thermal effects	Grandinétti Vdos	Brazil (São Paulo)	2015	Lasers Med Sci	**The thermal impact of phototherapy with concurrent super-pulsed lasers and red and infrared LEDs on human skin.**			PubMed "No significant skin temperature increases were observed among the different skin color groups ($p > 0.05$), age groups ($p > 0.05$), or gender groups ($p > 0.05$). Our results indicate that the concurrent use of super-pulsed lasers and pulsed red and infrared LEDs can be utilized in patients with all types of skin pigmentation without concern over safety or excessive tissue heating."
	Penetration	Thermal effects	Joensen	Norway (Bergen)	2011	Photomed Laser Surg	**The thermal effects of therapeutic lasers with 810 and 904 nm wavelengths on human skin.**			PubMed "The thermal effects of LLLT at doses recommended by WALT-guidelines for musculoskeletal and inflammatory conditions are negligible (<1.5°C) in light, medium, and dark skin. However, higher LLLT doses delivered with a strong 3B laser (200 mW) are capable of increasing skin temperature significantly and these photothermal effects may exceed the thermal pain threshold for humans with dark skin color." Comment: The power density is very high in this study.
	Penetration	Melanin	Brondon	USA (Rochester, MN)	2007	Photomed Laser Surg	**Melanin density affects photobiomodulation outcomes in cell culture.**	In vitro		PubMed "The Proliferation Index (PI) as measured by CyQuant assay was not statistically different amongst the groups in either cell line. MTT assay results demonstrated a significant dose response effect ($p < or = 0.05$) in both cell lines with activity inversely proportional to melanin concentration." "These results demonstrate that cutaneous melanin content should be taken into consideration in photobiomodulation paradigms. Further studies to quantify these effects are warranted."
	Penetration		Bashkatov	Russia (Saratov)	2005	J Phys D Appl Phys	**Optical properties of human skin, subcutaneous and mucous tissues in the wavelength range from 400 to 2000 nm**			IOPscience "The optical properties of human skin, subcutaneous adipose tissue and human mucosa were measured in the wavelength range 400–2000 nm."
	Penetration		Muller & Wilson		1986	Phys Med Biol	**An update on the penetration depth of 630 nm light in normal and malignant human brain tissue in vivo.**			
	Peritoneum	Peritonitis	Correa	Brazil (São Paulo)	2007	Photomed Laser Surg	**Low-level laser therapy (GaAs lambda = 904 nm) reduces inflammatory cell migration in mice with lipopolysaccharide-induced peritonitis.**	Mouse		PubMed "The 3-J/cm(2) exposure group showed the best results at 24 hours, with reductions of 77% in neutrophil and 49% in leukocyte counts." "Low-level laser therapy (904 nm) can reduce inflammatory cell migration in mice with LPS-induced peritonitis in a dose-dependent manner." Note: The single dose was given in three parts, within 3h
	Plastic surgery		Hersant	France (Creteil)	2015	Photomed Laser Surg	**Current indications of low-level laser therapy in plastic surgery: a review.**	Systematic review		PubMed
	Polychromatic light		Ülker	Turkey	2016	Lasers Med Sci	**Polychromatic light-induced osteogenic activity in 2D and 3D cultures**	In vitro		Springer "We decided to use a specially designed plasma arc light source providing wavelengths between 590 and 1500 nm" "Light source used in this study induces formation of bone tissue and so, this light source is proposed as an appropriate system for in vitro bone tissue engineering applications"
☹	Poor science		Wellington J	USA (Indianapolis, IN)	2014	Neuromodulation	**Noninvasive and alternative management of chronic low back pain (efficacy and outcomes).**	Review		PubMed

☹	Poor science			Malm	Sweden	1991	Scand J Plast Reconstr Surg Hand Surg	**Effect of low power gallium arsenide laser on healing of venous ulcers.**			"One group received standard conservative treatment and gallium arsenide laser, and the other received the same standard treatment and placebo laser treatment. There were no differences in results between the two groups." The parameters stated in the report are: "A GaAs laser (Irradia) was used. The wavelength was 904 nm, average output 4 mW, peak power 10 W, pulse frequency 3800 Hz and duration 180 ns, and divergence 70 mrad. Energy density was 1.96 J/cm2 . The placebo laser was of the same brand but the invisible GaAs laser light had been removed so that nobody in the study could tell the difference between the two." According to Hode&Tuner: [Read additional info]	PubMed
☹	Poor science			Lundeberg	Sweden	1988	Acupunct Electrother Res	**Effect of low power laser irradiation on nociceptive cells in Hirudo medicinalis.**	Leech	Nociception	"The results show that low power laser irradiation does not: affect the membrane potential or the excitability of the nociceptive neurons, affect the mechanical pressure required to activate the nociceptors or their action potentials." As mentioned by Hode&Tuner: "In this study, Lars Hode did not take part but is listed as a co-author. He was asked before it started if he wanted to take part and he said yes. About half a year later he found out that it was published!"	PubMed
☹	Poor science			Lundeberg	Sweden	1987	Acta Physiol Scand	**A comparative study of the pain-relieving effect of laser treatment and acupuncture.**	Human	Pain relief	"Our results indicate that the analgesic effects reported in humans with similar modes of low power laser might be due to placebo." According to Hode&Tuner, "the study was published without the knowledge of Lars Hode". This is interesting, since Hode's name is in the author list. Regarding the researcher: [See additional info]	PubMed
☹	Poor science			Lundeberg	Sweden	1987	Scand J Rehabil Med	**Effect of laser versus placebo in tennis elbow.**	Human	Tennis Elbow	"The results show that laser treatment is not significantly better than placebo in treating tennis elbow."	PubMed
	Protozoa	Paramecium		Amaroli	Italy (Genoa)	2016	Photochem Photobiol	**Photobiomodulation by Infrared Diode-Laser: Effects on Intracellular Calcium Concentration and Nitric Oxide Production of Paramecium.**	Protozoa	Calcium release by 980nm	"Lastly, the 980nm and 64J/cm2 or 96J/cm2 were the only parameters to induce a release of stored calcium."	PubMed
	Protozoa	Paramecium		Amaroli	Italy (Genoa)	2016	Lasers Med Sci	**808-nm laser therapy with a flat-top handpiece photobiomodulates mitochondria activities of Paramecium primaurelia (Protozoa).**	Protozoa	Penetration	"Our results suggest that thanks to flat-top handpiece we used, high fluences by high-powered laser have to be reconsidered as an effective and non-invasive therapy. Possible associated benefits of deeper tissue penetration would increase treatment effectiveness and reduced irradiation time."	PubMed
	Protozoa	Paramecium		Amaroli	Italy (Genoa)	2015	Altern Lab Anim	**The protozoan, Paramecium primaurelia, as a non-sentient model to test laser light irradiation: The effects of an 808nm infrared laser diode on cellular respiration.**	Protozoa		808nm LLLT increased oxygen consumption of protozoa by 40%.	PubMed
	Protozoa	Paramecium		Amaroli	Italy (Genoa)	2015	Photomed Laser Surg	**Paramecium: a promising non-animal bioassay to study the effect of 808 nm infrared diode laser photobiomodulation.**	Protozoa		"The 808 nm infrared diode laser light, at the irradiation parameters used in our work, results in a precocious fission rate in P. primaurelia cells, probably through an increase in metabolic activity, secondary to an energy transfer."	PubMed
	Protozoa	Paramecium		Amaroli	Italy (Genoa)	2015	Photochem Photobiol	**Effect of 808 nm Diode Laser on Swimming Behavior, Food Vacuole Formation and Endogenous ATP Production of Paramecium primaurelia (Protozoa).**	Protozoa		"(1) the 808 nm laser stimulates the P. primaurelia without a thermal effect, (2) the laser effect is demonstrated by an increase in swimming speed and in food vacuole formation, (3) the laser treatment affects endogenous adenosine triphosphate (ATP) production in a positive way, (4) the effects of irradiation dose suggest an optimum exposure time of 50 s (64 J cm(-2) of fluence) to stimulate the Paramecium cells; irradiation of 25 s shows no effect or only mild effects and irradiation up to 100 s does not increase the effect observed with 50 s of treatment, (5) the increment of endogenous ATP concentration highlights the positive photobiomodulating effect of the 808 nm laser and the optimal irradiation conditions by	PubMed
	Purinergic signalling	Extracellular ATP		Wang	China (Shanghai)	2015	Mediators Inflamm	**Modulation of extracellular ATP content of mast cells and DRG neurons by irradiation: studies on underlying mechanism of low-level-laser therapy.**	In vitro		"Our results show that irradiation led to elevation of extracellular ATP level in the human mast cell line HMC-1 in a dose-dependent manner, which was accompanied by elevation of intracellular ATP content, an indicator for ATP synthesis, together with [Ca(2+)]i elevation, a trigger signal for exocytotic ATP release. In contrast to MCs, irradiation attenuated the extracellular ATP content of neurons, which could be abolished by ARL 67156, a nonspecific ecto-ATPases inhibitor. "	PubMed
	Radiation	Gamma radiation		Efremova	Czech Republic (Kladno)	2015	Photomed Laser Surg	**Protective effect of 940 nm laser on gamma-irradiated mice.**	Mouse	Gamma radiation Biphasic dose response	Only the low-dose LLLT seemed to protect against the lethal effect of gamma radiation: "In Table 4, we summarized the means for survival time for all groups and found that 50% of mice in the gamma-laser3 group and 9.1% of mice in the gamma-laser18 group had survived to the 30th day after gamma irradiation, but only in the first one was the difference in survival compared with the gamma group significant (p=0.007 vs. 0.875). Meanwhile, survival in the gamma-laser3 group was significantly different than in other gamma-irradiated groups, except the gamma-laser18 group, in which p=0.23 in comparison with the gamma group."	PubMed
	Radiation	Gamma radiation		Abdul-Aziz & Tuorkey	Egypt (Damanhour)	2010	J Photochem Photobiol B	**Argon laser phototherapy could eliminate the damage effects induced by the ionizing radiation "gamma radiation" in irradiated rabbits.**	Rabbit	Blue light	"In conclusion, argon laser therapy appears propitious protective effect against the hazard effects of gamma radiation."	PubMed
	Radiation	Cancer radiotherapy		Zharinov	Russia (St. Petersburg)	2010	Laser Ther	**Late radiation lesions of urinary bladder and rectum in patients with prostate cancer after external radiation therapy and phototherapy with low power near infrared laser.**	Human	Prostate cancer patients	"In the control group the radiation damage of urinary bladder and rectum appeared in 7.6% and 10.7% of patients, while in the main group - in 1.95% and 2.92%, respectively ($p < 0.01$). Thus, the course of phototherapy with the near infrared low power laser at performance of radiotherapy decreases incidence of radiation damages of urinary bladder and rectum in patients with prostate cancer."	J-STAGE
	Radiation			Freitinger Skalická	Czech	2012	J Photochem Photobiol B	**Indicators of oxidative stress after ionizing and/or non-ionizing radiation: superoxid dismutase and malondialdehyde.**	Mouse	Gamma radiation	LLLT didn't protect from gamma radiation in this study.	PubMed

	Respiratory system	Acute respiratory distress syndrome	de Lima	Brazil (São José dos Campos)	2011	Lasers Med Sci	**Low-level laser therapy (LLLT) acts as cAMP-elevating agent in acute respiratory distress syndrome.**	Mouse + in vitro	Alveolar macrophages (for in vitro experiments)	↓neutrophil infiltration ↓TNF-α in BALF ↓LPS-induced alveolar macrophages TNF production ↓LPS-induced alveolar macrophages TNF-α mRNA expression "Taken together, the results obtained in the present manuscript evidenced that LLLT potentiates the effect of rolipram on ALI by a mechanism that, at least initially, is not directly linked to generation of cAMP but involves the reduction of TNF-α mRNA expression in AM from mice in an experimental model of LPS aerosol-induced ALI." Note: This paper also has a lot of data related to cAMP.	PubMed
	Respiratory system	Airway smooth muscle relaxation	Aimbire	Brazil (São José dos Campos)	2006	Lasers Surg Med	**Low level laser therapy partially restores trachea muscle relaxation response in rats with tumor necrosis factor alpha-mediated smooth airway muscle dysfunction.**	In vitro		"[LLLT] partially restored TSM relaxation response to isoproterenol. Tension reduction was 47.0 % (+/-2.85) in the laser-irradiated group compared to 22.0% (+/-2.21) in the control group ($P < 0.01$). Accumulation of cAMP was almost normalized after LLLT at 22.3 pmol/mg (+/-2.1) compared to 17.6 pmol/mg (+/-2.1) in the non-irradiated control group ($P < 0.01$)."	PubMed
★	Respiratory system	Allergic asthma	Silva	Brazil (São Paulo)	2014	Respir Physiol Neurobiol	**Low-level laser therapy inhibits bronchoconstriction, Th2 inflammation and airway remodeling in allergic asthma.**	Mouse		"Reduction of [bronchial hyperresponsiveness] post LLLT coincided with lower RhoA expression in bronchial muscle as well as reduction in eosinophils and eotaxin. LLLT also diminished ICAM expression and Th2 cytokines as well as signal transducer and activator of transduction 6 (STAT6) levels in lungs from challenged mice. Our results demonstrated that LLLT reduced [bronchial hyperresponsiveness] via RhoA and lessened allergic lung inflammation via STAT6." Comment: In this study, the authors refer to many russian human studies on LLLT and airways.	PubMed
	Respiratory system	Allergic asthma	Wang	China (Tianjin)	2014	Lasers Med Sci	**Effect of low-level laser therapy on allergic asthma in rats.**	Rat	LLLT vs budesonide	"LLLT could reduce levels of IL-4 and increase IFN-γ levels in bronchoalveolar lavage fluid and serum, meanwhile reduce serum IgE levels. Flow cytometry assay showed that LLLT can regulate the Th1/Th2 imbalance of asthmatic rats. LLLT had a similar effect to that of budesonide." "These findings suggest that the mechanism of LLLT treatment of asthma is by adjustment of Th1/Th2 imbalance. Thus, LLLT could take over some of the effects of budesonide for the treatment of asthma, thereby reducing some of the side effects of	PubMed
	Respiratory system	Allergic rhinitis	Lee	Korea (Seoul)	2013	Photochem Photobiol	**A comparative pilot study of symptom improvement before and after phototherapy in Korean patients with perennial allergic rhinitis.**	Human Open-label		Improvement of nasal obstruction, rhinorrhea, sneezing, itching in 68% of the patients. "The overall RQLQ scores significantly improved by 45% from the baseline with the treatment after 4 weeks." "These results indicate that phototherapy is an effective modality for treating perennial allergic rhinitis and is another option in the steroid-free management of immune-mediated mucosal diseases."	PubMed
	Respiratory system	Allergic rhinitis	Choi	Korea (Seoul)	2013	Evid Based Complement Alternat Med	**Effects of low level laser therapy on ovalbumin-induced mouse model of allergic rhinitis.**	Mouse	Biphasic dose response	"LLLT significantly inhibited total IgE, IL-4, and TARC expression in ovalbumin-induced mice at low dose irradiation. The protein expression level of IL-4 in spleen was inhibited in low dose irradiation significantly. IL-4 expression in EL-4 cells was inhibited in a dose dependent manner. Histological damages of the epithelium in the nasal septum were improved by laser irradiation with marked improvement at low dose irradiation." "These results suggest that LLLT might serve as a new therapeutic tool in the treatment of AR with more effectiveness at low dose irradiation. To determine the optimal dose of laser irradiation and action mechanisms of laser therapy, further studies will be needed."	PubMed
	Respiratory system	Allergic rhinitis	Neuman&Finkelstein	Israel (Petah Tikva)	1997	Ann Allergy Asthma Immunol	**Narrow-band red light phototherapy in perennial allergic rhinitis and nasal polyposis.**	Human RCT/DB (?)	Allergic rhinitis Nasal polyposis LED phototherapy BioNase LED light	"Allergic rhinitis, if uncomplicated by polyps or chronic sinusitis, can be effectively treated by narrow-band red light illumination of the nasal mucosa at 660 nm, with marked alleviation of clinical symptoms." Comment: If I remember correctly, the sham group results in abstract contradict a little bit with the results presented in full text (improvement in 3% vs 21%). Comment: The sham-controlling is suboptimal, since it's bright red light vs no light.	PubMed
	Respiratory system	Bronchial hyperresponsiveness	Mafra de Lima	Brazil (São José dos Campos)	2009	Lasers Surg Med	**Low level laser therapy (LLLT): attenuation of cholinergic hyperreactivity, beta(2)-adrenergic hyporesponsiveness and TNF-alpha mRNA expression in rat bronchi segments in E. coli lipopolysaccharide-induced airway inflammation by a NF-kappaB dependent mechanism.**	In vitro		↓BSM hyperreactivity to cholinergic agonist ↑BSM relaxation to isoproterenol ↓TNF-alpha mRNA expression "An NF-kappaB antagonist (BMS205820) blocked the LLLT effect" "The results obtained in this work indicate that the LLLT effect on alterations in responsiveness of airway smooth muscles observed in TNF-alpha-induced experimental acute lung inflammation seems to be dependent of NF-kappaB activation."	PubMed
	Respiratory system	Bronchial hyperresponsiveness	Aimbire	Brazil (São José dos Campos)	2009	Lasers Med Sci	**Effect of low level laser therapy on bronchial hyper-responsiveness.**	In vitro		↓TNF-α, ↓inositol phosphate accumulation, ↓(TNF-α)-induced contractile response to carbachol, ↓IP3R mRNA "We conclude that LLLT can reduce Ca2+ sensitization and inositol phosphate accumulation in rat BSM cells in a TNF-α-induced bronchial hyper-responsiveness model."	PubMed
	Respiratory system	COPD	Aksenova & Burduli	Russia (Vladikavkaz)	2016	Ter Arkh	**[Pathogenetic effects of low-intensity laser therapy for chronic obstructive pulmonary disease].** **[Article in Russian]**	Human		"Laser therapy used in the combination treatment of patients with COPD promotes correction of the typical pathological processes."	PubMed
	Respiratory system	COPD	Peron	Brazil	2015	PLoS One	**Human Tubal-Derived Mesenchymal Stromal Cells Associated with Low Level Laser Therapy Significantly Reduces Cigarette Smoke-Induced COPD in C57BL/6 mice.**	Mouse	COPD Stromal cell therapy	LLLT augmented the beneficial effect of stromal cell therapy.	PubMed

