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ORIGINAL ARTICLE

Investigation of Efficacy of High and Low Intensity Laser Therapy in Patients with Lumbar Disc Herniation: a Randomized Controlled Trial

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Abstract

Purpose The aim of this study was to compare the efficacy of high intensity laser therapy (HILT) and low-intensity laser therapy (LILT) on pain level and disability level in patients with lumbar disc herniation (LDH).

Methods This study was designed as a randomised controlled trial in three groups of 20 participants each. All groups performed home exercise three times a week for three weeks. In addition, the LILT group received laser treatment with an energy density of 50 J/cm^2 for 30 min/session for three weeks, totalling nine sessions. The HILT group received a total of 9 sessions of laser treatment in biostimulating mode with 12 W power, 150 J/cm^2 energy. Pain level with Visual Analogue Scale and disability was evaluated with Oswestry Disability Index before and after treatment was evaluated.

Results Significant differences were found in pain rest-activity and disability level between the three groups in post-treatment improvements. The HILT group showed significantly higher improvement in pain resting levels compared to the LILT and placebo groups. In disability, the HILT group improvements were significantly higher compared to the placebo group.

Conclusion In conclusion, in this study, HILT application in addition to exercise therapy was found to be more effective than LILT application in reducing resting pain intensity in patients with lumbar disc herniation, and laser dose was found to be effective on pain activity and disability without any difference.

Keywords Lumbar disc herniation · Laser therapy · High dose laser therapy · Low dose laser therapy

1 Introduction

Low back pain (LBP) is the leading musculoskeletal condition and approximately 15% of these are caused by disc herniation [1]. Most people in developed countries have been affected by lumbar disc herniation (LDH) at some point in their lives [2]. Nerve root compression is seen in most cases of LDH. Radiculopathy occurs in the roots of the nerves in contact with the vertebrae and intervertebral discs. Almost 50% of patients with disc herniation have neurological symptoms such as paresis due to radiculopathy [2, 3].

In LDH, pain, reduced mobility and motor symptoms can affect quality of life. Managing pain and disability is of great importance in the treatment of LDH. Treatment aims to prevent recurrence and chronicity of pain [3, 4]. There are pharmaceutical intervention, physiotherapy applications, orthosis use and lumbar decompressive surgery options for the treatment of disc herniation [4]. Various electrophysical modalities, such as massage, heat and cold applications, exercise, transcutaneous electrical nerve stimulation, and laser therapy are frequently used as physiotherapeutic interventions for managing LDH [5].

In physiotherapy, low-intensity laser therapy (LILT) and high-intensity laser therapy (HILT) are frequently used for pain management and recovery. Photomechanical, photothermal and photo-chemical properties of laser therapy are utilised. LILT therapy is known to have analgesic, anti-inflammatory and therapeutic effects that promote nerve regeneration LILT stimulates cell metabolism, accelerates tissue repair and reduces pain. Yttrium aluminium garnet

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HILT, which is high intensity laser radiation, can reach deep tissues [6]. HILT reduces muscle spasms and inflammation thanks to its high penetration feature, and also accelerates the healing process by increasing blood circulation. The analgesic effects of laser treatments in diseases such as chronic rheumatoid arthritis, osteoarthritis, fibromyalgia have been conclusively established [6, 7]. LILT and HILT treatments generally help in pain management, functional improvement and improvement of quality of life in patients who do not require surgical intervention.

There is no consensus in the literature on the frequency, dosage and efficacy of laser therapy on pain-related symptoms in LDH patients. In this context, the aim of our study was to evaluate the effectiveness of HILT and LILT treatment on pain level and disability in LDH patients.

2 Methods

2.1 Study Design

This study was a randomized controlled trial conducted in a local Physical Medicine and Rehabilitation Clinic. Ethics committee approval for the study was obtained from the Research Committee of Eldivaniyah Health Administration Department (Approval Number: 4). Prior to participation, all participants provided written and verbal informed consent. The study adhered to the ethical principles outlined in the Declaration of Helsinki.

2.2 Participants

Sixty patients with a diagnosis of lumbar disc herniation were included in the study. They were randomly allocated to one of three groups: HILT ($n=20$), (LILT) ($n=20$), and a placebo laser group ($n=20$). Participants had to have a confirmed diagnosis of lumbar disc herniation by lumbar MRI, no history of trauma or congenital conditions, and the cognitive ability to understand and respond to the rating scale. Individuals were excluded if they had a history of severe osteoporosis or had received lumbar injections within the previous 4 weeks; had inflammatory pain, acute trauma, previous lumbar surgery, lumbar instability, or neurological disorders; or had severe systemic diseases or uncontrolled cardiovascular conditions. Additionally, those who had received physical therapy within the previous three months were not included in the study.

