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ORIGINAL ARTICLE

Short-Term Efficacy Comparison of High-Intensity and Low-Intensity Laser Therapy in the Treatment of Lateral Epicondylitis: A Randomized Double-Blind Clinical Study

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ABSTRACT

Objectives: This study aims to evaluate and compare the short-term efficacies of high-intensity laser therapy (HILT) and low-intensity laser therapy (LILT) in the treatment of lateral epicondylitis (LE).

Patients and methods: Sixty patients (16 males, 44 females; mean age 44.2±9.3 years; range, 18 to 65 years) with unilateral elbow pain were randomized into two groups as 30 patients treated with HILT (9 males and 21 females) and 30 patients treated with LILT (7 males and 23 females). The HILT (1,064 nm) and LILT (904 nm) were administered three times a week for three weeks, and each treatment was combined with an epicondylitis bandage. A visual analog scale (VAS), quick Disabilities of the Arm, Shoulder, and Hand (QDASH) questionnaire, Medical Outcomes Study Questionnaire Short Form 36 Health Survey (SF-36), and hand grip strength test were used to evaluate the patients before and three weeks after treatment.

Results: The two groups had similar demographic characteristics, including age, sex, occupation, and body mass index ($p>0.05$). There were no statistically significant differences between the two groups in terms of the pretreatment VAS, QDASH, hand grip strength, and SF-36 scores ($p>0.05$). After three weeks, both groups showed significant improvements in all of the parameters ($p<0.05$). However, in the HILT group, the QDASH, hand grip strength, and SF-36 physical component summary (PCS) scores showed superior improvement compared to the LILT group ($p<0.05$).

Conclusion: Each treatment modality was found to be effective and safe for the short-term treatment of LE. However, the HILT exhibited more significant effects on the hand grip strength, QDASH, and SF-36 PCS scores than the LILT.

Keywords: Hand grip strength, high-intensity laser therapy, lateral epicondylitis; low-intensity laser therapy, pain.

Lateral epicondylitis (LE) is a common cause of elbow pain. Rather than an inflammatory condition, it is an overuse-underuse tendinopathy (i.e., chronic symptomatic degeneration of the tendon) that affects the common attachment of the tendons of the extensor muscles of the forearm (extensor carpi radialis brevis, extensor digitorum, extensor digiti minimi and extensor carpi ulnaris) to the lateral epicondyle.[1,2] LE occurs in 1-3% of the general population between 30 and 50 years of age, and it is often seen in females in the dominant hand.[3] In LE, the pain in the tendons of the wrist and finger extensor muscles increases with wrist extension in both supination and pronation.[4] Moreover, LE is frequently seen in people who are prone to

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repetitive wrist movements, strong pronounced forearm supination movements, and constant vibrations.[5] In these cases, repeated activity leads to chronic pain syndrome.

In LE cases, treatment is administered to reduce the pain, accelerate and improve patient recovery, prevent excessive arm use, and help patients in enhancing their quality of life and functional capacity. Treatment can be divided into three main types: the first one is medical therapies combined with local injection and non-electrotherapeutic approaches such as manipulation, acupuncture, banding, orthotics, and exercises; the second one is electrotherapeutic methods such as extracorporeal shock wave therapy (ESWT), laser therapy, electromagnetic field treatments, and phonophoresis; and the last approach is surgical treatment.[6] Laser treatment is noninvasive, painless and can be combined with other treatment methods. Also, it can be easily applied in physical therapy clinics with a wide range of conditions. Over the last decade, high-intensity laser therapy (HILT) has gained importance for the treatment of different kinds of sports injuries such as tendon injuries, contusions, and muscle spasms. Low-intensity laser therapy (LILT) has exhibited contradictory results when used for the treatment of LE.[7,8] However, Tumilty *et al.*[9] reported that LILT, with an appropriate dosing regimen, may be an effective tendinopathy treatment modality. In their study, Akkurt *et al.*[10] showed that HILT is an effective and safe treatment for LE over both the short- and long-terms. Moreover, in 2017, it was reported that HILT was more effective than LILT in the treatment of patients with plantar fasciitis (PF).[11] However, to our knowledge, there have been no randomized controlled trials comparing the efficacies of these two treatments on LE, which is a more superficial tissue pathology than PF. Therefore, in this study, we aimed to evaluate and compare the short-term efficacies of HILT and LILT in the treatment of LE.