★	Respiratory system	COPD	Miranda	Brazil (São Paulo)	2015	Lasers Med Sci	**Phototherapy with combination of super-pulsed laser and light-emitting diodes is beneficial in improvement of muscular performance (strength and muscular endurance), dyspnea, and fatigue sensation in patients with chronic obstructive pulmonary disease.**	Human	COPD Muscular performance LED phototherapy LED cluster	"Significant differences were also found for MVIC (104.8 ± 26.0 N · m vs. 87.2 ± 24.0 N · m, p = 0.000), sensation of dyspnea (1 [0-4] vs. 3 [0-6], p = 0.003), and fatigue in the lower limbs (2 [0-5] vs. 5 [0.5-9], p = 0.002) in favor of phototherapy. We conclude that the combination of super-pulsed lasers and LEDs administered to the femoral quadriceps muscle of patients with COPD increased the PT by 20.2% and the TW by 12%. Phototherapy with a combination of super-pulsed lasers and LEDs prior to exercise also led to decreased sensation of dyspnea and fatigue in the lower limbs in patients with COPD." Comment: The parameters are quite complex in this study - read the full text for further information.	PubMed
	Respiratory system	COPD	Miranda	Brazil (São Paulo)	2014	Lasers Med Sci	**Acute effects of light emitting diodes therapy (LEDT) in muscle function during isometric exercise in patients with chronic obstructive pulmonary disease: preliminary results of a randomized controlled trial.**	Human RCT	Muscle function	"A single application of LEDT minimizes muscle fatigue and increases isometric endurance time."	PubMed
	Respiratory system	COPD	Miranda	Brazil (São Paulo)	2013	Trials	**Effects of light-emitting diodes on muscle fatigue and exercise tolerance in patients with COPD: study protocol for a randomized controlled trial.**	Study protocol			PubMed
	Respiratory system	Diaphragm	Aimbire	Brazil (São José dos Campos)	2006	Lasers Med Sci	**Low-level laser therapy can reduce lipopolysaccharide-induced contractile force dysfunction and TNF-alpha levels in rat diaphragm muscle.**	Rat	LPS-induced diaphragm muscle weakness	↑maximal tetanic force developed by diaphragm muscle ↑diaphragm muscle contractile force ↓TNF-α concentration of rat diaphragm "We conclude that LLLT can inhibit the release of TNF-α in the rat diaphragm muscle after LPS injection and thereby reduce the impairment of the contractile dysfunction in rat diaphragm muscle. Further studies are warranted in this novel area of research to elucidate the exact mechanism of LLLT action."	PubMed
	Respiratory system	Lung hemorrhage	Aimbire	Brazil (São José dos Campos)	2007	Photomed Laser Surg	**Effect of low-level laser therapy on hemorrhagic lesions induced by immune complex in rat lungs.**	Rat	Hemorrhage LLLT vs celecoxib vs dexamethasone	"LLLT at a dose of 2.6 Joules/cm(2) induces a reduction of HI (hemorrhagic index) levels and MPO activity in hemorrhagic injury that is not significantly different from celecoxib. Dexamethasone is slightly more effective than LLLT in reducing HI, but not MPO activity."	PubMed
★	Respiratory system	Lung inflammation	Costa Carvalho	Brazil (São José dos Campos)	2016	J Biophotonics	**The chemokines secretion and the oxidative stress are targets of low-level laser therapy in allergic lung inflammation.**		Allergic lung inflammation	"Laser-treated allergic mice presented reduction of both the ICAM-1 and eosinophil in the lungs. RANTES, CCL8, CCL3 and eotaxins were reduced in BALF of laser-treated allergic mice. In allergic mice lung LLLT decreased the CCR1 and CCR3 and restored the oxidative stress balance as well. Laser decreased the lipidic peroxidation in allergic mice lung as much as increased SOD, GPx and GR. It shows that LLLT on allergic lung inflammation involves leukocyte-attractant chemokines and endogenous antioxidant. Based on results, LLLT may ultimately become a non- invasive option in allergic lung disease treatment."	PubMed
☎	Respiratory system	Lung inflammation	Cury	Brazil (São Paulo)	2016	J Biophotonics	**Low level laser therapy reduces acute lung inflammation without impairing lung function.**	Mouse	Intratracheal LPS -> Lung inflammation	""Similarly to other authors, we detected a significant increase in the expression of several pro-inflammatory cytokines (TNF-α, IL-1β, IL-6), that was inhibited by laser treatment" "There was a marked increase in the expression of MCP-1 in the animals exposed to LPS, which was significantly reduced by laser irradiation. We suggest that this was one of the mechanisms by which LLLT reduced the number of inflammatory cells in the lung" "The LLLT application induced a significant decrease in both inflammatory cells influx and inflammatory mediators secretion. These effects did not affect lung mechanical properties, since no change was observed in tissue resistance or elastance. In conclusion LLLT is able to reduce inflammatory reaction in lungs exposed to LPS without affecting the pulmonary function and recovery."	PubMed
	Respiratory system	Lung inflammation	Miranda da Silva	Brazil (São Paulo)	2015	PLoS One	**Low Level Laser Therapy Reduces the Development of Lung Inflammation Induced by Formaldehyde Exposure.**	Rat	Formaldehyde exposure	"The treatment with LLLT reduced the development of neutrophilic lung inflammation induced by FA, as observed by the reduced number of leukocytes, mast cells degranulated, and a decreased myeloperoxidase activity in the lung. Moreover, LLLT also reduced the microvascular lung permeability in the parenchyma and the intrapulmonary bronchi. Alterations on the profile of inflammatory cytokines were evidenced by the reduced levels of IL-6 and TNF-α and the elevated levels of IL-10 in the lung." "Together, our results showed that LLLT abolishes FA-induced neutrophilic lung inflammation by a reduction of the inflammatory cytokines and mast cell degranulation. This study may provide important information about the mechanisms of LLLT in lung	PubMed
	Respiratory system	Lung inflammation	de Lima	Brazil (São José dos Campos)	2014	J Lasers Med Sci	**Low-level laser therapy attenuates the myeloperoxidase activity and inflammatory mediator generation in lung inflammation induced by gut ischemia and reperfusion: a dose-response study.**	Mouse	Dose response	"With exception of 1J/cm(2), LLLT reduced MPO activity as well as IL-1β levels in the lungs from inflamed mice. LLLT was also markedly effective in reducing both IL-6 and TNF expression and levels in the lungs from mice submitted to i-I/R in all laser doses studied. Otherwise, LLLT significantly increased the protein levels of IL-10 in inflamed mice by i-I/R; however only in the dose of 1J/cm(2)." "We conclude that the LLLT is able to control the neutrophils activation and proinflammatorycytokines release into the lungs in a model of i-I/R in mice."	PubMed
	Respiratory system	Lung inflammation	Oliveira	Brazil (São Paulo)	2014	J Photochem Photobiol B	**Low level laser therapy reduces acute lung inflammation in a model of pulmonary and extrapulmonary LPS-induced ARDS.**	Mouse		"LLLT significantly reduced pulmonary and extrapulmonary inflammation in LPS-induced ARDS, as demonstrated by reduced number of total cells (p<0.001) and neutrophils (p<0.001) in BAL, reduced levels of IL-1beta, IL-6, KC and TNF-alpha in BAL fluid and in serum (p<0.001), as well as the number of neutrophils in lung parenchyma (p<0.001). LLLT is effective to reduce pulmonary inflammation in both pulmonary and extrapulmonary model of LPS-induced ARDS."	PubMed

★	Respiratory system	Lung inflammation	de Lima	Brazil (São José dos Campos)	2013	Photochem Photobiol	**Low-level laser therapy restores the oxidative stress balance in acute lung injury induced by gut ischemia and reperfusion.**	Rat		↑GSH, ↑HSP70 expression, ↑PPARγ expression, ↓lung injury, ↓edema, ↓neutrophils influx, ↓MPO activity, ↓ICAM-1 mRNA expression, ↓ROS "Results indicate that laser effect in attenuating the acute lung inflammation is driven to restore the balance between the pro- and antioxidants mediators rising of PPARγ expression and consequently the HSP70 production."	PubMed
	Respiratory system	Lung inflammation	de Lima	Brazil (São José dos Campos)	2013	Lasers Med Sci	**Suppressive effect of low-level laser therapy on tracheal hyperresponsiveness and lung inflammation in rat subjected to intestinal ischemia and reperfusion.**	Rat	Tracheal and lung function after intestinal I/R	"LLLT (660 nm, 7.5 J/cm(2)) restored the tracheal hyperresponsiveness and hyporesponsiveness in all the periods after intestinal reperfusion. Although LLLT reduced edema and MPO activity, it did not do so in all the postreperfusion periods. It was also observed with the ICAM-1 expression. In addition to reducing both TNF-α and iNOS, LLLT increased IL-10 in the lungs of animals subjected to i-I/R. The results indicate that LLLT can control the lung's inflammatory response and the airway reactivity dysfunction by simultaneously reducing both TNF-α and iNOS."	PubMed
	Respiratory system	Lung inflammation	de Lima	Brazil (São José dos Campos)	2011	Lasers Surg Med	**Dual Effect of low-level laser therapy (LLLT) on the acute lung inflammation induced by intestinal ischemia and reperfusion: Action on anti- and pro-inflammatory cytokines.**	Rat	Acute lung inflammation	"The results indicate that the LLLT attenuates the i-I/R-induced acute lung inflammation which favor the IL-10 production and reduce TNF generation."	PubMed
★	Respiratory system	Lung inflammation	Mafra de Lima	Brazil (São José dos Campos)	2010	J Photochem Photobiol B	**Low intensity laser therapy (LILT) in vivo acts on the neutrophils recruitment and chemokines/cytokines levels in a model of acute pulmonary inflammation induced by aerosol of lipopolysaccharide from Escherichia coli in rat.**	Rat	Acute lung inflammation	"LILT inhibited pulmonary edema and endothelial cytoskeleton damage, as well as neutrophil influx and activation. Similarly, the LILT reduced the TNF-α and IL-1β, in lung and BALF. LILT prevented lung ICAM-1 up-regulation. The rise of CINC-1 and MIP-2 protein levels in both lung and BALF, and the lung mRNA expressions for IL-10, were unaffected. Data suggest that the LILT effect is due to the inhibition of ICAM-1 via the inhibition of TNF-α and IL-1β."	PubMed
	Respiratory system	Lung inflammation	Aimbire	Brazil (São José dos Campos)	2008	Int Immunopharmacol	**Low-level laser therapy decreases levels of lung neutrophils anti-apoptotic factors by a NF-kappaB dependent mechanism.**	Mouse		↓Bcl-xL mRNA in lung neutrophils ↓A1 mRNA in lung neutrophils "LLLT effect on mRNA expression of Bcl-xL and A1 in lung neutrophils was blocked by pretreatment with BMS 205820. From these results, it is reasonable to suggest that the anti-inflammatory effect of LLLT can be mediated by NF-κB."	PubMed
	Respiratory system	Lung inflammation	Aimbire	Brazil (São José dos Campos)	2008	Inflammation	**Low level laser therapy (LLLT) decreases pulmonary microvascular leakage, neutrophil influx and IL-1beta levels in airway and lung from rat subjected to LPS-induced inflammation.**	Rat	Acute lung inflammation	"LLLT attenuated lung permeability. In addition, there was reduced neutrophil influx, myeloperoxidase activity and both IL-1beta in BAL and IL-1beta mRNA expression in trachea obtained from animals subjected to LPS-induced inflammation."	PubMed
	Respiratory system	Lung inflammation	Aimbire	Brazil (São José dos Campos)	2006	Photomed Laser Surg	**Low-level laser therapy induces dose-dependent reduction of TNFalpha levels in acute inflammation.**	Rat	Lung injury by ovalbumin+antibody LLLT vs chlorpromazine Biphasic dose response	"LLLT at a dose of 0.11 Joules reduced the TNF concentration in bronchoalveolar lavage fluid to 50.2 (95% CI, 49.4–51.0), which was significantly lower ($p < 0.001$) than the control group and the other LLLT groups of 0.04 and 0.22 Joules, respectively."	PubMed
	Respiratory system	Lung inflammation	Aimbire	Brazil (São José dos Campos)	2005	Lasers Med Sci	**Effect of LLLT Ga-Al-As (685 nm) on LPS-induced inflammation of the airway and lung in the rat.**	Rat	Airway inflammation caused by LPS injection	"Our results demonstrate that LLLT produced anti-inflammatory effects on RTHR, BAL and lung neutrophils influx in association with inhibition of COX-2-derived metabolites."	PubMed
	Respiratory system	Pleurisy	Boschi	Brazil (Porto Alegre)	2008	Lasers Surg Med	**Anti-Inflammatory effects of low-level laser therapy (660 nm) in the early phase in carrageenan-induced pleurisy in rat.**	Rat	Pleurisy Biphasic dose response	"LLLT-660 nm induced an anti-inflammatory effect characterized by inhibition of either total or differential leukocyte influx, exudation, total protein, NO, IL-6, MCP-1, IL-10, and TNF-alpha, in a dose-dependent manner. Under these conditions, laser treatment with 2.1 J was more effective than 0.9 and 4.2 J."	PubMed
	Respiratory system	Pleurisy	Lopes-Martins	Brazil (São José dos Campos)	2005	Photomed Laser Surg	**Spontaneous effects of low-level laser therapy (650 nm) in acute inflammatory mouse pleurisy induced by carrageenan.**	Mouse	Biphasic dose response	"LLLT administered at 1-3 h after the induction of inflammatory pleurisy significantly reduces the inflammatory cell migration measured. Under these conditions and at 2.5 mW, 7.5 J/cm(2) was more effective than 3 J/cm(2) and 15 J/cm(2)."	PubMed
	Respiratory system	Rhinosinusitis	Naghdi	Iran (Tehran)	2013	Physiother Theory Pract	**A pilot study into the effect of low-level laser therapy in patients with chronic rhinosinusitis.**	Human	Chronic rhinosinusitis	Total symptom score was improved 39% at 2 weeks and 46% at 4 weeks. "The therapeutic effect was sustained for a mean of 5 months. This pilot study indicates that LLLT applied for 4 weeks improves symptoms in patients with CRS."	PubMed
	Respiratory system	Rhinosinusitis	Krespi&Kizhner	USA (New York)	2011	Lasers Surg Med	**Phototherapy for chronic rhinosinusitis.**	Human Randomized		"NILI of the nasal sinuses with or without PA agents proved to be beneficial objectively and subjectively in CRS patients who failed medical and surgical therapies."	PubMed
☹	Respiratory system		Ezzat	Egypt (Cairo)	2016	Acta Otorrinolaringol Esp	**Using low level laser therapy to reduce early postoperative airway obstruction following modified Hogan's flap.**	Human RCT/DB		"The mean of the average oxygen saturation was significantly less in the control group in the 1st and 2nd day as compared to the laser group. The need for oxygen and the incidence of OSA in the first 3 days were significantly higher in the control group as compared to the laser group. The degree of edema showed no significant difference in the first day but was significantly higher in the control group in the 2nd and 3rd days. Hence, the need of steroids was significantly higher in the control group in the first 3 days."	PubMed
	Respiratory system		de Lima	Brazil (São José dos Campos)	2010	Lasers Med Sci	**Low-level laser therapy (LLLT) attenuates RhoA mRNA expression in the rat bronchi smooth muscle exposed to tumor necrosis factor-alpha.**	Rat		"We conclude that LLLT administered with this protocol, reduces RhoA mRNA expression and BSM contraction force in TNF-alpha-induced BSM hyperreactivity."	PubMed
	Safety of LLLT	Brain cells	Sagar	USA (Miami, FL)	2016	Sci Rep	**Coupling of transient near infrared photonic with magnetic nanoparticle for potential dissipation-free biomedical application in brain.**	In vitro		"We demonstrated that transient NIR irradiation in presence of MNPs is dissipation free and safe for brain cells. Our results suggest that MNPs-NIR phototargeting does not have adverse effect on the viability, growth behavior and plasticity of brain cells. Thus, selected power density of ~1.5 W/cm2 and 2 minute time window for 808 nm NIR exposure in this report will open a referral point to explore higher power density laser for brain cells. This opens up a regime that can provide an exceptional opportunity for the safe use of this novel combinatorial approach for various biomedical innovations."	PubMed

★	Safety of LLLT		Engel	USA (Bethesda, MD)	2016	J Biophotonics	**Cell lineage responses to photobiomodulation therapy.**	In vitro	Fibroblasts Keratinocytes Reactive oxygen species (ROS)	"We observed keratinocytes have increased sensitivity to laser irradiances (>0.047 W/cm2 , 300 sec, 14.2 J/cm2) compared to the fibroblast cells (>0.057 W/cm2 , 300 sec, 15.1 J/cm2) ($p < 0.0001$). Laser treatments were noted to generate increased reactive oxygen species (ROS) levels in keratinocytes compared to fibroblasts that appeared to inversely correlate with higher basal catalase expression. To validate these observations, melatonin was used to treat keratinocytes to induce catalase activity ($p < 0.0001$). Increased melatonin-induced catalase levels were noted to significantly improve keratinocyte survival to phototoxic laser doses."	PubMed
	Safety of LLLT		Moon	South Korea	2016	Lasers Med Sci	**Safety assessment of trans-tympanic photobiomodulation.**	Rat		A very high LLLT dose (7560J) was associated with tympanic membrane injury.	PubMed
	Safety of LLLT		Kent	Australia (Canberra)	2015	J Perinatol	**A safety and feasibility study of the use of 670 nm red light in premature neonates.**	Human		"There were no skin burns or other documented adverse events. Entry into the study was readily achieved and treatment was well accepted by parents and nursing staff." "670 nm red light appears to be a safe and feasible treatment for further research in respect to [retinopathy of prematurity]"	PubMed
	Safety of LLLT		McCarthy	USA (Carlsbad, CA)	2010	Photomed Laser Surg	**Long-term safety of single and multiple infrared transcranial laser treatments in Sprague-Dawley rats.**	Rat		"Single and multiple applications of transcranial laser therapy with 808-nm CW laser light at a nominal power density of 10 mW/cm(2) at the surface of the cerebral cortex appears to be safe in Sprague-Dawley rats 1 year after treatment."	PubMed
	Safety of LLLT		Ilic	USA (Carlsbad, CA)	2006	Photomed Laser Surg	**Effects of power densities, continuous and pulse frequencies, and number of sessions of low-level laser therapy on intact rat brain.**	Rat		"Both the scores from standard neurological tests and the histopathological examination indicated that there was no long-term difference between laser-treated and control groups up to 70 days post-treatment. The only rats showing an adverse neurological effect were those in the 750 mW/cm2 (about 100-fold optimal dose), CW mode group." "Long-term safety tests lasting 30 and 70 days at optimal 10x and 100x doses, as well as at multiple doses at the same power densities, indicate that the tested laser energy doses are safe under this treatment regime."	PubMed
	Sinuses		Ozturan	Turkey (Istanbul)	2015	Photomed Laser Surg	**Effects of Nd:YAG laser irradiation for minimizing edema and pain after sinus lift surgery: randomized controlled clinical trial.**	Human RCT		"The results demonstrate that the 1064 nm Nd:YAG laser was effective in improving OHRQoL and reducing swelling after sinus lift surgery."	PubMed
	Skin	Acne vulgaris	Lee	Korea (Daegu)	2016	Ann Dermatol	**Efficacy of Red or Infrared Light-Emitting Diodes in a Mouse Model of Propionibacterium acnes-Induced Inflammation.**	Mouse	LLLT vs LED		PubMed
	Skin	Acne vulgaris	Alba	Brazil (São Paulo)	2016	J Cosmet Laser Ther	**Clinical comparison of salicylic acid peel and LED-Laser phototherapy to the treatment of acne vulgaris in teenagers.**	Human			PubMed
	Skin	Acne vulgaris	Momen & Al-Niaimi	UK (London)	2015	J Cosmet Laser Ther	**Acne vulgaris and light-based therapies.**	Review			PubMed
	Skin	Acne vulgaris	Liu	China (Beijing)	2014	Photodermatol Photoimmunol Photomed	**Randomized trial of three phototherapy methods for the treatment of acne vulgaris in Chinese patients.**	Human RCT (no control)		At 1 month, >90% clearance or moderate improvement occurred in 22/50 (44%) patients in the LED group. There was no control group.	PubMed
	Skin	Acne vulgaris	Kwon	Korea (Seoul)	2013	Br J Dermatol	**The clinical and histological effect of home-use, combination blue-red LED phototherapy for mild-to-moderate acne vulgaris in Korean patients: a double-blind, randomized controlled trial.**	Human RCT/DB		"At the final visit at 12 weeks, both inflammatory and noninflammatory acne lesions had decreased significantly, by 77% and 54%, respectively, in the treatment group. No significant difference was observed in the control group. In the treatment group, sebum output reduction, attenuated inflammatory cell infiltrations and a decreased size of the sebaceous gland were found. The immunostaining intensities for interleukin (IL)-8, IL-1α, matrix metalloproteinase-9, toll-like receptor-2, nuclear factor-κB, insulin-like growth factor-1 receptor and sterol response element binding protein (SREBP)-1 were reduced concomitantly. Messenger RNA expression of SREBP-1c was also decreased. No severe adverse reactions were reported."	PubMed
	Skin	Acne vulgaris	Aziz-Jalali	Iran (Tehran)	2012	Indian J Dermatol	**Comparison of Red and Infrared Low-level Laser Therapy in the Treatment of Acne Vulgaris.**	Human RCT/SB	Red vs NIR	"Ten weeks after treatment acne lesion were significantly decreased in the side treated by 630 nm LLLT (27.7±12.7 to 6.3±1.9) ($P<0.001$), but this decrease was not significant in the site treated by 890 nm LLLT (26.9±12.4 to 22.2±8.5) ($P>0.05$)."	PubMed
	Skin	Acne vulgaris	Sadick N	USA (New York, NY)	2009	J Cosmet Laser Ther	**A study to determine the effect of combination blue (415 nm) and near-infrared (830 nm) light-emitting diode (LED) therapy for moderate acne vulgaris.**	Human	LED phototherapy (w/ blue light)	"The combination therapy for acne produced results which were less effective in the reduction of inflammatory lesions than those achieved with the previously reported blue/red combination. Further study with a much larger patient population is warranted."	PubMed
	Skin	Acne vulgaris	Hörfelt	Sweden (Göteborg)	2009	Acta Derm Venereol	**Single low-dose red light is as efficacious as methyl-aminolevulinate--photodynamic therapy for treatment of acne: clinical assessment and fluorescence monitoring.**	Human		Red light ("control") was as beneficial as photodynamic therapy. There was no real control group receiving no treatment. "Seaton et al. (26), suggest that light treatment increases the production of transforming growth factor (TGF-ß). which promotes resolution of inflammation. Thus the improvement on the cheek treated with light only could be explained by anti-inflammatory properties by influencing cytokine release from macrophages or other cells (27–29)."	PubMed
	Skin	Acne vulgaris	Hamilton	UK (London)	2009	Br J Dermatol	**Laser and other light therapies for the treatment of acne vulgaris: systematic review.**	Systematic review			PubMed
	Skin	Acne vulgaris	Zane	Italy (Brescia)	2008	Photodermatol Photoimmunol Photomed	**Non-invasive diagnostic evaluation of phototherapeutic effects of red light phototherapy of acne vulgaris.**	Human			PubMed
	Skin	Acne vulgaris	Sadick NS	USA (New York, NY)	2008	J Drugs Dermatol	**Handheld LED array device in the treatment of acne vulgaris.**	Human	LED phototherapy (w/ blue light)	"Lesion counts progressively reduced throughout the 4-week light therapy period and continued to reduce up to 8 weeks posttherapy, with a final average reduction of 69% seen 8 weeks after the treatment course ($P>.001$). This pattern is similar to previously reported studies."	PubMed
☹	Skin	Acne vulgaris	Na & Suh	Korea (Seoul)	2007	Dermatol Surg	**Red light phototherapy alone is effective for acne vulgaris: randomized, single-blinded clinical trial.**	Human Split-face trial	LED phototherapy	"This study shows that red light phototherapy alone can be a new therapeutic option for acne vulgaris." Comment: The parameters were poorly reported.	PubMed
	Skin	Acne vulgaris	Lee	Korea (Seoul)	2007	Lasers Surg Med	**Blue and red light combination LED phototherapy for acne vulgaris in patients with skin phototype IV.**	Human	LED phototherapy (w/ blue light)	"Blue and red light combination LED phototherapy is an effective, safe and non-painful treatment for mild to moderately severe acne vulgaris, particularly for papulopustular acne lesions."	PubMed
	Skin	Acne vulgaris	Goldberg & Russell	USA (New York, NY)	2006	J Cosmet Laser Ther	**Combination blue (415 nm) and red (633 nm) LED phototherapy in the treatment of mild to severe acne vulgaris.**	Human	LED phototherapy (w/ blue light)		PubMed

	Skin	Acne vulgaris	Papageorgiou	UK (London)	2000	Br J Dermatol	**Phototherapy with blue (415 nm) and red (660 nm) light in the treatment of acne vulgaris.**	Human				PubMed
	Skin	Aging	Calderhead & Vasily	Korea & USA	2016	Clin Plast Surg	**Low Level Light Therapy with Light-Emitting Diodes for the Aging Face.**	Review			Comment: This paper contains two useful pictures of absorption spectra of light (penetration) in the 400-10000 nm wavelength range.	
★	Skin	Burns	Dahmardehei	Iran (Tehran)	2016	Lasers Med Sci	**Effects of low level laser therapy on the prognosis of split-thickness skin graft in type 3 burn of diabetic patients: a case series.**	Human Case series	Grade 3 burn ulcer (candidate for amputation)		"The results of this study showed complete healing in the last 8 weeks for all patients who were candidates for amputation. In this case series, we present 13 cases of diabetic ulcer with type 3 burn wound, candidate for amputation, who healed completely using LLLT and STSG. This is the first time that these two techniques are combined for treatment of burn ulcer in diabetic patients. Using LLLT with STSG might be a promising treatment for burn victims especially diabetic patients." Star: The results were interesting, supplied with scary/interesting photographs.	PubMed
	Skin	Cell protection	Mamalis	USA (Sacramento, CA)	2016	J Biophotonics	**High fluence light emitting diode-generated red light modulates characteristics associated with skin fibrosis.**	In vitro	Skin fibrosis		"We demonstrate that HF-LED-RL is capable of inhibiting the unifying cellular processes involved in skin fibrosis including proliferation, migration, and collagen production in vitro. These findings suggest that HF-LED-RL may represent a paradigm shifting approach to altering HDF function for treatment of skin fibrosis."	
	Skin	Cell protection	Chabert	France (Sophia Antipolis)	2015	Skin Res Technol	**Evaluation of light-emitting diodes (LED) effect on skin biology (in vitro study).**	In vitro	Fibroblasts Keratinocytes		"Combined, the LED wavelengths could improve in vitro the cell shape, the cell proliferation, and the level of major proteins involved in the healing process."	PubMed
	Skin	Cell protection	Tian	Korea (Goyang)	2012	Dermatol Surg	**Antiphotoaging effects of light-emitting diode irradiation on narrow-band ultraviolet B-exposed cultured human skin cells.**	In vitro	Wavelength combination Biphasic dose response		"The combination of 630/850- or 660/830-nm irradiation led to better direct and indirect antiphotoaging outcomes than single LED wavelengths in NB-UVB-irradiated cultured normal human skin cells."	PubMed
★	Skin	Dermal abrasion	Gupta	USA (Boston, MA)	2014	Lasers Med Sci	**Effect of red and near-infrared wavelengths on low-level laser (light) therapy-induced healing of partial-thickness dermal abrasion in mice.**	Mouse	Wavelengths		"Wavelengths of 635 and 810 nm were found to be effective in promoting the healing of dermal abrasions. However, treatment using 730- and 980-nm wavelengths showed no sign of stimulated healing. Healing was maximally augmented in mice treated with an 810-nm wavelength, as evidenced by significant wound area reduction ($p < 0.05$), enhanced collagen accumulation, and complete re-epithelialization as compared to other wavelengths and non-illuminated controls." "The effectiveness of 810-nm wavelength agrees with previous publications and, together with the partial effectiveness of 635 nm and the ineffectiveness of 730 and 980 nm wavelengths, can be explained by the absorption spectrum of cytochrome c	PubMed
	Skin	Fibrosis	Mamalis	USA (Sacramento, CA)	2016	Curr Dermatol Rep	**Visible Red Light Emitting Diode Photobiomodulation for Skin Fibrosis: Key Molecular Pathways.**	Review	Mechanisms			PubMed
	Skin	Laser skin resurfacing wounds / erythema	Barolet	Canada	2016	Curr Dermatol Rep	**Accelerating Ablative Fractional Resurfacing Wound Healing Recovery by Photobiomodulation**	Review				Springer
	Skin	Laser skin resurfacing wounds / erythema	Oh	Korea (Seoul)	2013	Dermatol Surg	**Efficacy of light-emitting diode photomodulation in reducing erythema after fractional carbon dioxide laser resurfacing: a pilot study.**	Human Split-face	LED phototherapy (Smartlux, Medmix)		"The postlaser erythema resolved faster on the experimental side than the control side, with improvements noted according to physician assessment and chromometer erythema index. Statistically significant improvements between the two sides were first noted on day 4." "Treatment using a 635-nm-wavelength LED array decreases the intensity and duration of post-fractional CO2 laser treatment erythema."	PubMed
☹	Skin	Laser skin resurfacing wounds / erythema	Alster & Wanitphakdeedecha	USA (Washington, D.C.)	2009	Dermatol Surg	**Improvement of postfractional laser erythema with light-emitting diode photomodulation.**	Human Split-face			"The LED-treated facial halves were less erythematous in all 20 patients 24 hours postoperatively. The six patients who received the highest mean energy densities during fractional laser treatment continued to exhibit decreased erythema in the LED-treated areas at 48 hours. At 96 hours post-treatment, no discernible differences between facial halves were observed in any patient." Comment: The parameters seem contradictory	PubMed
	Skin	Peptides	Hochman	Brazil (São Paulo)	2014	Lasers Med Sci	**Low-level laser therapy and light-emitting diode effects in the secretion of neuropeptides SP and CGRP in rat skin.**	Rat			"P was released in Infrared Laser Group ($p = 0.01$); there was no difference in the CGRP secretion among groups. Infrared (808 nm) LLLT enhances neuropeptide [substance P] secretion in healthy rat skin."	PubMed
	Skin	Psoriasis	Ablon G	USA (Los Angeles, CA)	2010	Photomed Laser Surg	**Combination 830-nm and 633-nm light-emitting diode phototherapy shows promise in the treatment of recalcitrant psoriasis: preliminary findings.**	Human Case series	Recalcitrant psoriasis		"Clearance rates at the end of the follow-up period ranged from 60% to 100%. Satisfaction was universally very high."	PubMed
	Skin	Rejuvenation	Pereira	Brazil (Santos)	2016	J Cosmet Laser Ther	**Non-ablative radiofrequency associated or not with Low Level Laser Therapy on the treatment of facial wrinkles in adult women: a randomized single-blind clinical trial.**	Human RCT/SB			"LLLT did not potentiate RF treatment."	PubMed
	Skin	Rejuvenation	Wunsch & Matuschka	Germany (Heidelberg)	2014	Photomed Laser Surg	**A controlled trial to determine the efficacy of red and near-infrared light treatment in patient satisfaction, reduction of fine lines, wrinkles, skin roughness, and intradermal collagen density increase.**	Human RCT Blinded evaluation	Polychromatic light		"The treated subjects experienced significantly improved skin complexion and skin feeling, profilometrically assessed skin roughness, and ultrasonographically measured collagen density. The blinded clinical evaluation of photographs confirmed significant improvement in the intervention groups compared with the control."	PubMed
★	Skin	Rejuvenation	Barolet	Canada	2009	J Invest Dermatol	**Regulation of skin collagen metabolism in vitro using a pulsed 660 nm LED light source: clinical correlation with a single-blinded study.**	Human split-face study	Collagen & wrinkles		"Results yielded a mean percent difference between LED-treated and non-LED-treated HRS of 31% in levels of type-1 procollagen and of -18% in MMP-1. No histological changes were observed. Furthermore, profilometry quantification revealed that more than 90% of individuals showed a reduction in rhytid depth and surface roughness, and, via a blinded clinical assessment, that 87% experienced a reduction in the Fitzpatrick wrinkling severity score after 12 LED treatments."	PubMed

Skin	Rejuvenation	Lee	Korea (Seoul)	2007	J Photochem Photobiol B	**A prospective, randomized, placebo-controlled, double-blinded, and split-face clinical study on LED phototherapy for skin rejuvenation: clinical, profilometric, histologic, ultrastructural, and biochemical evaluations and comparison of three different treatment settings.**	Human split-face study	Skin rejuvenation (wrinkles etc)	"Our study results showed that LED phototherapy is an effective treatment for skin rejuvenation through objectively measured data and histological and ultrastructural bodies of evidence of increased collagen and elastic fibers as well as clinical photographs and double-blinded assessment of the investigators and the subjects."	PubMed
Skin	Review	Barolet	Canada (Montreal)	2016	J Photochem Photobiol B	**Infrared and skin: Friend or foe.**	Review			PubMed
Skin	Review	Avci	USA (Boston, MA)	2013	Semin Cutan Med Surg	**Low-level laser (light) therapy (LLLT) in skin: stimulating, healing, restoring.**	Review	Mechanisms LED history Ablative fractional resurfacing		PubMed
Skin	Scars	Park	Korea (Suwon)	2016	Dermatol Surg	**Prevention of Thyroidectomy Scars in Asian Adults With Low-Level Light Therapy.**	Human	LED phototherapy	"The average VSS and GAS scores were lower in the treatment group, whereas the subjective score was not significantly different."	PubMed
Skin	Scars	Vranova	Czech	2015	Dermatol Ther	**Comparison of quality of facial scars after single low-level laser therapy and combined low-level with high-level (PDL 595 nm) laser therapy.**	Controlled trial		LLLT improved the appearance of facial scars.	PubMed
Skin	Vitiligo	Lan	Taiwan (Kaohsiung)	2009	Br J Dermatol	**Low-energy helium-neon laser induces melanocyte proliferation via interaction with type IV collagen: visible light as a therapeutic option for vitiligo.**	In vitro		"In summary, we have demonstrated that the He-Ne laser imparts a growth stimulatory effect on functional melanocytes via mitochondria-related pathways and proposed that other minor pathways including DNA damage may also be inflicted by laser treatment on irradiated cells. More importantly, we have completed the repigmentation scheme of vitiligo brought about by He-Ne laser light in vitro and provided a solid theoretical basis regarding how the He-Ne laser induces recovery of vitiligo in vivo."	PubMed
Skin	Vitiligo	Yu	Taiwan (Kaohsiung)	2003	J Invest Dermatol	**Helium-neon laser irradiation stimulates migration and proliferation in melanocytes and induces repigmentation in segmental-type vitiligo.**	Human non-controlled + in vitro		"The results of this in vitro study revealed a significant increase in basic fibroblast growth factor release from both keratinocytes and fibroblasts and a significant increase in nerve growth factor release from keratinocytes." "After an average of 16 treatment sessions, initial repigmentation was noticed. Marked repigmentation (>50%) was observed in 60% of patients with successive treatments." Comment: Nicely written paper and interesting results but the dose is surprisingly low... This paper also is highly cited.	PubMed
Skin		de Jesus	Brazil (Ribeirao Preto)	2016	J Biophotonics	**An ex vivo study of photobiostimulation in the treatment of skin pathologies.**	Ex vivo	Skin explants LLLT or LLLT+PDT	".The results indicate that even at the early phase of the treatment (7 days), the LLLT at low doses 70 mJ · cm–2 and 140 mJ · cm–2 promotes the deposition of new collagen, slightly higher for 70 mJ · cm–2, and the continuous irradiation with higher doses (700 mJ · cm–2) increases the production of type I collagen"	PubMed
Skin		Opel	USA (Maywood, IL)	2015	J Clin Aesthet Dermatol	**Light-emitting Diodes: A Brief Review and Clinical Experience.**	Review + case series			PubMed
Skin		Calderhead	Korea	2015	Laser Ther	**Adjunctive 830 nm light-emitting diode therapy can improve the results following aesthetic procedures.**	Review			PubMed
Skin		Iyomasa	Brazil (São Paulo)	2014	Biomed Res Int	**Ultrastructure and light microscope analysis of intact skin after a varying number of low level laser irradiations in mice.**	Mouse	Biphasic dose response (on collagen type I)	"Under these experimental conditions (20 J/cm2), three, six, and 10 laser applications provided photobiomodulation effect on intact epidermis and dermis of mice, strain HRS/J, without damage being revealed by electron microscopy. However, 10 laser applications decreased the type I collagen on the dermis. Thus, it is clear that more studies are needed to standardize the energy density and number of applications recommended for therapy of TMD to have a better cost-benefit ratio associated with treatment."	PubMed
Skin		Weiss	USA (Maryland)	2005	Dermatol Surg	**Clinical experience with light-emitting diode (LED) photomodulation.**	Case series		"LED photomodulation has been used alone for skin rejuvenation in over 300 patients but has been effective in augmentation of results in 600 patients receiving concomitant nonablative thermal and vascular treatments such as intense pulsed light, pulsed dye laser, KTP and infrared lasers, radiofrequency energy, and ablative lasers." "LED photomodulation reverses signs of photoaging using a new nonthermal mechanism. The anti-inflammatory component of LED in combination with the cell regulatory component helps improve the outcome of other thermal-based rejuvenation treatments."	PubMed
Spinal column	Spinal disk herniation	de Carvalho	Brazil (São José dos Campos)	2016	Lasers Med Sci	**Low intensity laser and LED therapies associated with lateral decubitus position and flexion exercises of the lower limbs in patients with lumbar disk herniation: clinical randomized trial.**	Human RCT/SB (?)		"We can conclude that in the treatment of L4-L5 and L5-S1 LDH with radiculopathy, LED, associated with lateral decubitus position and flexion exercises of the lower limbs, showed better therapeutic performance for radicular pain, gait claudication, and functional disability." Comment: In this study, LLLT fared as well as placebo (still a great improvement), but LED seemed to lead to better results. Comment: The parameters were nicely reported	PubMed
Stem cells & regeneration	Bone marrow stem cells	Cavalcanti	Brazil (São Paulo)	2015	Photomed Laser Surg	**Evaluation of the Proliferative Effects Induced by Low-Level Laser Therapy in Bone Marrow Stem Cell Culture.**	In vitro		The parameters used to irradiate DBMSC increased significantly proliferation without producing high levels of reactive oxygen species (ROS).	PubMed
Stem cells & regeneration	Myogenesis	Hou	China (Beijing)	2008	Lasers Surg Med	**In vitro effects of low-level laser irradiation for bone marrow mesenchymal stem cells: proliferation, growth factors secretion and myogenic differentiation.**	In vitro		"LLLI stimulates proliferation, increases growth factors secretion and facilitates myogenic differentiation of BMSCs. Therefore, LLLI may provide a novel approach for the preconditioning of BMSCs in vitro prior to transplantation."	PubMed
Stem cells & regeneration	Osteogenesis	Yang	China (Shenzhen)	2016	Sci Rep	**Effects of light-emitting diode irradiation on the osteogenesis of human umbilical cord mesenchymal stem cells in vitro.**	In vitro		"In conclusion, low levels of LED light at a wavelength of 620 nm enhance the proliferation and osteogenic differentiation of hUMSCs during a long culture period."	PubMed
Stem cells & regeneration	Osteogenesis	Peng	China (Wuhan)	2012	Lasers Med Sci	**The effect of noncoherent red light irradiation on proliferation and osteogenic differentiation of bone marrow mesenchymal stem cells.**	In vitro		"In conclusion, nonconherent red light can promote proliferation but cannot induce osteogenic differentiation of MSCs in normal media, while it enhances osteogenic differentiation and decreases proliferation of MSCs in media with osteogenic supplements."	PubMed
Stem cells & regeneration	Osteogenesis	Bouvet-Gerbettaz	France (Nice)	2009	Lasers Surg Med	**Effects of low-level laser therapy on proliferation and differentiation of murine bone marrow cells into osteoblasts and osteoclasts.**	In vitro		808nm LLLT didn't alter murine bone progenitor cell proliferation or differentiation.	PubMed
Stem cells & regeneration	Tenogenic induction	Gomiero	Italy & Belgium	2016	Vet Res Commun	**Tenogenic induction of equine mesenchymal stem cells by means of growth factors and low-level laser technology.**	In vitro		"In conclusion, the present study might furnish significant suggestions for developing an efficient approach for tenocyte induction since the external administration of bFGF2 and TGFβ3, along with LLLT, influences the differentiation of PB-MSCs towards the tenogenic fate."	PubMed