PATIENTS AND METHODS

This study was designed as a randomized clinical trial with a follow-up of three weeks. A total of 60 patients (16 males, 44 females; mean age 44.2±9.3 years; range, 18 to 65 years) with unilateral elbow pain who presented to the outpatient clinic of the Bor Physical Medicine and Rehabilitation Training and Research Hospital between April 2018 and July 2018 were screened for enrollment. According to the study design, the physician evaluating and following the patients (data collector) and the patients themselves were blinded to the study design and treatment groups. Only the clinical staff (physiotherapist for this study) who was administering the treatment was aware of the treatment approaches. The flow diagram of the study is shown in Figure 1. The study protocol was approved by the Selcuk University Medicine Faculty Ethics Committee (No: 2018/168). A written informed consent was obtained from each patient. The study was conducted in accordance with the principles of the Declaration of Helsinki.

After collecting each patient's medical history and physical examination, patients diagnosed with unilateral LE were randomly divided into two groups as the HILT treatment group and the LILT treatment group. The exclusion criteria were pain history of less than four weeks, upper extremity entrapment neuropathy, major psychiatric disease, upper extremity surgical treatment history, malignancy history, chronic rheumatic disease, cervical radiculopathy, cervical myelopathy, local corticosteroid injection prior to LE, and receiving physical therapy.

A computer-generated randomized table of numbers for concealed allocation was used for the randomization, and it was created prior to the initiation of the study. The PASW version 18.0 software (SPSS Inc., Chicago, IL, USA) was used to generate the block sizes and randomization schedules. The physicians remained blinded to these schedules.

Each patient was questioned regarding when their pain had started and the duration from the onset was recorded in weeks. The pain and functional levels of the patients were evaluated using a 0 to 10 cm visual analog scale (VAS) and the quick Disabilities of the Arm, Shoulder, and Hand (QDASH) questionnaire. The QDASH is a self-reported questionnaire that measures the physical functions and symptoms of patients with upper limb problems. The reliability of the Turkish version of the QDASH has been tested previously.[12,13] It includes 11 items from the DASH survey, and to calculate the QDASH score, at

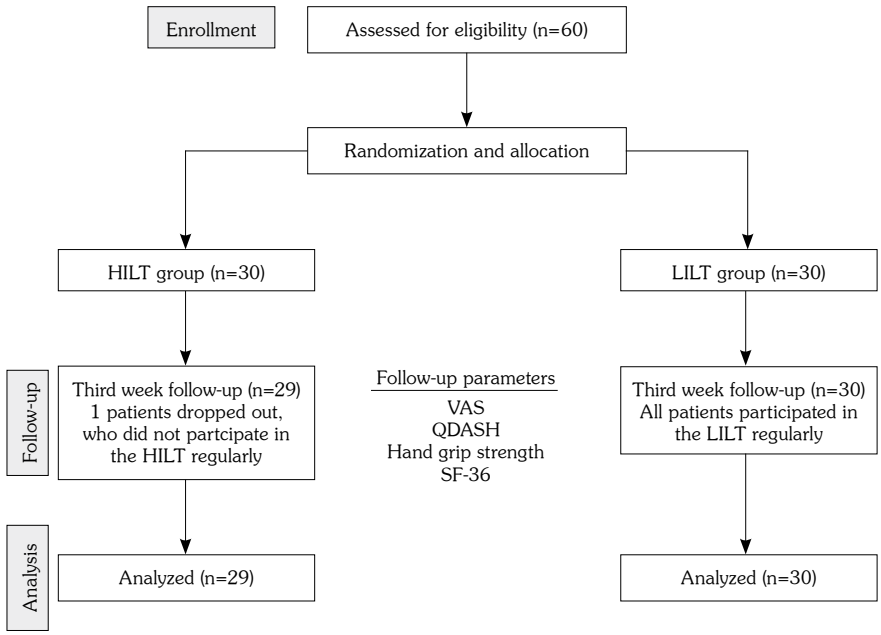

Figure 1. Flow diagram of study.
HILT: High-intensity laser therapy; LILT: Low-intensity laser therapy; VAS: Visual analog scale; QDASH: Quick Disabilities of Arm, Shoulder, and Hand; SF-36: Short form-36.

least 10 of the 11 items should be answered. Each item contains five answer options, and the total score of the scale is calculated from the individual item scores (0=no disability and 100=the most serious disability). The first eight items of the QDASH questionnaire measure the patient's daily life function and social activity limitations. The ninth question assesses the pain intensity, and the 10th question evaluates the feeling of "pins and needles" in the upper extremity. The last question is designed to evaluate the sleep problem due to pain.