	Stem cells & regeneration	Epithelial colony forming units	Khan & Arany	USA (Bethesda, MD)	2016	Photomed Laser Surg	**Photobiomodulation Therapy Promotes Expansion of Epithelial Colony Forming Units.**	In vitro	Laser vs LED	"This study noted a dose-dependent effect of 810 nm laser on increasing eCFUs, either in terms of size or numbers. Comparisons of different wavelengths and light sources noted better efficacy of collimated and coherent lasers compared to LEDs and broad-band light." "PBM therapy promotes expansion of eCFUs that represent progenitors and stem cell	PubMed
	Stem cells & regeneration		Fekrazad	Iran (Tehran)	2016	Photomed Laser Surg	**Effect of Photobiomodulation on Mesenchymal Stem Cells.**	Systematic review			PubMed
	Stem cells & regeneration		Fallahnezhad	Iran (Tehran)	2016	J Biomed Opt	**Low-level laser therapy with helium-neon laser improved viability of osteoporotic bone marrow-derived mesenchymal stem cells from ovariectomy-induced osteoporotic rats.**	In vitro		"LLLT can enhance the viability and proliferation rate of healthy and especially osteoporotic autologous BMMSCs that could be very useful in regenerative medicine for the treatment of OP and fracture of patients who are OP-dependent"	PubMed
	Stem cells & regeneration		Ginani	Brazil (Natal)	2015	Lasers Med Sci	**Effect of low-level laser therapy on mesenchymal stem cell proliferation: a systematic review.**	Meta-analysis			PubMed
	Stem cells & regeneration		Mvula & Abrahamse	South Africa (Johannesburg)	2016	Photomed Laser Surg	**Differentiation Potential of Adipose-Derived Stem Cells When Cocultured with Smooth Muscle Cells, and the Role of Low-Intensity Laser Irradiation.**			"Cell viability and proliferation increased significantly in the cocultured groups that were exposed to LILI alone, as well as in combination with growth factors. Further, there was a significant decrease in the expression of stem cell markers with a concomitant increase in SMC markers."	PubMed
	Stem cells & regeneration		Emelyanov & Kiryanova	Russia (St. Petersburg)	2015	Photomed Laser Surg	**Photomodulation of proliferation and differentiation of stem cells by the visible and infrared light.**	Systematic review			PubMed
	Stem cells & regeneration		Soleimani	Iran (Tehran)	2012	Lasers Med Sci	**The effects of low-level laser irradiation on differentiation and proliferation of human bone marrow mesenchymal stem cells into neurons and osteoblasts--an in vitro study.**	In vitro		"The effect of LLLI on differentiation and proliferation of BMSCs is dose-dependent. Considering these findings, LLLI could improve current in vitro methods of differentiating BMSCs prior to transplantation."	PubMed
	Stem cells & regeneration		Abrahamse H	South Africa (Johannesburg)	2012	Photomed Laser Surg	**Regenerative medicine, stem cells, and low-level laser therapy: future directives.**	Guest Editorial			PubMed
	Stem cells & regeneration		Tuby		2007	Lasers Surg Med	**Low-level laser irradiation (LLLI) promotes proliferation of mesenchymal and cardiac stem cells in culture.**	In vitro	Cardiac stem cells	"The present study clearly demonstrates the ability of LLLI to promote proliferation of MSCs and CSCs in vitro."	PubMed
	Stevens-Johnson syndrome		Simões	Brazil (São Paulo)	2011	Photomed Laser Surg	**Laser phototherapy for Stevens-Johnson syndrome: a case report.**	Case report		"Because of the lack of progress of the patient, the LPT was selected." "By 6 days after his initial session of LPT, most of the patient's intraoral lesions had disappeared, and the few that remained were painless; the patient was able to eat solid food by himself and was removed from the ICU. Ten sessions of LPT were conducted in the hospital."	PubMed
☎	Surgery (flap)	TRAM flap	das Neves	Brazil (Ribeirão Preto)	2016 epub	Lasers Med Sci	**Laser photobiomodulation (830 and 660 nm) in mast cells, VEGF, FGF, and CD34 of the musculocutaneous flap in rats submitted to nicotine.**	Rat		"PBM with a wavelength of 830 nm increased the viability of the TRAM flap, with a smaller area of necrosis, increased number of mast cells, and higher expression of VEGF and CD34. PBM increases the viability of musculocutaneous flaps treated with to nicotine." Note: The photograph quality is low.	PubMed
	Systemic effects		Johnstone	Australia	2015	Neural Regen Res	**Targeting the body to protect the brain: inducing neuroprotection with remotely-applied near infrared light.**	Perspective	Alzheimer's disease		PubMed
	Systemic effects		Lima	Brazil (Salvador, Bahia)	2014	Lasers Med Sci	**Evaluation of corticosterone and IL-1β, IL-6, IL-10 and TNF-α expression after 670-nm laser photobiomodulation in rats.**	Rat	Corticosterone Cytokines	"At 6 h after surgery, a significant increase in corticosterone and a significant reduction in the levels of IL-1β and IL-6 in tissues of irradiated wounds were observed when compared to controls ($p < 0.05$). The levels of TNF-α and IL-10 expression were not significantly different between the groups at different time intervals. Thus, this study strongly suggests a systemic and local biomodulation of low-level laser therapy as indicated by the blood levels of corticosterone and the tissue expression of IL-1β and IL-6, respectively."	PubMed
	Tendons	Achilles tendon	Tumilty	New Zealand	2016	Lasers Med Sci	**Photobiomodulation and eccentric exercise for Achilles tendinopathy: a randomized controlled trial.**	Human RCT		LLLT seemed to improve the benefits of exercise, but only in the group which had exercise sessions only twice a week.	PubMed
	Tendons	Achilles tendon	Mårdh & Lund	Sweden (Stockholm)	2016	J Lasers Med Sci	**High Power Laser for Treatment of Achilles Tendinosis - a Single Blind Randomized Placebo Controlled Clinical Study.**	Human RCT		"The between group difference were significant in four of nine questions regarding loading activities of the FAOS subscale. Assessed pain thresholds were found increased in the HPLT group, as compared to the placebo HPLT group. At individual level, the results varied." "The results indicate that HPLT may provide a future option for treatment of Achilles tendinosis related pain, but further studies are warranted."	PubMed
	Tendons	Achilles tendon	Da Ré Guerra	Brazil (Alfenas)	2016	Lasers Med Sci	**Low-level laser therapy modulates pro-inflammatory cytokines after partial tenotomy.**	Rats		"Our results showed that the pulsed LLLT seems to exert an anti-inflammatory effect over injured tendons, with reduction of the release of proinflammatory cytokines, such as TNF-α and the decrease in the i-NOS activity. Thanks to the pain reduction and the facilitation of movement, there was a stimulation in the TGF-β and IL-1β release. In conclusion, we believe that pulsed LLLT worked effectively as a therapy to reestablish the tendon integrity after rupture."	PubMed
	Tendons	Achilles tendon	Marques	Brazil (São Paulo)	2016	Lasers Med Sci	**Photobiomodulation therapy on collagen type I and III, vascular endothelial growth factor, and metalloproteinase in experimentally induced tendinopathy in aged rats.**	Rat	Collagenase-induced tendinopathy	"Our findings indicate that PBMT may lead to the improvement and acceleration of inflammation when compared to tendinopathy aged group."	PubMed
	Tendons	Achilles tendon	Helrigle	Brazil (São Paulo)	2016	Lasers Med Sci	**Effects of low-intensity non-coherent light therapy on the inflammatory process in the calcaneal tendon of ovariectomized rats.**	Rat	LED phototherapy	"It was concluded that low-intensity LED treatment using the parameters and wavelength of 945 nm in the time periods studied reduced the release of IL-6 and TNF-α and increased the release of IL-10, thereby improving the inflammatory response in OVX rats."	PubMed
	Tendons	Achilles tendon	Haslerud	Norway (Bergen)	2016	Photomed Laser Surg	**Low-Level Laser Therapy and Cryotherapy as Mono- and Adjunctive Therapies for Achilles Tendinopathy in Rats.**	Rat	Tendon injury	"Our results demonstrate that cryotherapy in combination with LLLT can produce an anti-inflammatory "add-on" effect." "The order of therapy administration seems essential, as superior histology and biomechanical results were found in the cryotherapy first/LLLT group."	PubMed
	Tendons	Achilles tendon	de Jesus	Brazil (São Paulo)	2016	Photomed Laser Surg	**Low-Level Laser Therapy (780 nm) on VEGF Modulation at Partially Injured Achilles Tendon.**	Rat	Tendon injury	LLLT did not stimulate the expression of VEGF in the treated Achilles tendons.	PubMed
	Tendons	Achilles tendon	Torres-Silva	Brazil (São Paulo)	2015	Lasers Med Sci	**The low level laser therapy (LLLT) operating in 660 nm reduce gene expression of inflammatory mediators in the experimental model of collagenase-induced rat tendinitis.**	Rat	Collagenase-induced tendinitis	"The laser irradiation (660 nm, 100 mW, 3 J) used in the treatment of the tendinitis induced by collagenase in Achilles tendon in rats was effective in the reduction of important pro-inflammatory markers such as IL-6 and TNF-α, becoming a promising tool for the treatment of tendon diseases."	PubMed

	Tendons	Achilles tendon	Ferreira	Brazil (São Paulo)	2015	Photomed Laser Surg	**Achilles Tendon Vascularization of Proximal, Medial, and Distal Portion Before and After Partial Lesion in Rats Treated with Phototherapy.**	Rat	Vascularization	"Low-level laser therapy (LLLT) had no effect on the studied parameters."	PubMed
	Tendons	Achilles tendon	de Jesus	Brazil (São Paulo)	2015	Lasers Med Sci	**Low-level laser therapy in IL-1β, COX-2, and PGE2 modulation in partially injured Achilles tendon.**	Rat	Tendon injury	"LLLT decreased Achilles tendon's inflammatory process."	PubMed
	Tendons	Achilles tendon	Chang	Taiwan (Taipei)	2015	J Orthop Sports Phys Ther	**Effects of Therapeutic Physical Agents on Achilles Tendon Microcirculation.**	Human	Microcirculation	"No significant THb and StO2 differences were found after the application of interferential current or low-level laser."	PubMed
	Tendons	Achilles tendon	Allahverdi	Iran (Tehran)	2015	Lasers Med Sci	**Evaluation of low-level laser therapy, platelet-rich plasma, and their combination on the healing of Achilles tendon in rabbits.**	Rabbit	Partial tenotomy	"The results for these parameters showed that PRP or LLLT alone has significant advantages over untreated animals (P < 0.05). Furthermore, it was found that the combined treatment with PRP and LLLT is even more efficient."	PubMed
	Tendons	Achilles tendon	Xavier	Brazil (Diamantina)	2014	Lasers Med Sci	**Low-level light-emitting diode therapy increases mRNA expressions of IL-10 and type I and III collagens on Achilles tendinitis in rats.**	Rat	LED phototherapy	"LED (880 nm) was effective in increasing mRNA expression of IL-10 and type I and III collagen. Therefore, LED therapy may have potentially therapeutic effects on Achilles tendon injuries."	PubMed
	Tendons	Achilles tendon	Pinfildi	Brazil (São Paulo)	2014	Photomed Laser Surg	**Mast cell curve-response in partial Achilles tendon rupture after 830 nm phototherapy.**	Rat	Tendon rupture by direct trauma	LLLT was shown to increase the quantity of mastocytes in the assessment periods compared with the simulation groups.	PubMed
★	Tendons	Achilles tendon	Marcos	Brazil (São Paulo)	2014	J Mech Behav Biomed Mater	**Biomechanical and biochemical protective effect of low-level laser therapy for Achilles tendinitis.**	Rat	Collagenase-induced tendinitis PBM vs diclofenac	"The treatment by non-steroidal anti-inflammatory drugs such as diclofenac sodium produces a low protective effect and can affect the short-term biochemical and biomechanical properties. On the contrary, it is shown that LLLT exhibits the best results in terms of MMPs reduction and mechanical properties recovery. Thus, LLLT looks to be a promising and consistent treatment for tendinopathies." Star: This article contains a lot of data - might be interesting to experts.	PubMed
	Tendons	Achilles tendon	Guerra Fda	Brazil (São Paulo)	2014	Lasers Med Sci	**Pulsed LLLT improves tendon healing in rats: a biochemical, organizational, and functional evaluation.**	Rat	Partial transection of tendon	"In conclusion, pulsed LLLT leads to increased organization of collagen bundles and improved gait recovery."	PubMed
	Tendons	Achilles tendon	de Jesus	Brazil (São Paulo)	2014	Photomed Laser Surg	**Low-level laser therapy on tissue repair of partially injured achilles tendon in rats.**	Rat	Partial tendon injury	"LLLT stimulated collagen I proliferation, improving the injured Achilles tendons' healing process."	PubMed
	Tendons	Achilles tendon	Casalechi	Brazil (São Paulo)	2014	Lasers Med Sci	**Analysis of the effect of phototherapy in model with traumatic Achilles tendon injury in rats.**	Rat	Injury by contusion	"It was concluded that treatment with LIL in the parameters used and the times studied reduces migration of inflammatory cells and improves the quality of repair while reducing the functional limitations."	PubMed
	Tendons	Achilles tendon	Aliodoust	Iran (Tehran)	2014	Lasers Med Sci	**Evaluating the effect of low-level laser therapy on healing of tentomized Achilles tendon in streptozotocin-induced diabetic rats by light microscopical and gene expression examinations.**	Rat	Surgical tenotomy	"LLLT significantly decreased inflammation in diabetic rats on days 5 (p = 0.03) and 10 (p = 0.02) compared to the corresponding control diabetic rats. According to the student's t test, LLLT significantly increased TGF-β1 gene expression in healthy (p = 0.000) and diabetic (p = 0.000) rats compared to their relevant controls. The He-Ne laser was effective in altering the inflammatory reaction and increasing TGF-β1 gene production."	PubMed
	Tendons	Achilles tendon	Nouruzian	Iran (Tehran)	2013	Lasers Med Sci	**Effect of low-level laser therapy on healing of tenotomized Achilles tendon in streptozotocin-induced diabetic rats.**	Rat	Tenotomy + diabetes	"LLLT at 2.9 J/cm(2) to the tenotomized Achilles tendons in the non-diabetic and diabetic rats significantly increased the strength and maximum stress of repairing Achilles tendons in our study."	PubMed
	Tendons	Achilles tendon	Barbosa	Brazil (São José dos Campos)	2013	Lasers Med Sci	**Low-level laser therapy combined with platelet-rich plasma on the healing calcaneal tendon: a histological study in a rat model.**	Rat		"Results showed that the deposition of collagen type I was higher when treatment with PRP and LLLT was combined, suggesting a faster regeneration of the tendon."	PubMed
	Tendons	Achilles tendon	Guerra	Brazil (São Paulo)	2013	Lasers Med Sci	**LLLT improves tendon healing through increase of MMP activity and collagen synthesis.**	Rat	Tenotomy	"Our results indicate that the pulsed LLLT improved the remodeling of the ECM during the healing process in tendons through activation of MMP-2 and stimulation of collagen synthesis."	PubMed
	Tendons	Achilles tendon	Casalechi	Brazil (São Paulo)	2013	Lasers Med Sci	**Low-level laser therapy in experimental model of collagenase-induced tendinitis in rats: effects in acute and chronic inflammatory phases.**	Rat		"Our results suggest that LLLT with parameters employed in the present study was able to modulate IL-10, VEGF, MMP1, and MMP13 mRNA gene expression both in acute than in chronic tendon inflammation. However, further studies are needed to establish optimal parameters for LLLT."	PubMed
	Tendons	Achilles tendon	Tumilty	New Zealand	2012	Arch Phys Med Rehabil	**Clinical effectiveness of low-level laser therapy as an adjunct to eccentric exercise for the treatment of Achilles' tendinopathy: a randomized controlled trial.**	Human RCT		"The clinical effectiveness of adding LLLT to eccentric exercises for the treatment of Achilles' tendinopathy has not been demonstrated using the parameters in this study." (See Comment & Reply. According to Bjordal&Lopes-Martins, the actual dose was more than 10x smaller than Tumilty et al. reported in their paper.)	PubMed
	Tendons	Achilles tendon	Rowe	UK (London)	2012	Sports Med	**Conservative management of midportion Achilles tendinopathy: a mixed methods study, integrating systematic review and clinical reasoning.**	Systematic review			PubMed
	Tendons	Achilles tendon	Ng & Chung	China (Hong Kong)	2012	Photomed Laser Surg	**Effects of a therapeutic laser and passive stretching program for treating tendon overuse.**	Rat	Achilles overuse	"We conclude that a therapeutic laser and combined laser with passive stretching might slow down the decrease in Achilles tendon strength but would not be able to stop the pathological changes of overuse from developing."	PubMed
	Tendons	Achilles tendon	Marcos	Brazil (São Paulo)	2012	J Orthop Res	**Low-level laser therapy in collagenase-induced Achilles tendinitis in rats: analyses of biochemical and biomechanical aspects.**	Rat	Collagenase-induced tendinitis PBM vs diclofenac	"Biomechanical properties were preserved in the laser-treated groups when compared to collagenase and diclofenac groups. We conclude that LLLT was able to reduce tendon inflammation and to preserve tendon resistance and elasticity."	PubMed
	Tendons	Achilles tendon	Laraia	Brazil (Campo Grande)	2012	Lasers Med Sci	**Effect of low-level laser therapy (660 nm) on acute inflammation induced by tenotomy of Achilles tendon in rats.**	Rat	Tenotomy	"We conclude that LLLT is an important modulator of inflammatory cytokines release after injury in Achilles tendon."	PubMed
	Tendons	Achilles tendon	Joensen	Norway (Bergen)	2012	Lasers Med Sci	**An experimental study of low-level laser therapy in rat Achilles tendon injury.**	Rat	Blunt trauma	"There was a significant increase in tendon thickness in the active LLLT group when compared with the placebo group (p < 0.05) and there were no significant differences between the placebo and uninjured left tendons. There were no significant differences in UTS between laser-treated, placebo-treated and uninjured tendons. Laser irradiation of the Achilles tendon at 0.158 W/cm(2) for 50 s (3 J) administered within the first 30 min after blunt trauma, and repeated after 15 h, appears to lead to edema of the tendon measured 23 hours after LLLT. "	PubMed
	Tendons	Achilles tendon	Pires	Brazil (São José dos Campos)	2011	Lasers Med Sci	**Low-level laser therapy (LLLT; 780 nm) acts differently on mRNA expression of anti- and pro-inflammatory mediators in an experimental model of collagenase-induced tendinitis in rat.**	Rat	Collagenase-induced tendinitis	"LLLT in both acute and chronic phases decreased IL-6, COX-2, and TGF-β expression after tendinitis, respectively, when compared to tendinitis groups: IL-6, COX-2, and TGF-β. The LLLT not altered IL-1β expression in any time, but reduced the TNF-α expression; however, only at chronic phase. We conclude that LLLT administered with this protocol reduces one of features of tendinopathies that is mRNA expression for pro-inflammatory mediators."	PubMed

	Tendons	Achilles tendon	Neves	Brazil (São Paulo)	2011	Photomed Laser Surg	**Different power settings of LLLT on the repair of the calcaneal tendon.**	Rat	Partial tendon rupture	"Low-level laser therapy resulted in significantly greater amounts of type III collagen (output powers of 60 mW or more) and type I collagen (output power of 80 mW), however, no significant differences between groups were found in the realignment of collagen fibers."	PubMed
	Tendons	Achilles tendon	Marcos	Brazil (São Paulo)	2011	Photochem Photobiol	**Infrared (810 nm) low-level laser therapy in rat achilles tendinitis: a consistent alternative to drugs.**	Rat Collagenase-induced tendinitis PBM vs diclofenac Biphasic dose response		"As LLLT seems to act on inflammation through a selective inhibition of the COX-2 isoform in collagenase-induced tendinitis, LLLT may have potential to become a new and safer nondrug alternative to coxibs." "We found that LLLT dose of 3 J significantly reduced inflammation through less COX-2-derived gene expression and PGE(2) production, and less edema formation compared to nonirradiated controls."	PubMed
	Tendons	Achilles tendon	Xavier	Brazil (São Paulo)	2010	Lasers Surg Med	**Anti-inflammatory effects of low-level light emitting diode therapy on Achilles tendinitis in rats.**	Rat	LED phototherapy	"Our results showed that LED decreases the inflammatory cells influx and mRNA expression to IL-1 beta, IL-6, tumor necrosis factor-alpha (TNF-alpha) in both phase, and cyclooxygenase-2 (COX-2) just in initial phase (P < 0.05)."	PubMed
	Tendons	Achilles tendon	Wood	Brazil (São Paulo)	2010	Lasers Surg Med	**Collagen changes and realignment induced by low-level laser therapy and low-intensity ultrasound in the calcaneal tendon.**	Rat		"Ultrasound, LLLT, and the combined use of LLLT and US resulted in greater synthesis of type I collagen"	PubMed
	Tendons	Achilles tendon	Oliveira	Brazil (São Paulo)	2009	Lasers Surg Med	**Effect of low level laser therapy (830 nm) with different therapy regimes on the process of tissue repair in partial lesion calcaneous tendon.**	Rat		"Low intensity laser therapy was effective in the improvement of collagen fibers organization of the calcaneous tendon after undergoing a partial lesion."	PubMed
	Tendons	Achilles tendon	Chen	Taiwan (Kaohsiung)	2009	J Orthop Res	**Low-level laser irradiation promotes cell proliferation and mRNA expression of type I collagen and decorin in porcine Achilles tendon fibroblasts in vitro.**	In vitro		"When compared to the control group, the cell proliferation of irradiated Achilles tendon fibroblasts in the other three groups increased significantly by 13% +/- 0.8% (Group 2), 30% +/- 0.4% (Group 3), and 12% +/- 0.6% (Group 4) respectively. But progressively higher laser intensity did not achieve a correspondingly higher cell proliferation effect in Achilles tendon fibroblasts. The mRNA expressions of decorin and type I collagen in fibroblasts with LLLI were significantly higher ($p < 0.05$). Therefore, suitable dosages of LLLI may result in more effective tissue healing by promoting type I collagen and decorin synthesis. However, these positive effects of LLLI on the repair of the Achilles tendon in humans should be [illegible]"	PubMed
	Tendons	Achilles tendon	Casalechi	Brazil (São Paulo)	2009	Lasers Med Sci	**The effects of low-level light emitting diode on the repair process of Achilles tendon therapy in rats.**	Rat		"This study demonstrated that LED interfered in the repair process of the tendon tissue, reducing the number of fibroblasts in the initial periods and improving the quality of the repair in all periods studied."	PubMed
	Tendons	Achilles tendon	Tumilty	New Zealand	2008	Photomed Laser Surg	**Laser therapy in the treatment of achilles tendinopathy: a pilot study.**	Human Pilot study		"This study has demonstrated the feasibility of undertaking a randomized controlled trial of LLLT for Achilles tendinopathy. Conclusions regarding effectiveness cannot be made due to the low statistical power of this pilot study."	PubMed
★	Tendons	Achilles tendon	Stergioulas	Norway (Bergen)	2008	Am J Sports Med	**Effects of low-level laser therapy and eccentric exercises in the treatment of recreational athletes with chronic achilles tendinopathy.**	Human RCT		"Low-level laser therapy, with the parameters used in this study, accelerates clinical recovery from chronic Achilles tendinopathy when added to an EE regimen. For the LLLT group, the results at 4 weeks were similar to the placebo LLLT group results after 12 weeks."	PubMed
★ ☹ ☎	Tendons	Achilles tendon	Elwakil TF	Egypt (Cairo)	2007	Lasers Med Sci	**An in-vivo experimental evaluation of He-Ne laser photostimulation in healing Achilles tendons.**	Rabbit tendons		"The histopathological findings suggest the favorable qualitative pattern of the newly synthesized collagen of the regenerating tendons after He-Ne laser photostimulation. The biomechanical results support the same favorable findings from the functional point of view as denoted by the better biomechanical properties of the regenerating tendons after He-Ne laser photostimulation with statistical significance ($p <or= 0.01$) at most of the biomechanical parameters" Star: Paper was supplied with photographs of Achilles tendon and LLLT. Comment: Parameters were insufficiently reported.	PubMed
	Tendons	Achilles tendon	Carrinho	Brazil (Sao Carlos)	2006	Photomed Laser Surg	**Comparative study using 685-nm and 830-nm lasers in the tissue repair of tenotomized tendons in the mouse.**	Mouse	Tenotomy	"All wavelengths and fluences used in this study were efficient at accelerating the healing process of Achilles tendon post-tenotomy, particularly after the 685-nm laser irradiation, at 3 J/cm(2). It suggests the existence of wavelength tissue specificity and dose dependencv."	PubMed
	Tendons	Achilles tendon	Salate	Brazil (São Paulo)	2005	Photomed Laser Surg	**Effect of In-Ga-Al-P diode laser irradiation on angiogenesis in partial ruptures of Achilles tendon in rats.**	Rat		"LLLT of different intensities seems to promote neovascularization in damaged Achilles tendons of rats after partial rupture compared to controls."	PubMed
	Tendons	Achilles tendon	Fillipin	Brazil (Rio Grande do Sul)	2005	Lasers Surg Med	**Low-level laser therapy (LLLT) prevents oxidative stress and reduces fibrosis in rat traumatized Achilles tendon.**	Rat		"LLLT by Ga-As laser reduces histological abnormalities, collagen concentration, and oxidative stress in an experimental model of Achilles tendon injury. Reduction of fibrosis could be mediated by the beneficial effects on the oxidant/antioxidant balance."	PubMed
	Tendons	Achilles tendon	Demir	Turkey (Kayseri)	2004	Lasers Surg Med	**Comparison of the effects of laser, ultrasound, and combined laser + ultrasound treatments in experimental tendon healing.**	Rat	Traumatized tendons	"Although US, L, and combined US + L treatments increased tendon healing biochemically and biomechanically more than the control groups, no statistically significant difference was found between them."	PubMed
	Tendons	Cells	Chen	Taiwan (Taipei)	2015	Lasers Med Sci	**Second messengers mediating the proliferation and collagen synthesis of tenocytes induced by low-level laser irradiation.**	In vitro	Tenocyte function	"The findings suggested that LLLT stimulated ATP production and increased intracellular calcium concentration. Directly or indirectly via production of TGF-β1, these second messengers mediated the proliferation of tenocytes and synthesis of collagen."	PubMed
	Tendons	Cells	Tsai	Taiwan (Taoyuan County)	2014	Lasers Med Sci	**Low-level laser irradiation stimulates tenocyte proliferation in association with increased NO synthesis and upregulation of PCNA and cyclins.**	In vitro	Tenocyte proliferation	"The results revealed that tenocytes proliferation was enhanced dose dependently by laser. NO secretion was increased after laser treatment. PCNA and cyclins E, A, and B1 were upregulated by laser. In conclusion, low-level laser irradiation stimulates tenocyte proliferation in a process that is mediated by upregulation of NO, PCNA, and cyclins E, A, and B1."	PubMed
	Tendons	de Quervain's tenosynovitis	Sharma	India (New Delhi)	2015	Indian J Orthop	**Outcome of low level lasers versus ultrasonic therapy in de Quervain's tenosynovitis.**	Human Comparison trial		"On comparing both the groups, no statistically significant difference was found. However, looking at the mean values, the grip strength and VAS showed better improvement in the US Th. group as compared to the laser therapy group."	PubMed
	Tendons	Digital flexor tendons	Iacopetti	Italy (Padua)	2015	Photomed Laser Surg	**Effect of MLS(®) laser therapy with different dose regimes for the treatment of experimentally induced tendinopathy in sheep: pilot study.**	Sheep	MLS laser therapy Biphasic dose response (?)	"In this study, clinical and histological evaluation demonstrated that a therapeutic dose <5 J/cm(2) furnished an anti-inflammatory effect, and induced a decrease of fibroblasts and vessel area. Overall, our results suggest that MLS laser therapy was effective in improving collagen fiber organization in the deep digital flexor tendon." "The aggravation of the inflammatory condition, observed during the applications of MLS laser therapy in the first group, seems to indicate that, for the treatment of an acute tendinitis with this type of laser emission, the dose of 5 J/cm2 was excessive for the therapeutic effect. Results from histological examinations indicate that both treatments induced a statistically significant cell number decrease, although only in the second group did the values return to normal. Moreover, the MLS dose of 2.5 J/ cm2 (group 2) caused a significant decrease of the vessel area"	PubMed

	Tendons	Digital flexor tendons	Ozkan	Turkey (Bursa)	2004	J Clin Laser Med Surg	**Investigation of the supplementary effect of GaAs laser therapy on the rehabilitation of human digital flexor tendons.**	Human RCT/DB		"The results of the study showed a significant improvement in the laser-treated group only for the parameter of edema reduction ($p < 0.01$) but the difference between the two groups was non-significant for pain reduction, hand grip strength, and functional evaluation performed according to Strickland and Buck-Gramcko systems using total active motion and fingertip-to distal palmar crease distance parameters ($p > 0.05$)." Comment: The final results were very good both for placebo and laser. Therefore, supplementary laser treatment might be not warranted for this condition.	PubMed
	Tendons	Shoulder	Haslerud	Norway (Bergen)	2015	Physiother Res Int	**The efficacy of low-level laser therapy for shoulder tendinopathy: a systematic review and meta-analysis of randomized controlled trials.**	Meta-analysis	Shoulder tendinopathy		PubMed
	Tendons		Doyle	USA (Marion, IN)	2016	J Sport Rehabil	**The Effects of Low-Level Laser Therapy on Pain Associated With Tendinopathy: A Critically Appraised Topic.**	Review	Tendinopathy		PubMed
	Tendons	Tennis elbow	Weber	Germany (Darmstadt)	2015	BMC Musculoskelet Disord	**Efficacy of physical therapy for the treatment of lateral epicondylitis: a meta-analysis.**	Meta-analysis			PubMed
	Tendons	Tennis elbow	Roberts	Canada (Castlegar)	2013	Lasers Surg Med	**The effectiveness of therapeutic class IV (10 W) laser treatment for epicondylitis.**	Human RCT/DB		"In the laser treated group handgrip strength improved by 17 ± 3%, 52 ± 7%, and 66 ± 6% at 3, 6, and 12 months respectively; function improved by 44 ± 1%, 71 ± 3%, and 82 ± 2%, and pain with resistance to extension of the middle finger was reduced by 50 ± 6%, 93 ± 4%, and 100 ± 1% at 3, 6 and 12 months, respectively. In contrast, no changes were seen until 12 months following sham treatment (12 months: strength improved by 13 ± 2%, function improved by 52 ± 3%, pain with resistance to extension of the middle finger reduced by 76 ± 2%)." [See additional info]	PubMed
★	Tendons	Tennis elbow	Chang	Taiwan (Miaoli)	2010	Photomed Laser Surg	**Therapeutic effects of low-level laser on lateral epicondylitis from differential interventions of Chinese-Western medicine: systematic review.**	Systematic review			PubMed
	Tendons	Tennis elbow	Bjordal	Norway (Bergen)	2008	BMC Musculoskelet Disord	**A systematic review with procedural assessments and meta-analysis of low level laser therapy in lateral elbow tendinopathy (tennis elbow).**	Meta-analysis			PubMed
	Tendons	Tennis elbow	Simunovic	Switzerland & Croatia	1998	J Clin Laser Med Surg	**Treatment of medial and lateral epicondylitis--tennis and golfer's elbow--with low level laser therapy: a multicenter double blind, placebo-controlled clinical study on 324 patients.**	Human RCT		The best result was achieved with combination therapy (trigger points + scanning). Total relief of the pain with consequently improved functional ability was achieved in 82% of acute and 66% of chronic cases	PubMed
	Tendons		Lopes-Martins RA	Brazil (São Paulo)	2014	Photomed Laser Surg	**Tendinitis, an open avenue for low-level laser therapy.**	Guest Editorial			PubMed
	Tendons		Tsai	Taiwan (Taoyuan County)	2012	PLoS One	**Low-level laser irradiation stimulates tenocyte migration with up-regulation of dynamin II expression.**	In vitro	Tenocyte migration	"In conclusion, low-level laser irradiation stimulates tenocyte migration in a process that is mediated by up-regulation of dynamin 2, which can be suppressed by dynasore."	PubMed
	Tendons		Tumilty	New Zealand	2010	Photomed Laser Surg	**Low level laser treatment of tendinopathy: a systematic review with meta-analysis.**	Meta-analysis	Tendinopathy: Achilles and epicondylitis Importance of dosage		PubMed
	Thyroid	Hormones	Morcos	Egypt (Cairo)	2015	Photochem Photobiol	**Phototherapeutic Effect of Low-Level Laser on Thyroid Gland of Gamma-Irradiated Rats.**	Rat	Gamma radiation	"Results revealed improvement in thyroid function, liver function and antioxidant levels, and the blood cells count after LLLT."	PubMed
💼	Thyroid	Hormones	Weber	Brazil (Porto Alegre)	2014	Photomed Laser Surg	**Effect of three different protocols of low-level laser therapy on thyroid hormone production after dental implant placement in an experimental rabbit model.**	Rabbit		"Although not reaching abnormal values, LLLT applied to the mandible influenced thyroid function in this model."	PubMed
	Thyroid	Hormones	Fronza	Brazil (Porto Alegre)	2013	Int J Oral Maxillofac Surg	**Assessment of the systemic effects of low-level laser therapy (LLLT) on thyroid hormone function in a rabbit model.**	Rabbit	Systemic effects	"With the irradiation protocol used in this study, LLLT did not affect thyroid function in rabbits as assessed by circulating serum triiodothyronine and thyroxine levels."	PubMed
★	Thyroid	Hypothyroidism	Höfling	Brazil (São Paulo)	2013	Lasers Med Sci	**Low-level laser in the treatment of patients with hypothyroidism induced by chronic autoimmune thyroiditis: a randomized, placebo-controlled clinical trial.**	Human RCT	Autoimmune hypothyroidism	"The results showed a significant difference in the mean levothyroxine dose required to treat the hypothyroidism between the L group (38.59 ± 20.22 μg/day) and the P group (106.88 ± 22.90 μg/day, $P<0.001$). Lower TPOAb ($P=0.043$) and greater echogenicity ($P<0.001$) were also noted in the L group."	PubMed
	Thyroid	Hypothyroidism	Höfling	Brazil (São Paulo)	2012	ISRN Endocrinol	**Assessment of the effects of low-level laser therapy on the thyroid vascularization of patients with autoimmune hypothyroidism by color Doppler ultrasound.**	Human RCT	Autoimmune hypothyroidism	LLLT improved thyroid vascularization in the patients.	PubMed
	Thyroid	Hypothyroidism	Höfling	Brazil (São Paulo)	2010	Lasers Surg Med	**Low-level laser therapy in chronic autoimmune thyroiditis: a pilot study.**	Human Pilot study	Autoimmune hypothyroidism	The first English paper on treating hypothyroid patients with LLLT. 47% of patients could discontinue thyroxine medication.	PubMed
	Toxins	Snake venom	Franco	Brazil (São Paulo)	2016	Lasers Med Sci	**Effect of photobiomodulation on endothelial cell exposed to Bothrops jararaca venom.**	In vitro		"PBM at 660 and 780 nm wavelength was able to increase cellular viability and decrease the release of LDH and the loss of cellular integrity. In addition, the concentration of pro-inflammatory cytokine IL1-β was reduced after PBM by both wavelengths. The data reported herein indicates that irradiation with red or near-infrared laser resulted in protection on endothelial cells after exposure to Bothrops venom and could be, at least in part, a reasonable explanation by the beneficial effects of PBM inhibiting the local effects induced by Bothrops venoms, in vivo."	PubMed
	Toxins	Snake venom	Vieira	Brazil (São Paulo)	2016	PLoS One	**Low-Level Laser Therapy (904 nm) Counteracts Motor Deficit of Mice Hind Limb following Skeletal Muscle Injury Caused by Snakebite-Mimicking Intramuscular Venom Injection.**	Mouse		"The venom + laser group kept the values at 3 hours post-Bjssu equal to that at 24 hours before Bjssu injection indicating that the GaAs laser therapy improved spatially and temporally gait parameters at the critical injury period caused by Bjssu."	PubMed
	Toxins	Snake venom	Silva	Brazil (São Paulo)	2016	PLoS One	**Photobiomodulation Protects and Promotes Differentiation of C2C12 Myoblast Cells Exposed to Snake Venom.**	In vitro		"Infrared and red laser at all energy densities were able to considerably decrease venom-induced cytotoxicity. Laser irradiation induced myoblasts to differentiate into myotubes and this effect was accompanied by up regulation of MyoD and specially myogenin. Moreover, LLL was able to reduce the extracellular while increased the intracellular ATP content after venom exposure."	PubMed