Hand grip strength measurements taken with a JAMAR hydraulic hand dynamometer (Lafayette Instrument, Lafayette, IN, USA) are known to provide reliable results,[14] and these measurements were obtained while the patient was standing with a full extension of the elbow and wrist. Each patient was asked to squeeze the dynamometer with full force for a maximum of three sec. First on the healthy side and then on the LE side, three measurements were taken, and the averages were obtained. Between each measurement, a 30-sec rest period was given. Each patient was asked to perform a maximum grip for the maximum grip strength measurement. The measurement results were recorded on the follow-up form in kilograms.[15]

The quality of life of the participants was evaluated with the Medical Outcomes Study Questionnaire Short Form 36 Health Survey (SF-36), which is a reliable and valid method that can be used as a standardized questionnaire to evaluate patients with musculoskeletal disorders. The SF-36 includes 36 questions that span eight areas, including physical function, role limitations due to physical function, bodily pain, general health perception, vitality, social functioning, role limitations arising from emotional problems, and general mental health. These domains are scored from 0 to 100 (worst and best health). Additionally, there are two summary scales, the physical component summary (PCS) and mental component summary.[16] The validity and reliability testing of the Turkish version of the SF-36 was performed by Koçyiğit et al.[17]

The HILT was performed using a BTL-6000 high-intensity laser (12 W; BTL Industries, Inc., Greeneville, TN, USA) at 1,064 nm, which is considered to be a hot laser (neodymium-doped yttrium aluminum garnet laser source).[18] In the HILT group, we applied the device to the most painful area of the lateral epicondyle in two phases. In both phase I and phase II, the laser was applied using continuous circular movements.

The first three sessions (phase I) were used to provide analgesic effects at an intermittent phase, applying a 75 sec, 8 W, 6 J/cm^2 treatment for a total of 150 J of energy. The subsequent six sessions (phase II) were to provide a biostimulatory effect at a continuous phase, applying a 30 sec, 6 W, 120 to 150 J/cm^2 treatment. The HILT was applied for a total of nine treatment sessions over a period of three consecutive weeks.

The LILT treatment was administered at a wavelength of 904 nm, output power of 240 MW, and frequency of 5,000 Hz using a gallium aluminum arsenide infrared diode laser (Chattanooga Medical Supply Inc., Chattanooga, TN, USA). The standard treatment was provided, which consisted of super-pulsed irradiation over the most painful areas. The spot area was approximately 0.5 cm^2, with six areas over the facet of the lateral epicondyle, while administering a power density of 2.4 J/cm^2 at a treatment duration of 30 sec per point. Three LILT treatment sessions per week were administered over a period of three weeks.[7]

The strapped epicondylitis bandages apply moderate pressure to the forearm muscles via gel like pads. The patients in both treatment groups were given LE bandages for regular use during the follow-up period. All participants were asked to wear the bandages during the daily activates and wrist extensor strengthening exercises and remove them while sleeping and bathing.

Statistical analysis

The PASW version 18.0 software (SPSS Inc., Chicago, IL, USA) was used for the statistical analysis. The Kolmogorov-Smirnov test was used to determine the conformity of the continuous variables with normal distributions, and all of the variables were normally distributed. The descriptive data were presented as the mean ± standard deviation. The Chi-squared test was used to compare the demographic and clinical characteristics, and the within- and between-group differences were investigated. The paired samples t-test was used to determine the differences between the baseline and post-treatment values, and the independent samples t-test was used to compare the two groups. A *p* value of less than 0.05 was considered to be statistically significant.