	Toxins	Snake venom	Nadur-Andrade	Brazil (São Paulo)	2014	Photochem Photobiol Sci	**Photobiostimulation reduces edema formation induced in mice by Lys-49 phospholipases A2 isolated from Bothrops moojeni venom.**	Mouse	LLLT+LED LLLT vs LED LED phototherapy	"LLL and LED irradiation significantly reduced the edema formation by both myotoxins from 1 up to 6 hours after the injection. Both LLL and LEDs were similar in reducing the edema formation induced by myotoxins. The combined photobiostimulation with antivenom had the same effect in reducing edema as treatment with the LLL or LEDs alone."	PubMed
	Toxins	Snake venom	Aranha de Sousa	Brazil (Macapa)	2013	Photochem Photobiol Sci	**Effects of a low-level semiconductor gallium arsenide laser on local pathological alterations induced by Bothrops moojeni snake venom.**	Mouse		"The results indicated that GaAs laser irradiation can help in reducing some local effects produced by the B. moojeni venom in mice, stimulating phagocytosis, proliferation of myoblasts and the regeneration of muscle fibers."	PubMed
	Toxins	Snake venom	Nadur-Andrade	Brazil (São Paulo)	2012	Lasers Med Sci	**Effects of photobiostimulation on edema and hemorrhage induced by Bothrops moojeni venom.**	Mouse	LED phototherapy	"In conclusion, both LLL and LED irradiation reduced venom-induced local effects even though symptoms were already present."	PubMed
	Toxins	Snake venom	Dourado	Brazil (Campinas)	2011	Photochem Photobiol	**Low-level laser therapy promotes vascular endothelial growth factor receptor-1 expression in endothelial and nonendothelial cells of mice gastrocnemius exposed to snake venom.**	Mouse	LLLT vs LED	"At 3 days, LLLT increased angiogenesis (80%:HeNe vs 40%:GaAs), decreased neutrophils and increased proliferation of regenerating cells. However, after 21 days, myoregeneration observed in the [633nm] group appeared delayed compared with the V group. As LLLT improved revascularization, the suggestive delay in myoregeneration could be a dose-response inhibitory effect caused by multiple irradiations in myogenesis."	PubMed
	Toxins	Snake venom	Doin-Silva	Brazil (São Paulo)	2009	Photochem Photobiol Sci	**The ability of low level laser therapy to prevent muscle tissue damage induced by snake venom.**	Rat nerve-muscle preparation	Myonecrosis	"We conclude that HeNe laser irradiation at a dosage of 3.5 J cm(-2) effectively reduces myonecrosis and the neuromuscular transmission blocking effect caused by B. jararacussu snake venom."	PubMed
	Toxins	Snake venom	Barbosa	Brazil (São Paulo)	2009	Photomed Laser Surg	**Effect of low-level laser therapy in the myonecrosis induced by Bothrops jararacussu snake venom.**	Mouse	Myonecrosis	"LLLT significantly reduced myonecrosis by 83.5% at 24 h ($p < 0.05$) but not at 3 h, and AV therapy alone was ineffective for reducing myonecrosis at 3 and 24 h."	PubMed
	Toxins	Snake venom	Barbosa	Brazil (São Paulo)	2008	Toxicon	**Effect of low-level laser therapy in the inflammatory response induced by Bothrops jararacussu snake venom.**	Mouse	Edema	"In conclusion, LLLT significantly reduced the edema and leukocyte influx into the envenomed muscle, suggesting that LLLT should be considered as a potentially therapeutic approach for the treatment of the local effects of Bothrops species."	PubMed
	Toxins	Snake venom	Dourado	Brazil (São Paulo)	2003	Lasers Surg Med	**Effects of the Ga-As laser irradiation on myonecrosis caused by Bothrops Moojeni snake venom.**	Mouse	Myonecrosis	"Ga-As irradiation significantly decreased the amount of myonecrosis in all the periods tested ($P < 0.05$)."	PubMed
	Turtles	Skin and shell ulceration	Kraut	Germany (Birkenfeld)	2013	Tierarztl Prax Ausg K Kleintiere Heimtiere	**Laser therapy in a soft-shelled turtle (Pelodiscus sinensis) for the treatment of skin and shell ulceration. A case report.**	Soft-shelled turtle Case report		"The presented case report describes aetiology including differential diagnoses, diagnostic procedures and therapy of a soft-shelled turtle (Pelodiscus sinensis) suffering from a septicaemic ulcerative dermatitis. Central aspect hereby is the positive curing effect of laser therapy on skin and shell lesions."	PubMed
	Ultra-low level laser		Gallamini	Italy	2015	J Acupunct Meridian Stud	**Biolite: A Patented Ultra-Low-Level Laser-Therapy Device for Treating Musculoskeletal Pain and Associated Impairments.**	Advertisement			PubMed
	Uncategorized		Dias Schalch	Brazil (São Paulo)	2016	J Biophotonics	**Photomodulation of the osteoclastogenic potential of oral squamous carcinoma cells.**	In vitro		"The irradiation of SCC9 cells with PBM with an energy density of 4 J/cm2 decreased the pro-osteoclastogenic potential of those cells. This may represent a potential useful side effect of PBM therapy. PBM (using recommended parameters for mucositis treatment) decreases the osteoclastogenic potential of oral squamous carcinoma cells."	PubMed
	Uncategorized		Havel	Germany (Munich)	2014	Lasers Surg Med	**Diode laser-induced tissue effects: in vitro tissue model study and in vivo evaluation of wound healing following non-contact application.**				PubMed
	Uncategorized	Tissue repair	Enwemeka	USA (Old Westbury, NY)	2004	Photomed Laser Surg	**The efficacy of low-power lasers in tissue repair and pain control: a meta-analysis study.**	Meta-analysis			PubMed
	Urinary bladder		Ito	Japan (Akita)	2011	Low Urin Tract Symptoms	**Pulse Diode Laser Irradiation (830 nm) of Lumbosacral Spinal Roots Diminished Hyperreflexia-Induced by Acetic Acid or Prostaglandin E2 Infusion in Rat Urinary Bladder.**	Rat		"During continuous saline infusion to the urinary bladder, neither continuous (1 W) nor pulse (10 W) laser irradiation altered the intercontraction interval and nerve firing during distention of the bladder. Pulse laser, but not continuous laser irradiation, increased the intercontraction interval with AA or PGE2 infusion and diminished nerve firing during distention of the bladder with AA or PGE2 infusion."	PubMed
★	Vaccination and light/laser		Kashiwagi	USA (Charlestown, MA)	2013	PLoS One	**Near-infrared laser adjuvant for influenza vaccine.**			"We show that non-tissue damaging, near-infrared (NIR) laser light given in short exposures to small areas of skin, without the use of additional chemical or biological agents, significantly increases immune responses to intradermal influenza vaccination without augmenting IgE. The NIR laser-adjuvanted vaccine confers increased protection in a murine influenza lethal challenge model as compared to unadjuvanted vaccine. We show that NIR laser treatment induces the expression of specific chemokines in the skin resulting in recruitment and activation of dendritic cells and is safe to use in both mice and humans. The NIR laser adjuvant technology provides a novel, safe, low-cost, simple-to-use, potentially broadly applicable and clinically feasible approach to enhancing vaccine efficacy as an alternative to chemical and biological adjuvants."	PubMed
★	Vestibular system		Zhang	Australia (Sydney)	2015	J Vis Exp	**Near infrared (NIr) light increases expression of a marker of mitochondrial function in the mouse vestibular sensory epithelium.**	Mouse		Note: The authors do not refer to LLLT/PBM research. However, I think this type of method can be categorized as photobiomodulation. "Figure 2 shows a significant increase in β-actin normalized SOD-1 expression of more than 2-fold in young NIr-treated animals compared to young sham-treated animals ($p < 0.01$) and young NIr-blocked animals ($p < 0.01$). Older NIr-treated animals also showed more than a 2-fold up-regulation of SOD-1 when compared with older NIr-blocked animals ($p < 0.05$)." "Since there are currently no available, affordable, non-invasive methods of therapy to improve vestibular hair cell function, the application of external NIr radiation provides a potential strategy to counteract the impact of aging on cellular metabolism inthe vestibular sensory epithelium." Star: The article contains a very high-quality video depicting many of the relevant phases of the study execution. Two photographs are also supplied. Comment: Parameters weren't reported, though they can be found from other papers	PubMed

Veterinary medicine		Pryor & Millis	USA (Newark, DE)	2015	Vet Clin North Am Small Anim Pract	**Therapeutic laser in veterinary medicine.**				PubMed
Voice	Vocal fatigue	Kagan & Heaton	USA (Boston, MA)	2016	J Voice	**The Effectiveness of Low-Level Light Therapy in Attenuating Vocal Fatigue.**	Human	LED phototherapy LED array	"Red light significantly normalized the combination of PTP, IPSV, and RFF measures compared to other conditions." "The red setting heats the neck surface to approximately 43.3°C, whereas the IR setting heats the neck surface to 35.5°C based on a thermometer" "Results indicate that red light may be effective in improving acoustic, aerodynamic, and self-perceptual markers of vocal fatigue. Although these findings indicate that LLLT is a promising treatment for vocal fatigue, future work is needed to determine optimal light doses, whether wavelengths are more efficacious in combination vs isolation, and when the doses should be applied relative to phonotrauma (before, after, or both) for providing fatigue resistance or hastening recovery. LLLT is a simple, potentially efficacious treatment for vocal fatigue that could have wide clinical relevance to populations with voice disorders or occupations with high voice use demands."	PubMed
Water-filtered infrared-A	Body contouring	Möckel	Germany	2006	Ger Med Sci	**Influence of water-filtered infrared-A (wIRA) on reduction of local fat and body weight by physical exercise.**	Human RCT		wIRA improved body composition compared to the control group (quite significant differences).	PubMed
Water-filtered infrared-A	Fibromyalgia	Brockow	Germany	2007	Clin J Pain	**A randomized controlled trial on the effectiveness of mild water-filtered near infrared whole-body hyperthermia as an adjunct to a standard multimodal rehabilitation in the treatment of fibromyalgia.**	Human RCT		Heating fibromyalgia patients (-->38.1 celcius) yielded superior results compared to "multimodal treatment" (MR).	PubMed
Water-filtered infrared-A	Scleroderma	von Felbert	Germany	2011	Dermatology	**Irradiation with water-filtered infrared A plus visible light improves cutaneous scleroderma lesions in a series of cases.**	Human		"wIRA(+VIS) therapy led to a marked improvement, persistent even during long-term follow-up, in 7 out of 10 patients with CS."	PubMed
Water-filtered infrared-A	Venous ulcer	Schumann	Germany	2011	Br J Dermatol	**Water-filtered infrared A for the treatment of chronic venous stasis ulcers of the lower legs at home: a randomized controlled blinded studv.**	Human		wIRA appeared to improve healing of chronic venous stasis ulcers.	PubMed
Water-filtered infrared-A	Venous ulcer	Mercer	Norway	2008	Ger Med Sci	**Improvement of wound healing by water-filtered infrared-A (wIRA) in patients with chronic venous stasis ulcers of the lower legs including evaluation using infrared thermography.**	Human		wIRA seemed to have clear beneficial effects on ulcer healing.	PubMed
Water-filtered infrared-A	Wound healing	Künzli	Switzerland	2013	Ann Surg	**Impact of preoperative local water-filtered infrared A irradiation on postoperative wound healing: a randomized patient- and observer-blinded controlled clinical trial.**	Human		wIRA appeared to reduce surgical site infections and post-operative pain.	PubMed
Wavelengths	Blue & Green	Wang	China (Beijing)	2016	Sci Rep	**Photobiomodulation (blue and green light) encourages osteoblastic-differentiation of human adipose-derived stem cells: role of intracellular calcium and light-gated ion channels.**	In vitro	Human adipose-derived stem cells	"The 420 nm and 540 nm wavelengths were more effective in stimulating osteoblast differentiation compared to 660 nm and 810 nm. Intracellular calcium was higher after 420 nm and 540 nm, and could be inhibited by capsazepine and SKF96365, which also inhibited osteogenic differentiation. We hypothesize that activation of light-gated calcium ion channels by blue and green light could explain our results."	PubMed
Wavelengths	Blue & Green	Becker	Germany (Mannheim)	2016	Sci Rep	**Gene expression profiling reveals aryl hydrocarbon receptor as a possible target for photobiomodulation when using blue light.**	In vitro			PubMed
Wavelengths	Far-infrared	Shingyochi	Japan (Tokyo)	2017	PLoS One	**A Low-Level Carbon Dioxide Laser Promotes Fibroblast Proliferation and Migration through Activation of Akt, ERK, and JNK.**			"In MTS and cell migration assays, fibroblast proliferation and migration were promoted after LLLT with a CO2 laser at 1.0 J/cm2. Western blot analysis revealed that Akt, ERK, and JNK activities were promoted in fibroblasts after LLLT with a CO2 laser at 1.0 J/cm2. Moreover, inhibition of Akt, ERK, or JNK significantly blocked fibroblast proliferation and migration." "These findings suggested that LLLT with a CO2 laser would accelerate wound healing by promoting the proliferation and migration of fibroblasts. Activation of Akt, ERK, and JNK was essential for CO2 laser-induced proliferation and migration of fibroblasts."	PubMed
Wavelengths	Far-infrared	Constantin	Romania (Bucharest)	2016	Lasers Med Sci	**CO2 laser increases the regenerative capacity of human adipose-derived stem cells by a mechanism involving the redox state and enhanced secretion of pro-angiogenic molecules.**			"CO2 laser has a beneficial effect on stem cells by mechanisms that are not clearly elucidated. We hypothesize that the effect of fractional CO2 laser on human adipose-derived stem cells (ADSC) could be due to changes in redox homeostasis and secretion of factors contributing to cellular proliferation and angiogenic potential." "In conclusion, the mechanisms underlying the benefic effect of CO2 laser on ADSC are the activation of the redox pathways which increases cell proliferation and enhances secretion of angiogenic molecules."	PubMed
Wavelengths	Far-infrared	Lai	Taiwan (Taipei)	2013	Eur J Vasc Endovasc Surg	**Post-angioplasty far infrared radiation therapy improves 1-year angioplasty-free hemodialysis access patency of recurrent obstructive lesions.**	Human Observational		"The study provides data regarding far infrared (FIR) radiation therapy on recurrent hemodialysis (HD) access stenosis that has been treated with balloon angioplasty. The positive results obtained show that FIR radiation therapy following balloon angioplasty is beneficial in the case of recurrent HD access stenosis, especially arteriovenous graft stenosis, in terms of improving the angioplasty-free patency at 1 year. The data may be clinically valid for management of recurrent HD access stenosis and guidance of FIR radiation therapy."	PubMed
Wavelengths	Far-infrared	Huang	Taiwan (Taipei)	2012	Cardiovasc Diabetol	**Far infra-red therapy promotes ischemia-induced angiogenesis in diabetic mice and restores high glucose-suppressed endothelial progenitor cell functions.**	Mouse	Diabetic mice Angiogenesis	"Administration of IFR therapy promoted collateral flow recovery and new vessel formation in STZ-induced diabetic mice, and these beneficial effects may derive from enhancement of EPC functions and homing process."	PubMed
Wavelengths	Far-infrared	Yu	Taiwan (Taipei)	2006	Photodermatol Photoimmunol Photomed	**Biological effect of far-infrared therapy on increasing skin microcirculation in rats.**	Rat		"In conclusion, FIR therapy exerts a NO-related biological effect to increase skin microcirculation in rats. This might bring into perspective the clinical application of FIR to treat ischemic disease by augmenting L-arginine/NO pathway."	PubMed
Wavelengths	Far-infrared	Lee	Korea (Seoul)	2006	Yonsei Med J	**Effects of infrared radiation on skin photo-aging and pigmentation.**	Human		"These results suggest that infrared radiation may have beneficial effects on skin texture and wrinkles by increasing collagen and elastin contents from the stimulated fibroblasts. Therefore, skin treatment with infrared radiation may be an effective and safe non-ablative remodeling method, and may also be useful in the treatment of photo-aged skin."	PubMed

	Wavelengths	Far-infrared	Toyokawa	Japan (Osaka)	2003	Exp Biol Med (Maywood)	**Promotive effects of far-infrared ray on full-thickness skin wound healing in rats.**			"Wound healing was significantly more rapid with than without FIR. Skin blood flow and skin temperature did not change significantly before or during FIR irradiation. Histological findings revealed greater collagen regeneration and infiltration of fibroblasts that expressed transforming growth factor-beta1 (TGF-beta1) in wounds in the FIR group than in the group without FIR. Stimulation of the secretion of TGF-beta1 or the activation of fibroblasts may be considered as a possible mechanisms for the promotive effect of FIR on wound healing independent of skin blood flow and skin temperature."	PubMed
★	Wound healing	Burns	Yadav	India (Delhi)	2016	J Photochem Photobiol B	**Photobiomodulatory effects of superpulsed 904nm laser therapy on bioenergetics status in burn wound healing.**	Rat		"The present study recapitulated the benefits of LLLT in enhancing CCO activity and ATP synthesis in injured tissue. In addition to this, our results also displayed the role of cellular redox homeostasis in regulation of energy generation. These findings indicated that superpulsed 904 nm LLLT favor aerobic regulation of cellular energy metabolism and a synchronized evasion from the anaerobic glycolysis in burn wound healing." Comment: The huge increase in ATP levels is very interesting. Many other changes were also noted.	PubMed
★	Wound healing	Burns	Rathnakar	India (Manipal)	2016	Lasers Med Sci	**Photo-biomodulatory response of low-power laser irradiation on burn tissue repair in mice.**	Mouse	Wavelength comparison Dose optimization	"In summary, low-power lasers at wavelength 632.8, 785, and 830 nm have shown beneficial effects in burn wound healing, compared to untreated controls. Further, 3-J/cm2 fluence of 830 nm exhibited the best response among the other wavelengths and fluences under study in enhancing wound repair in full thickness burn injury in mice. The treatment promoted proliferation, neovascularization, deposition of collagen, denser packing of connective tissue, and epithelialization at faster rate to contract the wound, compared to untreated controls. Surprisingly, the response observed in the single exposure of 3-J/cm2 treatment of 830 nm was equivalent to the reference standard applied on daily basis." Star: Nice work with a huge amount of mice (n=170).	PubMed
	Wound healing	Burns	Brassolatti	Brazil (São Carlos)	2016	Microsc Res Tech	**Comparative effects of two different doses of low-level laser therapy on wound healing third-degree burns in rats.**	Rat	3rd degree burn Dose optimization	"Therefore, our findings suggest that the use of 25 J/cm(2) and 1 J of energy was more effective in stimulating the cellular processes involved in tissue repair on third-degree burns in rats by reducing the inflammatory phase, and stimulating angiogenesis, thus restoring the local microcirculation which is essential for cell migration."	PubMed
	Wound healing	Burns	Trajano	Brazil (Rio de Janeiro)	2015	Lasers Med Sci	**Low-level red laser improves healing of second-degree burn when applied during proliferative phase.**	Rat	2nd degree burn	"Low-level red laser exposure contributes to the process of tissue repair of second-degree burns, but the intervention during proliferative phase is crucial in the final outcome of the repair process."	PubMed
★	Wound healing	Burns	Gupta	India (Delhi)	2015	J Biophotonics	**Superpulsed (Ga-As, 904 nm) low-level laser therapy (LLLT) attenuates inflammatory response and enhances healing of burn wounds.**	Rat		"The irradiated animals showed a significant reduction in wound area (50%, $p < 0.05$) on eighth day post-wounding compared with the non-irradiated control animals (18%, $p < 0.05$)" "Irradiated group exhibited enhanced DNA, total protein, hydroxyproline and hexosamine contents compared to the control and silver sulfadiazine (reference care) treated groups. LLLT exhibited decreased TNF-α level and NF-kB, and up-regulated protein levels of VEGF, FGFR-1, HSP-60, HSP-90, HIF-1α and matrix metalloproteinases-2 and 9 compared to the controls. In conclusion, LLLT using superpulsed 904 nm laser reduced the inflammatory response and was able to enhance cellular proliferation, collagen deposition and wound	PubMed
★	Wound healing	Burns	Fiório	Brazil (Chapecó)	2014	Lasers Med Sci	**Effect of low-level laser therapy on types I and III collagen and inflammatory cells in rats with induced third-degree burns.**	Rat	3rd degree burn	"Laser irradiation (both 3 and 4 J/cm(2)) resulted in reduction in the inflammatory process and improved collagen deposition, thereby ameliorating the healing of third-degree burns."	PubMed
	Wound healing	Burns	Chiarotto	Brasil (Araras)	2014	Lasers Med Sci	**Effects of laser irradiation (670-nm InGaP and 830-nm GaAlAs) on burn of second-degree in rats.**	Rat	2nd degree burn	"Morphometric analysis showed that different lasers 670-nm InGaP and 830-nm GaAlAs reduced the number of granulocytes and an increase of newly formed vessels in radiated lesions. The 670-nm InGaP laser therapy was more effective in increasing the number of fibroblasts. The different treatments modified the expression of VEGF and TGF-β1, when compared with lesions not irradiated. The different types of light sources showed similar effects, improved the healing of second-degree burns and can help for treating this type of injury. Despite the large number of studies with LLTI application in second-degree burns, there is still divergence	PubMed
	Wound healing	Burns	Fiório	Brazil (Chapecó)	2011	J Cosmet Laser Ther	**Effect of incoherent LED radiation on third-degree burning wounds in rats.**	Rat	3rd degree burn	"The inflammatory cells as well as the damaged area at the 8th day after burns were significantly lower for the LED-treated group when compared to control. Furthermore, the LED phototherapy effect on cellular migration was even more pronounced at the 16th day." "Our results indicated that the treatment with a LED system was clearly effective in reducing the number of inflammatory cells and improving the healing process in an	PubMed
	Wound healing	Burns	Renno	Brazil (São Paulo)	2011	J Cosmet Laser Ther	**Effect of low-level laser therapy (660 nm) on the healing of second-degree skin burns in rats.**	Rat	2nd degree burn	"Histopathological analysis revealed a significant decrease in the necrotic area in the laser-treated group compared to the controls at days 7 and 14 post-injury. COX-2 positive cells were found in a strong pattern in the group submitted to laser therapy after 7 days. Regarding VEGF immunomarker, a significant VEGF immunoexpression was detected in the laser-exposed group after 14 days when compared to the negative control group. Taken together, our results demonstrate that laser therapy is able to promote skin repair of burned rats as a result of decreasing necrotic area and an up-regulation of COX-2 and VEGF immunoexpression."	PubMed