RESULTS

The initial demographic and clinical characteristics of the patients are shown in Table 1. A total of 60 patients were included in the study; however, one patient in the HILT group was excluded due to the lack of regular participation. The results showed no differences between the two experimental groups in the demographic data, including sex, age, occupation, and body mass index. Also, there were no statistically significant differences between the HILT and LILT groups regarding the VAS, QDASH, and hand grip strength values (p>0.05). The disease durations were similar between the two groups (p>0.05).

No treatment-related adverse reaction was observed in any of the patients. In both the HILT and LILT groups, the VAS and QDASH scores

Table 1. Baseline demographic and clinical data of study groups

	HILT group (n=29)		LILT group (n=30)		
	n	Mean±SD	n	Mean±SD	*p*
Age (year)		45.4±10.3		43.1±8.3	0.361
Sex					0.506
Female	20		23		
Male	9		7		
Body mass index (kg/m^2)		26.7±4.5		26.2±3.7	0.627
Duration of complaints (weeks)		10.0±4.2		9.1±4.6	0.461
Employment					0.490
Housewife	18		14		
Worker	6		9		
Officer	2		1		
Other (retired etc.)	3		6		

HILT: High-intensity laser therapy; LILT: Low- intensity laser therapy; SD: Standard deviation (Chi-squared test).

Table 2. Assessment of pain and functional parameters

	HILT group (n=29)	LILT group (n=30)	HILT vs. LILT groups
	Mean±SD	Mean±SD	*p*
Visual analog scale pain score			
Baseline	7.2±1.4	7.1±1.5	0.783
After treatment	2.9±1.5	3.3±1.5	0.360
p	<0.001*	<0.001*	
Hand grip strength (kg)			
Baseline	21.4±8.8	19.2±5.4	0.245
After treatment	27.3±9.1	22.5±5.6	0.018‡
p	<0.001*	<0.001*	
QDASH score			
Baseline	54.8±14.5	59.1±13.3	0.234
After treatment	24.2±10.8	30.1±11.1	0.046‡
p	<0.001*	<0.001*	

HILT: High-intensity laser therapy; LILT: Low-intensity laser therapy; SD: Standard deviation; QDASH: Quick Disabilities of Arm, Shoulder, and Hand; * Baseline versus after treatment. Paired samples t-test; p<0.05; ‡ High-intensity laser therapy versus low-intensity laser therapy. Independent samples t-test; p<0.05.

Table 3. Comparison of Short Form-36 physical and mental scores

	HILT group (n=29)	LILT group (n=30)	HILT vs. LILT groups
	Mean±SD	Mean±SD	*p*
SF-36 (physical component)			
Baseline	38.6±5.3	38.2±4.9	0.725
After treatment	63.2±5.1	59.4±4.9	0.014‡
p	<0.001*	<0.001*	
SF-36 (mental component)			
Baseline	43.3±5.8	41.1±5.4	0.133
After treatment	60.1±6.3	58.9±4.3	0.809
p	<0.001*	<0.001*	

HILT: High-intensity laser therapy; LILT: Low-intensity laser therapy; SD: Standard deviation; SF-36: Short Form-36; * Baseline versus after treatment. Paired-samples t-test; p<0.05; ‡ High-intensity laser therapy versus low-intensity laser therapy. Independent samples t-test; p<0.05.

were significantly improved after the treatment in all of the parameters evaluated, including the SF-36 scores and hand grip strength values (p<0.05). In the HILT group, the improvements in the hand grip strength, QDASH (Table 2), and SF-36 PCS scores were significantly higher than those of the LILT group (p<0.05) (Table 3).

DISCUSSION

Lateral epicondylitis is one of the most commonly seen painful pathologies of the musculoskeletal system. Nonsurgical treatment methods, such as local and oral nonsteroidal anti-inflammatory drugs, steroid injections, patient education, exercises, ESWT, physiotherapy, and splinting, are frequently used in the treatment of LE. One physiotherapy method, laser therapy, has been used more often for the treatment of LE in recent years. Both LILT and HILT have been used to treat LE, and many studies have shown both the short- and long-term results. However, to our knowledge, there have been no studies comparing the efficacies of these two LE treatment modalities. Therefore, in this study, we investigated the short-term effects of HILT and LILT in the treatment of LE, and we found that both treatment modalities were effective and safe in terms of pain, functional capacity, hand grip strength, and quality of life. Additionally, we detected statistically significant differences between the two groups in terms of the handgrip strength, QDASH, and SF-36 PCS scores in favor of the HILT group.