	Wound healing	Burns	Khoshvaghti	Iran (Tehran)	2011	Photomed Laser Surg	**Effect of low-level treatment with an 80-Hz pulsed infrared diode laser on mast-cell numbers and degranulation in a rat model of third-degree burn.**	Rat	3rd degree burn Mast cells	"We conclude that LLLT can significantly decrease total numbers of mast cells during the proliferation and remodeling phases of healing in a rat model of third-degree burn."	PubMed
	Wound healing	Burns	Ezzati	Iran (Tehran)	2010	Photomed Laser Surg	**Low-level laser therapy with a pulsed infrared laser accelerates second-degree burn healing in rat: a clinical and microbiologic study.**	Rat	2nd degree burn	"Pulsed LLLT with 11.7 J/cm(2)/890 nm of a deep second-degree burn model in rat significantly increased the rate of wound closure compared with control burns." Comment: The paper says they used 70-watt output, but it is more likely it was 70 milliwatts.	PubMed
	Wound healing	Burns	Vasheghani	Iran (Tehran)	2009	Photomed Laser Surg	**Low-level laser therapy using 80-Hz pulsed infrared diode laser accelerates third-degree burn healing in rat.**	Rat	3rd degree burn	"LLLT using an 80-Hz pulsed infrared diode laser accelerated third-degree burn healing in rat." [17.6 vs 19.6 days]	PubMed
	Wound healing	Burns	Ezzati	Iran (Tehran)	2009	J Rehabil Res Dev	**Low-level laser therapy with pulsed infrared laser accelerates third-degree burn healing process in rats.**	Rat	3rd degree burn	"Pulsed LLLT with 11.7 J/cm(2)/890 nm of a third-degree burn in a rat model significantly increased wound-closure rate compared with control burns." Comment: The paper says they used 70-watt output, but it is more likely it was 70 milliwatts.	PubMed
	Wound healing	Burns	Oliveira	Brazil (Salvador, Bahia)	2008	Photomed Laser Surg	**The use of light photobiomodulation on the treatment of second-degree burns: a histological study of a rodent model.**	Rat	LLLT vs polychromatic polarized light	"The analysis of the results demonstrated that the damaged tissue was able to efficiently absorb and process the light at all tested wavelengths. LPBM at 660 nm showed better results at early stages of wound healing. However, the use of 780-nm laser light had beneficial effects throughout the experimental period, with the animals growing newly-formed tissue similar to normal dermis." "Despite our findings that the use of both types of light energy improved the healing of second-degree burns at the early stages, long-term assessment is needed to verify if this improvement will influence the final results of treatment."	PubMed
	Wound healing	Burns	Meireles	Brazil (Salvador, Bahia)	2008	Photomed Laser Surg	**Effectiveness of laser photobiomodulation at 660 or 780 nanometers on the repair of third-degree burns in diabetic rats.**	Rat	3rd degree burn Diabetic rats Wavelength comparison	"The use of 780-nm laser energy was not as effective as 660-nm energy, but it had positive effects at early stages on the onset and development of inflammation. At the end of the experimental period the primary effect seen was on the amount and quality of the granulation tissue. The 660-nm laser at 20 J/cm(2), when used on a daily basis, was more effective than the 780-nm laser for improving the healing of third-degree burns in the diabetic rats beginning at the early stages post-burn."	PubMed
	Wound healing	Burns	Meireles	Brazil (Salvador, Bahia)	2008	Photomed Laser Surg	**A comparative study of the effects of laser photobiomodulation on the healing of third-degree burns: a histological study in rats.**	Rat	3rd degree burn	"The results showed more deposition of collagen fibers, larger amounts of granulation tissue, less edema, a more vigorous inflammatory reaction, and increased revascularization on all laser-treated animals. These features were more evident at early stages when the 660-nm laser was used, and were more evident throughout the experimental period for the animals receiving 780-nm laser therapy."	PubMed
	Wound healing	Incisions	Figurová	Slovakia (Košice)	2016	Photomed Laser Surg	**Histological Assessment of a Combined Low-Level Laser/Light-Emitting Diode Therapy (685 nm/470 nm) for Sutured Skin Incisions in a Porcine Model: A Short Report.**	Pig (minipig)	LED array (4 red + 13 blue) LED phototherapy	"Combined red and blue PBM accelerated the process of re-epithelization and formation of cross-linked collagen fibers compared with sham irradiated control wounds." "Our results demonstrate that the current dose of combined red and blue PBM improves the healing of sutured skin incisions in minipigs."	PubMed
	Wound healing	Leprosy	Barreto & Salgado	Brazil (Marituba)	2010	BMC Infect Dis	**Clinic-epidemiological evaluation of ulcers in patients with leprosy sequelae and the effect of low level laser therapy on wound healing: a randomized clinical trial.**	Human RCT		"Statistical analysis of the data determined that there were no significant differences in the variables analyzed before and after treatment with low level laser therapy."	PubMed
	Wound healing	Pressure ulcer	Kazemikhoo	Iran (Tehran)	2015	J Skin Stem Cell	**Low-Level Laser Therapy Along With Intravascular Laser in Deep Pressure Ulcer Resistant to Conventional Therapies**	Human Case report		"The combination of laser therapy with conventional therapy and surgery increases the process of wound healing remarkably, particularly in resistant wound cases. In other words, it accelerates the reconstruction of blood vessels and increases the lesion revascularizations, increases the production and formation of granulation tissue in the wound, eradicates microbial flora, sterilizes the wound pathogens, and facilitates graft surgery repairing success. This process not only leads to a better healing of ulcers, but also prevents recurrent ulcers due to improvement of perfusion in the treated area."	SSRC
	Wound healing	Pressure ulcer	Taradaj	Poland (Katowice)	2013	Evid Based Complement Alternat Med	**Effect of Laser Irradiation at Different Wavelengths (940, 808, and 658 nm) on Pressure Ulcer Healing: Results from a Clinical Study.**	Human Placebo-controlled		"The laser therapy at a wavelength of 658 nm appeared to be effective at healing pressure ulcers. The wavelengths of 808 and 940 nm did not have any effect in our study."	PubMed
	Wound healing	Pressure ulcer	Shojaei	Iran (Tehran)	2008	Iran J Med Sci (IJMS)	**Low Level Laser Therapy in the Treatment of Pressure Ulcers in Spinal Cord Handicapped Veterans Living in Tehran**	Human		"The results demonstrated a statistically significant enhancement of the healing process by combination of Low Level Laser with conventional treatments of pressure ulcers."	IJMS
★	Wound healing	Pressure ulcer	Lanzafame	USA (Rochester, NY)	2007	Lasers Surg Med	**Reciprocity of exposure time and irradiance on energy density during photoradiation on wound healing in a murine pressure ulcer model.**	Mouse	Parameters	"Specific combinations of parameters were necessaryto achieve accelerated wound healing despite the delivery ofthe same total daily energy density to all wounds. Variationof exposure time and irradiance may account for conflictingresults in the literature. This study appears to confirmearlier in vitro studies demonstrating that the provisionof multiple treatments per day is more effective than thetraditional strategy of delivering a single treatment perday. Further investigations directed at identifying dose–response curves for specific tissues and cell lines should beconducted." Comment: This kind of research of different parameters is important. Hopefully more of similar studies will be conducted.	PubMed
	Wound healing	Pressure ulcer	Dehlin	Sweden (Malmö)	2007	Aging Clin Exp Res	**Monochromatic phototherapy: effective treatment for grade II chronic pressure ulcers in elderly patients.**	Human Controlled	Light probe (110)	"The mean normalized reduction in pressure ulcer size at week 12 was 0.79 for the phototherapy group and 0.50 for the placebo group (95% confidence interval 0.01-0.53; p=0.039). No serious side-effects were noted." "Monochromatic pulsating light accelerates healing in grade II pressure ulcers in elderly patients." PDF full text: https://www.researchgate.net/profile/Soelve_Elmstahl/publication/5678172_Monochromatic_phototherapy_Effective_treatment_for_grade_II_chronic_pressure_ulcers_in_elderl	PubMed

	Wound healing	Pressure ulcer	Taly	India (Bangalore)	2004	Arch Phys Med Rehabil	**Efficacy of multiwavelength light therapy in the treatment of pressure ulcers in subjects with disorders of the spinal cord: A randomized double-blind controlled trial.**	Human RCT/DB	LLLT cluster (46)	"Multiwavelength light therapy from a gallium-aluminum-arsenide laser source did not influence overall healing pressure ulcers. Limited evidence suggested that it improved healing of stage 3 and 4 pressure ulcers."	PubMed
	Wound healing	Pressure ulcer	Lucas	Netherlands (Amsterdam)	2003	Lasers Med Sci	**Efficacy of low-level laser therapy in the management of stage III decubitus ulcers: a prospective, observer-blinded multicentre randomised clinical trial.**	Human RCT/SB Multicenter		"In this trial we found no evidence that justifies using low-level laser therapy as an adjuvant to the consensus decubitus ulcer treatment."	PubMed
	Wound healing	Surgical wounds	Lima	Brazil (São Paulo)	2017	Photomed Laser Surg	**Photobiomodulation (Laser and LED) on Sternotomy Healing in Hyperglycemic and Normoglycemic Patients Who Underwent Coronary Bypass Surgery with Internal Mammary Artery Grafts: A Randomized, Double-Blind Study with Follow-Up.**	Human RCT/DB (?)	LLLT vs LED LED phototherapy	"LLLT and LED groups had similarly less hyperemia and less incision bleeding or dehiscence ($p \leq 0.005$) and the outcomes were also analogous between hyperglycemic and normoglycemic patients, which indicates no difference observed in an intragroup analysis ($p \geq 0.05$)."	PubMed
	Wound healing	Surgical wounds	Lima	Brazil (São Paulo)	2016	Photomed Laser Surg	**Low-Level Laser and Light-Emitting Diode Therapy for Pain Control in Hyperglycemic and Normoglycemic Patients Who Underwent Coronary Bypass Surgery with Internal Mammary Artery Grafts: A Randomized, Double-Blind Study with Follow-Up.**	Human RCT/DB	LLLT vs LED LED phototherapy	"LLLT and LED had similar analgesic effects in hyperglycemic and normoglycemic patients, better than placebo and control groups."	PubMed
★	Wound healing	Surgical wounds	Ojea	Brazil (São Paulo)	2016	Photomed Laser Surg	**Beneficial Effects of Applying Low-Level Laser Therapy to Surgical Wounds After Bariatric Surgery.**	Human RCT/SB		"LLLT applied with the described protocol led to a decrease by biochemical markers and wound temperature compared with the placebo, which indicated that LLLT was able to control the inflammatory process; in addition, seroma and pain were reduced and cicatrization was improved by this preventive procedure."	PubMed
	Wound healing	Surgical wounds	Fernandes	Brazil (São Paulo)	2016	Lasers Med Sci	**Low-intensity laser (660 nm) on sternotomy healing in patients who underwent coronary artery bypass graft: a randomized, double-blind study.**	Human RCT/DB		"The sternotomy incisions in the LLLT group demonstrated less hyperemia, incisional bleeding, and dehiscence ($p \leq 0.005$)."	PubMed
	Wound healing	Surgical wounds	Karlekar	India (New Delhi)	2015	Ann Card Anaesth	**Assessment of feasibility and efficacy of Class IV laser therapy for postoperative pain relief in off-pump coronary artery bypass surgery patients: A pilot study.**	Human	LCT-1000™ (LiteCure Medical)	"The mean (standard deviation [SD]) VRS of all the 100 patients just before application of the first dose of laser was 7.31 (0.94) while on MMT; the same fell to 4.0 (1.279) and 3.40 (2.697) at 1 h and 24 h respectively following first dose of laser. The change of VRS over first 24 h among all the 100 patients was statistically significant (P = 0.000). Laser was re-applied in 40 patients whose VRS was ≥5 (mean [SD] - 6.38 [0.868]) at 24th h. After receiving the 2nd dose of laser the VRS scores fell significantly (P = 0.000) and became 0 at 54th h. No patients required 3rd dose of the laser. No patient required rescue analgesic while on laser therapy."	PubMed
	Wound healing	Surgical wounds	de Oliveira	Brazil (São Paulo)	2014	Lasers Med Sci	**The effects of LED emissions on sternotomy incision repair after myocardial revascularization: a randomized double-blind study with follow-up.**	Human RCT/DB	LED phototherapy	"Three researchers blindly analyzed the incision photographs to determine hyperemia and wound closure, and they found that the LED group had both less hyperemia and less incision bleeding or dehiscence. The LED therapy (640 nm) had an analgesic effect on the sternotomies of patients who underwent CABG, increasing their incision healing and preventing dehiscence."	PubMed
	Wound healing	Surgical wounds	Dixit	India (Manipal)	2013	Indian J Palliat Care	**Photobiomodulation of surgical wound dehiscence in a diabetic individual by low-level laser therapy following median sternotomy.**	Human Case report	Diabetic patient Delayed CABG sternotomy wound healing LED phototherapy LED cluster (34+35)	"After irradiation, proliferation of healthy granulation tissue was observed with decrease in scores of PUSH for sternal dehiscence and VAS for bilateral shoulders and sternal dehiscence. We found that LLLT irradiation could be a novel method of treatment for chronic sternal dehiscence following coronary artery bypass grafting, as it augments wound healing with an early closure of the wound deficit."	PubMed
★	Wound healing	Ulcers	Sobanko & Alster	USA (Washington, D.C.)	2008	Dermatol Surg	**Efficacy of low-level laser therapy for chronic cutaneous ulceration in humans: a review and discussion.**	Review			PubMed
	Wound healing	Ulcers	Saltmarche AE	Canada (Mississauga)	2008	Int Wound J	**Low level laser therapy for healing acute and chronic wounds - the extendicare experience.**	Human		"Staff rated low level laser, easy to learn and use, effective for the majority of their residents worth the additional time. Staff requested a continuation of low level laser even after study completion."	PubMed
	Wound healing	Ulcers	Kubota J	Japan (Tokyo)	2004	J Cosmet Laser Ther	**Defocused diode laser therapy (830 nm) in the treatment of unresponsive skin ulcers: a preliminary trial.**	Human Controlled (n=5)		"In all five patients, the ulcers healed completely between 3 weeks and 7 months (22.8 +/- 19.3 weeks), without recurrence during a minimum 12-month follow-up." "Defocused 830 nm diode laser therapy was well tolerated, and was very effective in the treatment of this small number of compromised skin ulcers of different aetiologies and in a large range of patient ages. Further controlled studies in larger populations are required. Defocused diode laser therapy nonetheless appears to be a very useful adjunctive method in the treatment of slow-to-heal and non-healing skin ulcers." Comment: The LLLT photo is black-and-white.	PubMed
	Wound healing	Venous ulcer	Caetano	Brazil (Ribeirão Preto)	2009	Photomed Laser Surg	**Phototherapy improves healing of chronic venous ulcers.**	Human RCT/DB		"Ulcers treated with phototherapy healed significantly faster than controls when compared at day 30 (p +/- 0.01), day 60 (p +/- 0.05), and day 90 (p +/- 0.001), and similarly healed faster than the placebo-treated ulcers at days 30 and 90 (p +/- 0.01), but not at day 60. The beneficial effect of phototherapy was more pronounced when the confounding effect of small-sized ulcers was removed from the analysis. Medium- and large-sized ulcers healed significantly faster with treatment (>or=40% rate of healing per month) than placebo or control ulcers (p +/- 0.05)."	PubMed
	Wound healing	Venous ulcer	Franek	Poland (Katowice)	2002	Med Eng Phys	**Does low output laser stimulation enhance the healing of crural ulceration? Some critical remarks.**	Human		"No significant impact of laser light (lambda=810 nm, P=65 mW, p=4 J/cm2) on any of the stages of ulceration healing was observed."	PubMed
	Wound healing	Venous ulcer	Flemming&Cullum	UK (York)	2000	Cochrane Database Syst Rev	**Laser therapy for venous leg ulcers.**	Meta-analysis			PubMed
	Wound healing	Venous ulcer	Flemming	UK (York)	1999	J Wound Care	**A systematic review of laser therapy for venous leg ulcers.**	Systematic review			PubMed

★	Wound healing	Venous ulcer	Gupta	Canada (Toronto)	1998	Dermatol Surg	**The use of low energy photon therapy (LEPT) in venous leg ulcers: a double-blind, placebo-controlled study.**	Human RCT/DB		"Nine patients with 12 venous ulcers were randomized to receive LEPT or placebo therapy. At the conclusion of the study, the percentage of the initial ulcer area remaining unhealed in the LEPT and placebo groups was 24.4% and 84.7%, respectively (P = 0.0008). The decrease in ulcer area (compared to baseline) observed in the LEPT and placebo groups was 193.0 mm2 and 14.7 mm2, respectively (P = 0.0002)."	PubMed
	Wound healing	Venous ulcer	Gupta	Canada (Toronto)	1997	J Dermatolog Treat	**The use of low-energy photon therapy in the treatment of leg ulcers – a preliminary study**	Human Pilot study		"Of 15 venous ulcers, 12 (75%) had healed or improved markedly (greater than 75% reduction in pretherapy area of ulcer) by the end of the study. Side-effects consisted of erythema at the ulcer site in one patient."	T&F
	Wound healing	Wounds	Yadav & Gupta	India (Delhi)	2016	Photodermatol Photoimmunol Photomed	**Non-invasive red and near-infrared wavelength-induced photobiomodulation: promoting impaired cutaneous wound healing.**	Review	Cutaneous wound healing		PubMed
	Wound healing	Wounds	Solmaz	Turkey (Istanbul)	2016	Lasers Med Sci	**Laser biostimulation of wound healing: bioimpedance measurements support histology.**	Rat		"Laser irradiations of both energy densities stimulated the wound healing process. In particular, laser irradiation of lower energy density had more evidence especially for the first days of healing process. On the 7th day of healing, 3 J/cm2 laser-irradiated tissues had significantly smaller wound areas compared to non-irradiated wounds ($p < 0.05$). The electrical impedance results supported the idea of laser biostimulation on healing of cutaneous skin wounds." "Thus, bioimpedance measurements may be considered as a non-invasive supplementary method for following the healing process of laser-irradiated tissues." Comment: On the 10th day, the wound area was smaller in the control group, compared to the irradiated groups...	PubMed
★	Wound healing	Wounds	Tatmatsu-Rocha	USA (Boston, MA) & Brazil (São Paulo)	2016	J Photochem Photobiol B	**Low-level laser therapy (904nm) can increase collagen and reduce oxidative and nitrosative stress in diabetic wounded mouse skin.**			"The increased production of collagen and decreased oxidative and nitrosative stress suggests that LLLT may be a viable therapeutic alternative in diabetic wound healing." Star: The parameters were exceptionally well reported. Worth a look!	PubMed
	Wound healing	Wounds	Kuffler DP	Puerto Rico	2016	Regen Med	**Photobiomodulation in promoting wound healing: a review.**	Review			PubMed
	Wound healing	Wounds	Li	China (Beijing)	2016	PLoS One	**The Histopathological Investigation of Red and Blue Light Emitting Diode on Treating Skin Wounds in Japanese Big-Ear White Rabbit.**	Rabbit		"On days 16 and 17 of irradiation, the healing rates in red (15 min and 30 min) and blue (15 min and 30 min) groups were 50%, 37.5%, 25% and 37.5%, respectively, while the healing rate in the control group was 12.5%. The percentage healed area in the red light groups was significantly higher than those in other groups. Collagen fiber and skin thickness were significantly increased in both red light groups; expression of EGF, FGF, CD31 and Ki67 in the red light groups was significantly higher than those in other groups; the expression of FGF in red (30 min) group was not significantly different from that in the blue light and control groups." "The effect of blue light on wound healing was poorer than that of red light. Red light appeared to hasten wound healing by promoting fibrous tissue, epidermal and endothelial cell proliferation. An increase in the exposure time to 30 min did not confer any additional benefit in both red and blue light groups. This study provides a theoretical basis for the potential therapeutic application of LED light in clinical settings."	PubMed
★	Wound healing	Wounds	Keshri	India (Delhi)	2016	PLoS One	**Photobiomodulation with Pulsed and Continuous Wave Near-Infrared Laser (810 nm, Al-Ga-As) Augments Dermal Wound Healing in Immunosuppressed Rats.**	Rat	Immunosuppressed wound healing Pulsed vs continuous	"Results clearly delineated that 810 nm PBM at 10 Hz was more effective over continuous and 100 Hz frequency in accelerating wound healing by attenuating the pro-inflammatory markers (NF-kB, TNF-α), augmenting wound contraction (α-SM actin), enhancing cellular proliferation, ECM deposition, neovascularization (HIF-1α, VEGF), re-epithelialization along with up-regulated protein expression of FGFR-1, Fibronectin, HSP-90 and TGF-β2 as compared to the non-irradiated controls. Additionally, 810 nm laser irradiation significantly increased CCO activity and cellular ATP contents." Star: Parameters were well reported.	PubMed
	Wound healing	Wounds	França	Brazil (São Paulo)	2016	Photomed Laser Surg	**Photobiomodulation in Wound Healing: What Are We Not Considering?**	Guest Editorial			PubMed
	Wound healing	Wounds	Ranjbar & Takhtfooladi	Iran (Tehran)	2016	Acta Cir Bras	**The effects of photobiomodulation therapy on Staphylococcus aureus infected surgical wounds in diabetic rats. A microbiological, histopathological, and biomechanical study.**	Rat	Diabetic rats Infection (staph)	"The result revealed that PBMT resulted in a significant decrease in S. aureus CFU in the PBMT group in comparison to the control group (P<0.05). The length of wounds, in the 2nd and 3rd weeks, in the PBMT group were significantly shorter compared to the control group (P<0.05). PBMT caused a significant increase in the histological parameters in comparison to the control group (P<0.05). Moreover, PBMT significantly increased the breaking strength of the surgical scars produced in the skin of the PBMT group when compared to the control group (P<0.05)." "Photobiomodulation therapy may be useful in the management of wound infection through a significant bacterial growth inhibition and an acceleration of wound healing process."	PubMed
	Wound healing	Wounds	Uzêda-E-Silva	Brazil (Salvador, Bahia)	2016	Lasers Med Sci	**Laser phototherapy improves early stage of cutaneous wound healing of rats under hyperlipidic diet.**	Rat		"It can be concluded that the hyperlipidic diet modified the inflammation pattern in wound healing and that laser light has a positive biomodulative effect on the healing process only in early stages."	PubMed
	Wound healing	Wounds	de Medeiros	Brazil (Natal)	2016	Lasers Med Sci	**Effect of low-level laser therapy on angiogenesis and matrix metalloproteinase-2 immunoexpression in wound repair.**	Rat		"LLLT improves wound healing by enhancing neocollagenesis, increasing the amount of new vessels formed in the tissue (neoangiogenesis), and modulating MMP-2 expression."	PubMed
	Wound healing	Wounds	Aragão-Neto	Brazil (Recife)	2016	Int J Biol Macromol	**Combined therapy using low level laser and chitosan-policaju hydrogel for wound healing.**	Rat		"These results demonstrated that POLI-CHI contributed to more efficient healing process and modulation of the inflammation; furthermore, the combined use with LLLT subtle potentiated this process."	PubMed