The use of LILT began in Europe and Russia in the 1960s, and it has been accepted that the primary biological effects of this treatment are through the light radiation effect, instead of the

thermal effects.[19] However, it is unclear how LILT provides analgesic effects. In the case of pain, LILT may affect the release of neurotransmitters like serotonin,[20] which increases the production of mitochondrial adenosine triphosphate (ATP),[21] increases endorphin release,[22] and exhibits anti-inflammatory effects.[23] Moreover, LILT increases the production of intracellular secondary messengers, such as ATP and calcium ion (Ca^{2+}). Additionally, it can mediate the proliferation of tenocytes and collagen synthesis,[24] which prevents oxidative stress and reduces tendon fibrosis.[25] Through these mechanisms, it can accelerate tendon healing and alleviate tendinous inflammation and pain.

Contrary results have been reported regarding the efficacy of LILT in the treatment of LE. Some LE studies have shown that LILT provides better results than placebo.[9] In one meta-analysis performed by Bjordal et al. in 2008,[26] which evaluated the effects of LILT treatments of different wavelengths, the LILT treatment at the 904 nm wavelength was reported to cause short-term improvement in the pain and physical functions of the patients. In contrast, in their 2005 meta-analysis, Bisset et al.[27] claimed that LILT was ineffective in the treatment of LE. In our study, the LILT treatment was performed at a wavelength of 904 nm, and it caused a significant decrease in the pain of the patients, improved their forearm functions, increased the quality of life, and exhibited a significant increase in the hand grip strength.

The HILT mechanism of action is not precise. Unlike LILT, it is considered to have both photochemical and photothermal effects, which result in anti-inflammatory, anti-edema, analgesic, and restorative treatment effects.[28] The analgesic effects of HILT are thought to be based on different mechanisms of action, such as slowing the transmission of the pain stimulus and increasing the production of morphine-mimetic substances in the body.[17] In addition, it may have direct effects on nervous structures, which may increase the improvement rate of conduction blocks or inhibit transmission through the A-delta and C pain fibers.[29] This treatment provides changes in blood flow, an increase in permeability of blood vessels and accelerates the cellular metabolic response.[30] Moreover, the photochemical and photothermal effects of HILT can stimulate collagen production within the tendons, and may increase the blood flow and vascular permeability and cause anti-inflammatory effects. Thus, HILT can help repair damaged tissues and remove painful stimuli.

A number of previous studies have investigated the efficacy of HILT in LE. For example, Salli et al.[31] investigated the HILT treatment efficacy with epicondylitis bandages and observed significant improvement in favor of the HILT in all of the hand grip strength, pain, disability, and quality of life parameters. Additionally, Akkurt et al.[10] investigated the long-term HILT treatment effects and reported significant improvements in the VAS (in both activity and rest), DASH, hand grip strength, and SF-36 scores starting at the second week after treatment, which continued to increase through the sixth month.

There have been a limited number of studies comparing LILT and HILT in the treatment of musculoskeletal disorders. In comparative studies of the treatment of knee osteoarthritis[32] and PF,[11] it was shown that HILT was more effective on pain and other clinical parameters than LILT due to its ability to reach and stimulate wider and deeper local areas. In contrast, in one recent study of knee osteoarthritis, Taghizade et al.[33] reported that both treatments resulted in significant improvements in the pain and physical functions, but they found no statistically significant differences between the two treatment groups. In a comparison study by Alayat et al.[34] in patients with Bell's palsy, both the HILT and LILT treatments resulted in statistically significantly superior functional recovery than traditional therapy. Additionally, this improvement was more significant in the HILT group than in the LILT group.

In our study findings, there were significant improvements in the pain VAS scores, upper extremity functions, hand grip strength, and life quality scores in both treatment groups. These improvements were found to be more significant in favor of the HILT group in the handgrip strength, QDASH and SF-36 PCS scores ($p<0.05$). Although there was more improvement in the HILT group (59.7%) according to the LILT group (53.5%) in pain VAS scores, the change was not statistically significant ($p>0.05$). This result may be due to the lack of precision evaluation of VAS for pain, such as during strenuous activity, routine

events, or rest at different follow-up evaluation points.

This study has some important limitations, such as the short follow-up period and the low number of participants. In a six-month follow-up study by Akkurt et al.,[10] it was shown that the improvement in the VAS activity and DASH scores continued to increase significantly up to the sixth month after the end of the treatment. Another limitation was that a single treatment procedure was applied, since the optimal frequency, dose, wavelength, and treatment time for HILT and LILT LE treatments are not yet clear. In addition, the VAS pain scores were not evaluated separately with regard to rest and activity. Finally, although there were significant differences in the hand function and quality of life scores between the HILT and LILT groups after the treatment, it would have been useful to determine the reasons why there was no significant difference between the VAS pain scores.

In conclusion, based on the results of this study, the HILT and LILT were effective and reliable for the treatment of LE. Additionally, the HILT treatment was more effective than the LILT treatment in the hand grip strength, QDASH, and SF-36 PCS scores. We believe that these findings should be supported with additional studies conducted using different doses and wavelengths and with more participants and longer follow-up durations.

Declaration of conflicting interests

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REFERENCES

1. Tang HY, Yu T, Wei W, Zhao Y. Effect of extracorporeal shock wave for tennis elbow: A protocol for systematic review of randomized controlled trial. Medicine (Baltimore) 2019;98:e14517.
2. Ahmad Z, Siddiqui N, Malik SS, Abdus-Samee M, Tytherleigh-Strong G, Rushton N. Lateral epicondylitis: a review of pathology and management. Bone Joint J 2013;95:1158-64.
3. Nirschl RP, Ashman ES. Tennis elbow tendinosis (epicondylitis). Instr Course Lect 2004;53:587-98.
4. Stasinopoulos D, Johnson MI. Cyriax physiotherapy for tennis elbow/lateral epicondylitis. Br J Sports Med 2004;38:675-7.
5. Kaiman MD, Fink K. Upper extremity soft-tissues injuries. In: DeLisa JA, Bruce M, Gans BM, editors. Physical Medicine and Rehabilitation: Principles and Practice. 4th ed. Philadelphia: Lippincott Williams & Wilkins; 2005. p. 829-42.
6. Luk JK, Tsang RC, Leung HB. Lateral epicondylalgia: midlife crisis of a tendon. Hong Kong Med J 2014;20:145-51.
7. Stergioulas A. Effects of low-level laser and plyometric exercises in the treatment of lateral epicondylitis. Photomed Laser Surg 2007;25:205-13.
8. Basford JR, Sheffield CG, Cieslak KR. Laser therapy: a randomized, controlled trial of the effects of low intensity Nd:YAG laser irradiation on lateral epicondylitis. Arch Phys Med Rehabil 2000;81:1504-10.
9. Tumilty S, Munn J, McDonough S, Hurley DA, Basford JR, Baxter GD. Low level laser treatment of tendinopathy: a systematic review with meta-analysis. Photomed Laser Surg 2010;28:3-16.
10. Akkurt E, Kucuksen S, Yılmaz H, Parlak S, Sallı A, Karaca G. Long term effects of high intensity laser therapy in lateral epicondylitis patients. Lasers Med Sci 2016;31:249-53.
11. Ordahan B, Karahan AY, Kaydok E. The effect of high-intensity versus low-level laser therapy in the management of plantar fasciitis: a randomized clinical trial. Lasers Med Sci 2018;33:1363-9.
12. Gummesson C, Ward MM, Atroshi I. The shortened disabilities of the arm, shoulder and hand questionnaire (QuickDASH): validity and reliability based on responses within the full-length DASH. BMC Musculoskelet Disord 2006;7:44.
13. Available from: http://www.dash.iwh.on.ca/sites/dash/public/translations/QuickDASH_Turkish_2012.pdf
14. Bohannon RW, Schaubert KL. Test-retest reliability of grip-strength measures obtained over a 12-week interval from community-dwelling elders. J Hand Ther 2005;18:426-7.
15. Dorf ER, Chhabra AB, Golish SR, McGinty JL, Pannunzio ME. Effect of elbow position on grip strength in the evaluation of lateral epicondylitis. J Hand Surg Am 2007;32:882-6.
16. Ware JE Jr. SF-36 health survey update. Spine (Phila Pa 1976) 2000;25:3130-9.
17. Koçyigit H, Aydemir O, Fişek G, Ölmez N, Memiş A. Reliability and validity of the Turkish version of short form-36 (SF-36): a study in a group of patients will rheumatic diseases. Turk J Drugs Ther 1999;12:102-6.
18. Zati A, Valent A. Laser therapy in medicine. In: Medica M, editor. Terapia Fisica: Nuove Tecnologie in Medicina Riabilitativa. Rome: Edizioni Minerva Medica; 2006. p. 162-85.