	Wound healing	Wounds	Wu	USA (Bethesda, MD)	2015	Wound Repair Regen	**Organic light emitting diode improves diabetic cutaneous wound healing in rats.**	Rat + in vitro	In vitro: hyperglycemic diabetic cell culture LED vs LLLT	In vitro: ↑total ATP concentration ↑metabolic activity (MTS assay) ↑cell proliferation (CyQuant assay) In vivo: ↑wound closure ↑histological score ↑fibroblast growth factor-2 expression	PubMed
	Wound healing	Wounds	Sperandio	Brazil (Alfenas)	2015	J Biophotonics	**Low-level laser irradiation promotes the proliferation and maturation of keratinocytes during epithelial wound repair.**	Rat		"To the best of our knowledge, this is the first time that the quicker wound healing promoted by LLLT has been linked to the rapid maturation of KCs, which was confirmed by the accelerated expression of CK10 (terminal differentiation biomarker [32]) by these cells. The significantly higher proliferation of in vivo KCs (p63 expression) was also confirmed in vitro with the improved Cyclin D1 expression for the laser groups. In conclusion, a correlation between the in vitro and in vivo results was established and may help to elucidate the in vivo laser mechanisms as well as to support upcoming studies."	PubMed
	Wound healing	Wounds	Andrade Fdo	Brazil (Itabuna)	2014	Rev Col Bras Cir	**Effects of low-level laser therapy on wound healing.**	Review			PubMed
★	Wound healing	Wounds	Chaves	Brazil (Belo Horizonte)	2014	An Bras Dermatol	**Effects of low-power light therapy on wound healing: LASER x LED.**	Review			PubMed
	Wound healing	Wounds	Nussbaum	Canada (Toronto)	2014	Photonics Lasers Med	**Effects of low intensity laser irradiation during healing of infected skin wounds in the rat.**	Rat		"Red light improved healing of wounds. Only one 808-nm light protocol enhanced healing; lack of benefit using the remaining 808-nm light protocols may have been due to stimulatory effects of the light on S. aureus growth."	PubMed
	Wound healing	Wounds	Kilik	Slovakia	2014	Biomed Res Int	**Effect of equal daily doses achieved by different power densities of low-level laser therapy at 635 nm on open skin wound healing in normal and diabetic rats.**	Rat	Open skin wound	LLLT decreased the infiltration of polymorphonuclear leukocytes. It also stimulated neovascularization of the tissue and early formation of collagen fibres.	PubMed
	Wound healing	Wounds	Dungel	Austria (Vienna)	2014	Lasers Surg Med	**Low level light therapy by LED of different wavelength induces angiogenesis and improves ischemic wound healing.**	Rat	LED phototherapy	"LED therapy with both wavelengths significantly increased angiogenesis in the sub-epidermal layer and intramuscularly (panniculus carnosus muscle) which was associated with significantly improved tissue perfusion 7 days after the ischemic insult. Accordingly, tissue necrosis was significantly reduced and shrinkage significantly less pronounced in the LED-treated groups of both wavelengths."	PubMed
	Wound healing	Wounds	Gonçalves	Brazil (Juiz de Fora)	2013	Pathol Res Pract	**Comparative study of the effects of laser photobiomodulation and extract of Brassica oleracea on skin wounds in wistar rats: A histomorphometric study.**	Rat		"In the present study, LLLT and balsam and Ointment B. oleracea were more effective at reducing the size of the wounds compared to the control group. LLLT and B. oleracea application promoted acceleration of wound healing, enhanced remodeling and repair."	PubMed
	Wound healing	Wounds	Oliveira Sampaio	Brazil (Salvador, Bahia)	2013	Lasers Med Sci	**Effect of laser and LED phototherapies on the healing of cutaneous wound on healthy and iron-deficient Wistar rats and their impact on fibroblastic activity during wound healing.**	Rat	Cutaneous wound Healthy rats Iron-deficient rats LED phototherapy LED vs LLLT	"It is concluded that the use of LED light caused a significant positive biomodulation of fibroblastic proliferation on anemic animals and laser was more effective on increasing proliferation on non-anemics."	PubMed
	Wound healing	Wounds	Dadpay	Iran (Tehran)	2012	J Photochem Photobiol B	**Effects of pulsed infra-red low level-laser irradiation on open skin wound healing of healthy and streptozotocin-induced diabetic rats by biomechanical evaluation.**	Rat	Diabetic rats Dose response (?)	"Laser irradiation with 0.03J/cm(2) significantly decreased the maximum load for wound repair in healthy rats (p=0.015). Laser irradiation with 0.2J/cm(2) significantly increased the maximum load in wounds from the healthy control (p=0.021) and diabetic (p<001) groups. Laser treatments with a pulsed infrared laser at 0.2J/cm(2) significantly accelerated wound healing in both healthy and diabetic rats."	PubMed
	Wound healing	Wounds	Dixit	India (Manipal)	2012	Adv Biomed Res	**Photobiomodulation by helium neon and diode lasers in an excisional wound model: A single blinded trial.**	Rat		"The results indicate that He-Ne laser resulted in more stimulatory effect than diode lasers. From the histopathological examination, we can conclude that 8 J/cm2 of He-Ne lasers appear to be the threshold dosage for an enhanced regeneration of tissue and reduced inflammation."	PubMed
	Wound healing	Wounds	Santos	Brazil (Salvador, Bahia)	2011	Photomed Laser Surg	**Influence of the combination of infrared and red laser light on the healing of cutaneous wounds infected by Staphylococcus aureus.**	Rat	Infections	"Histological analysis showed that control subjects had a lower amount of blood vessels when compared with irradiated subjects. Irradiated subjects had more advanced resolution of inflammation compared with controls. Irradiated subjects also showed a more intense expression of the collagen matrix. The collagen fibers were mostly mature and well organized in these subjects at the end of the experimental time especially when both wavelengths were used." Comment: It seems unclear whether the red laser was 660 or 680 nanometers	PubMed
	Wound healing	Wounds	Gonçalves	Brazil (Viçosa)	2010	Photomed Laser Surg	**Comparative study of the effects of gallium-aluminum-arsenide laser photobiomodulation and healing oil on skin wounds in wistar rats: a histomorphometric study.**	Rat		"Results show that the 60 J/cm2 laser was more effective in stimulating angiogenesis. In addition, the 60 J/cm2 and the 30 J/cm2 laser were both more effective in promoting collagen maturation in the scar tissue of rats, respectively"	PubMed
	Wound healing	Wounds	Chung	New Zealand (Dunedin)	2010	Photomed Laser Surg	**Laser photobiomodulation of wound healing in diabetic and non-diabetic mice: effects in splinted and unsplinted wounds.**	Mouse	Dose response	"Healing of splinted wounds was delayed compared to unsplinted wounds, but laser irradiation (1.6 J/day, 7 days) stimulated healing by re-epithelization and granulation tissue formation." Comment: The higher dose was better	PubMed
	Wound healing	Wounds	Marchionni	Brazil (Salvador, Bahia)	2010	Photomed Laser Surg	**Influence of laser (λ670 nm) and dexamethasone on the chronology of cutaneous repair.**	Rat	LLLT vs dexamethasone	"Laser was effective in reducing swelling and polymorphonuclear cells and accelerated tissue repair, even in the presence of dexamethasone."	PubMed
	Wound healing	Wounds	Santos	Brazil (Salvador, Bahia)	2010	Photomed Laser Surg	**Effects of laser photobiomodulation on cutaneous wounds treated with mitomycin C: a histomorphometric and histological study in a rodent model.**	Rat		"LPBM resulted in reduced inflammation and an increase in both fibroblast proliferation and collagen deposition."	PubMed
	Wound healing	Wounds	Peplow	New Zealand (Dunedin)	2010	Photomed Laser Surg	**Laser photobiomodulation of wound healing: a review of experimental studies in mouse and rat animal models.**	Review (animal models)			PubMed

	Wound healing	Wounds		Leclère	France	2010	Wound Repair Regen	**A prospective randomized study of 980 nm diode laser-assisted venous ulcer healing on 34 patients.**	Human Observational		"980 nm diode laser-assisted venous ulcer healing was easy to perform and very well tolerated. However, there were no statistically significant differences in reduction of ulcer size between the two groups, suggesting that this particular laser regimen does not promote wound healing." Note: This paper isn't actually LLLT, since a very high dose laser was used and it led to significant heating of the irradiated tissue	PubMed
	Wound healing	Wounds		Dall Agnol	Brazil (São José dos Campos)	2009	Lasers Med Sci	**Comparative analysis of coherent light action (laser) versus non-coherent light (light-emitting diode) for tissue repair in diabetic rats.**	Rat	Diabetic rats LLLT vs LED LED phototherapy	"The coherent and non-coherent lights produced similar effects during a period of 168 h after the lesions had been made. For the group composed of diabetic animals, 72 h after creation of the lesion, it was observed that the therapy with LEDs had been more efficient than that with the laser in the reduction of the wounds' diameters."	PubMed
	Wound healing	Wounds		Whinfield & Aitkenhead	UK (London)	2009	Foot (Edinb)	**The light revival: does phototherapy promote wound healing? A review.**	Review			PubMed
	Wound healing	Wounds		Ribeiro	Brazil (Salvador, Bahia)	2009	Photomed Laser Surg	**Immunohistochemical assessment of myofibroblasts and lymphoid cells during wound healing in rats subjected to laser photobiomodulation at 660 nm.**	Rat		"The average number of myofibroblasts was statistically significantly higher in the irradiated group than in the non-irradiated group on the eighth (p = 0.001) but not the 14th (p = 0.555) day. B and T cells were significantly more conspicuous in the irradiated group on both the eighth (p = 0.004 and 0.02, respectively) and 14th days (p = 0.04 and 0.03, respectively)." "Our results suggest that LLLT facilitates myofibroblastic differentiation during the early stages of the cicatricial repair process. Furthermore, LLLT also appears to modulate the inflammatory response by downregulating lymphocytic proliferation during the wound healing process."	PubMed
	Wound healing	Wounds		Rodrigo	Brazil (Porto Alegre)	2009	Photomed Laser Surg	**Analysis of the systemic effect of red and infrared laser therapy on wound repair.**	Rat		"The combined application of red and infrared lasers resulted in the most evident systemic effect on the repair of skin wounds produced in rats."	PubMed
	Wound healing	Wounds		Gonzaga Ribeiro	Brazil (Aracaju)	2009	Indian J Dent Res	**Morphological analysis of second-intention wound healing in rats submitted to 16 J/cm 2 lambda 660-nm laser irradiation.**	Rat		"We found that LLLT was able to slightly reduce the intensity of the inflammatory reaction as well as to enhance substantially the epithelization process at both 8 th and 14 th days. In addition, it also appeared to stimulate the deposition of collagen fibers at the final stages of wound healing."	PubMed
	Wound healing	Wounds		Medrado	Brazil (Salvador, Bahia)	2008	J Photochem Photobiol B	**Influence of laser photobiomodulation upon connective tissue remodeling during wound healing.**	Rat		"Thus, laser photobiomodulation was able to induce several modifications during the cutaneous healing process, especially in favoring newly-formed collagen fibers to be better organized and compactedly disposed."	PubMed
	Wound healing	Wounds		Reis	Brazil (Salvador, Bahia)	2008	Photomed Laser Surg	**Effect of 670-nm laser therapy and dexamethasone on tissue repair: a histological and ultrastructural study.**	Rat	"Surgical" wound Edema LLLT vs dexamethasone	"LLLT alone accelerates post-surgical tissue repair and reduces edema and the polymorphonuclear infiltrate even in the presence of dexamethasone."	PubMed
	Wound healing	Wounds		Machneva	Russia	2008	Biozifika	**[A study of the effect of low-intensity laser radiation of the blue, green, and red spectral regions on the healing of experimental skin wounds in rats].** **[Article in Russian]**	Rat		"It was shown that irradiation with laser accelerated the healing of wounds in all cases. The exposure to laser radiations in the red (1.5 J/cm), blue, and green (0.75 J/cm2) spectral regions shortened the time of wound healing from 22 to 17 and 19 days, respectively."	PubMed
	Wound healing	Wounds		Corazza	Brazil (São Carlos)	2007	Photomed Laser Surg	**Photobiomodulation on the angiogenesis of skin wounds in rats using different light sources.**	Rat	Angiogenesis Biphasic dose response LED phototherapy LED vs LLLT	"On days 3, 7, and 14, the proliferation of blood vessels in all irradiated groups was superior in comparison to those of the control group (p < 0.05). Treatment with fluence of 5 J/cm(2) was better than the laser group with 20 J/cm(2) on day 21." "Red LLLT and LED demonstrated expressive results in angiogenesis. Light coherence was shown not to be essential to angiogenesis."	PubMed
	Wound healing	Wounds		Yasukawa	Japan	2007	J Vet Med Sci	**The effect of low reactive-level laser therapy (LLLT) with helium-neon laser on operative wound healing in a rat model.**	Rat	Surgical wounds	LLLT with a He-Ne laser was found to promote the healing of operative wounds in the present rat model, in which the most favorable application of LLLT was the 17.0 mW setting of 15 seconds a day with a frequency of every other day.	PubMed
	Wound healing	Wounds		Demidova-Rice	USA (Boston, MA)	2007	Lasers Surg Med	**Low-level light stimulates excisional wound healing in mice.**	Mouse	Biphasic dose response Laser vs non-coherent	"820 nm is the most effective wavelength" "laser and non-coherent lamp are equivalent" "LLLT stimulates wound contraction in susceptible mouse strains but the mechanism remains uncertain."	PubMed
	Wound healing	Wounds		Posten	USA (Chicago, IL)	2005	Dermatol Surg	**Low-level laser therapy for wound healing: mechanism and efficacy.**	Review			PubMed
	Wound healing	Wounds		Pinheiro	Brazil (Salvador, Bahia) (?)	2005	Photomed Laser Surg	**Polarized light (400-2000 nm) and non-ablative laser (685 nm): a description of the wound healing process using immunohistochemical analysis.**	Rat	Biphasic dose response	"Dose was also shown to have influence on the outcome of the treatment as on both cases, the use of 20 J/cm2 resulted on better effects on the healing process resulting on better organization and distribution of collagen fibers and influencing the numbers of myofibroblast" "The present study indicates that the use of 685-nm laser light or polarized light with a dose of 20 J/cm2 resulted in increased collagen deposition and better organization on healing wounds, and that the number of myofibroblasts is increased when polarized light is used."	PubMed
	Wound healing	Wounds		Vidinský	Slovenia	2005	Rozhl Chir	**[Effect of laser irradiation of diode laser on healing of surgical wounds in rats]. [Article in Czech]**	Rat	Surgical wounds	LLLT accelerated wound healing.	PubMed
	Wound healing	Wounds		Byrnes	USA (Bethesda, MD)	2004	Photomed Laser Surg	**Photobiomodulation improves cutaneous wound healing in an animal model of type II diabetes.**	Sand rat		"Significant improvement in wound healing histology and wound closure were found following treatment with 4 J/cm(2) (16 mW, 250-sec treatments for 4 consecutive days; p < 0.05). The 4 J/cm(2) dosage significantly improved histology and closure of wounds in the diabetic group in comparison to the non-irradiated diabetic group."	PubMed
	Wound healing	Wounds		Woodruff	USA (Dahlonega, GA)	2004	Photomed Laser Surg	**The efficacy of laser therapy in wound repair: a meta-analysis of the literature.**	Meta-analysis			PubMed
	Wound healing	Wounds		Mendez	Brazil (São Paulo)	2004	J Clin Laser Med Surg	**Dose and wavelength of laser light have influence on the repair of cutaneous wounds.**	Rat		"Group IV (lambda 830 nm and lambda 685 nm, 20 J/cm(2)) presented better results at the end of the experimental period. It is concluded that low-level light therapy (LLLT) can have a positive biomodulatory effect on the repair of cutaneous wounds."	PubMed
	Wound healing	Wounds		Hopkins	USA (Provo, UT)	2004	J Athl Train	**Low-Level Laser Therapy Facilitates Superficial Wound Healing in Humans: A Triple-Blind, Sham-Controlled Study.**	Human RCT/DB (TB)	Superficial wounds Laser clusted (46 diodes)	"These data indicate that LLLT is an effective modality to facilitate wound contraction of partial-thickness wounds."	PubMed

Wound healing	Wounds	Whelan	USA (Milwaukee, WI)	2002	J Clin Laser Med Surg	**Effect of NASA light-emitting diode irradiation on molecular changes for wound healing in diabetic mice.**	Mouse	Diabetic mice LED phototherapy	"Our studies have revealed certain tissue regenerating genes that were significantly upregulated upon LED treatment when compared to the untreated sample. Integrins, laminin, gap junction proteins, and kinesin superfamily motor proteins are some of the genes involved during regeneration process." "We believe that the use of NASA light-emitting diodes (LED) for light therapy will greatly enhance the natural wound healing process, and more quickly return the patient to a preinjury/illness level of activity." "This work is supported and managed through the Defense Advanced Research Projects Agency (DARPA) and NASA Marshall Space Flight Center-SBIR Program."	PubMed
Wound healing	Wounds	Simunovic	Switzerland	2000	J Clin Laser Med Surg	**Wound healing of animal and human body sport and traffic accident injuries using low-level laser therapy treatment: a randomized clinical study of seventy-four patients with control group.**	Human		"After comparing the healing process between two groups of patients, we obtained the following results: wound healing was significantly accelerated (25%-35%) in the group of patients treated with LLLT. Pain relief and functional recovery of patients treated with LLLT were significantly improved comparing to untreated patients."	PubMed
Wound healing	Wounds	Ghamsari	Japan (Hokkaido)	1997	Vet Surg	**Evaluation of low level laser therapy on primary healing of experimentally induced full thickness teat wounds in dairy cattle.**	Cattle		"The LLLT affects various aspects of the healing process, including minimizing inflammation, formation of edema, improvement of skin regeneration and enhancement of collagen synthesis."	PubMed
Wound healing	Wounds	Longo	Italy (Florence)	1987	Lasers Surg Med	**Effect of diodes-laser silver arsenide-aluminium (Ga-Al-As) 904 nm on healing of experimental wounds.**	Rat	Biphasic dose response	LLLT for 5 minutes daily: "promoted healing of experimental wounds in rats from both a microscopic and histologic point of view" LLLT for 10 minutes daily: "did not affect the experimental wounds"	PubMed