19. Ohshiro T, Calderhead RG. Development of low reactive-level laser therapy and its present status. J Clin Laser Med Surg 1991;9:267-75.
20. Walker J. Relief from chronic pain by low power laser irradiation. Neurosci Lett 1983;43:339-44.
21. Passarella S. He-Ne laser irradiation of isolated mitochondria. J Photochem Photobiol B 1989;3:642-3.
22. Yamamoto H, Ozaki A, Iguchi N, Kinoshita S. Antinociceptive effects of laser irradiation of Hoku point in rats. Pain Clin 1988;8:43-8.
23. Ailioaie C, Lupusoru-Ailioaie LM. Beneficial effects of laser therapy in the early stages of rheumatoid arthritis onset. Laser Ther 1999;11:79-87.
24. Chen MH, Huang YC, Sun JS, Chao YH, Chen MH. Second messengers mediating the proliferation and collagen synthesis of tenocytes induced by low-level laser irradiation. Lasers Med Sci 2015;30:263-72.
25. Fillipin LI, Mauriz JL, Vedovelli K, Moreira AJ, Zettler CG, Lech O, et al. Low-level laser therapy (LLLT) prevents oxidative stress and reduces fibrosis in rat traumatized Achilles tendon. Lasers Surg Med 2005;37:293-300.
26. Bjordal JM, Lopes-Martins RA, Joensen J, Couppe C, Ljunggren AE, Stergioulas A, et al. A systematic review with procedural assessments and meta-analysis of low level laser therapy in lateral elbow tendinopathy (tennis elbow). BMC Musculoskelet Disord 2008;9:75.
27. Bisset L, Paungmali A, Vicenzino B, Beller E. A systematic review and meta-analysis of clinical trials on physical interventions for lateral epicondylalgia. Br J Sports Med 2005;39:411-22.
28. Monici M, Cialdai F, Fusi F, Romano G, Pratesi R. Effects of pulsed Nd: YAG laser at molecular and cellular level. A study on the basis of Hilterapia. Energy for Health 2008;3:27-33.
29. Chow R, Armati P, Laakso EL, Bjordal JM, Baxter GD. Inhibitory effects of laser irradiation on peripheral mammalian nerves and relevance to analgesic effects: a systematic review. Photomed Laser Surg 2011;29:365-81.
30. Kujawa J, Zavodnik L, Zavodnik I, Buko V, Lapshyna A, Bryszewska M. Effect of low-intensity (3.75-25 J/cm2) near-infrared (810 nm) laser radiation on red blood cell ATPase activities and membrane structure. J Clin Laser Med Surg 2004;22:111-7.
31. Salli A, Akkurt E, Izki AA, Şen Z, Yilmaz H. Comparison of High Intensity Laser and Epicondylitis Bandage in the Treatment of Lateral Epicondylitis. Arch Rheumatol 2016;31:234-8.
32. Kheshie AR, Alayat MS, Ali MM. High-intensity versus low-level laser therapy in the treatment of patients with knee osteoarthritis: a randomized controlled trial. Lasers Med Sci 2014;29:1371-6.
33. Taghizade Delkhosh C, Fatemy E, Ghorbani R, Mohammadi R. comparing the immediate and long-term effects of low and high power laser on the symptoms of knee osteoarthritis. J-Mazand-Univ-Med-Sci 2018;28:69-77.
34. Alayat MS, Elsodany AM, El Fiky AA. Efficacy of high and low level laser therapy in the treatment of Bell's palsy: a randomized double blind placebo-controlled trial. Lasers Med Sci 2014;29:335-42.