2.3 Interventions

Each of the three groups participated in a home exercise program, which incorporated exercises for strengthening the back and abdominal muscles, as well as stretching exercises for the back. The exercises were performed three times per week over a period of three weeks. Participants were instructed to avoid the use of painkillers or non-steroidal anti-inflammatory drugs throughout the duration of the study [8].

2.3.1 LILT Protocol

A gallium-aluminum-arsenide (GaAlAs) diode laser (Chattanooga Group, USA) was utilized for treatment, emitting infrared light at a wavelength of 850 nm and a power of 800 mW. The laser operated in continuous wave mode with a 1 cm^2 spot size and was set to a pulsed frequency of 1 kHz, with an 80% duty cycle. Each session delivered an energy density of 50 J/cm^2 over a duration of 30 min, totaling approximately 1200 J per session. The treatments were administered three times per week for a total of three weeks (nine sessions).

2.3.2 HILT Protocol

The BTL-6000 high-intensity laser therapy (HILT) device, featuring a gallium-arsenide diode laser, was set to biostimulation mode with a power of 12 W, an energy density of 150 J/cm^2, and a wavelength of 1064 nm, with a 1 cm^2 radiation spot size. The laser was applied in a continuous motion across the treatment area. Each session involved the delivery of approximately 1200 J of energy, with treatments administered three times per week over three weeks, totaling nine sessions. Each session lasted for 15 min.

2.4 Outcome Measurements

Socio-demographic data, including age, body mass index (BMI), gender, and marital status, were collected through face-to-face interviews. Disability and pain severity were assessed in all three groups both before and after the treatment program.

2.4.1 Severity of Pain

Pain intensity at rest and during activity was measured using the Visual Analogue Scale (VAS), which is a reliable instrument for assessing pain levels. Participants were asked to mark their pain intensity on a 10 cm horizontal line. The VAS scores range from 0 to 10, with 0 indicating ‘no pain’ and 10 representing ‘the most intense pain possible [9].

2.4.2 Disability

Disability levels associated with LBP were evaluated using the Turkish version of the Oswestry Disability Index (ODI), a widely recognized and reliable tool for assessing disability in individuals with LBP [10]. The ODI includes 10 questions that assess various aspects of daily life, such as pain intensity, personal care, lifting, walking, sitting, standing, sleep, social interactions, travel, and sexual activities. Each item is rated on a scale of 0 to 5, and the total score ranges from 0 to 50. The disability percentage is calculated by dividing the total points obtained by the maximum possible points and multiplying by 100. Higher scores indicate greater disability [11, 12].

2.5 Sample Size

The sample size was calculated using G*Power software (version 3.1), with a significance level (α) of 0.05, Z = 1.95, and a statistical power of 0.80 [13]. The power analysis determined that a minimum of 18 participants per group was required. To account for an anticipated dropout rate of 10%, a total of 60 participants were planned for inclusion in the study.

2.6 Randomization

Randomization was conducted for 60 patients diagnosed with lumbar disc herniation. Participants were stratified by age and gender and randomly assigned to one of three groups: high-intensity laser therapy (HILT), low-intensity laser therapy (LILT), or placebo laser therapy. All evaluations, both before and after the three-week treatment period, were carried out by the same researcher to ensure consistency.

2.7 Statistical Analysis

SPSS software (version 25, IBM Corp., Armonk, NY, USA) was used for statistical analysis. Categorical variables were summarized by frequencies and percentages, whereas continuous variables were presented as means with standard deviations. Medians and interquartile ranges were reported for variables with non-normal distributions. The Kruskal-Wallis test was used to compare variables among groups, and chi-squared and exact tests were used to analyze categorical data. When a significant difference was found with the Kruskal-Wallis test, pairwise comparisons were performed using the Tukey's post hoc test. For all statistical tests, a significance threshold of $p<0.05$ was used.

3 Results

A total of 66 volunteer individuals who met the inclusion criteria were also treated with HILT. 60 individuals aged 18–60 years completed the treatment programme completely (Fig. 1). 24 of the participants were female and 36 were male. Demographic and physical characteristics of the participants are given in Table 1. No significant differences were observed between the groups with regard to age, gender distribution, and physical characteristics.

The pre-treatment values of the three groups were compared by chi square test and fisher exact test and no statistically significant difference was observed between the groups (Table 2).

Post-treatment comparisons revealed that the VAS resting scores in the HILT group were significantly lower than those in the LILT and placebo groups ($p<0.05$). However, no significant difference was found between the placebo and LILT groups ($p>0.05$).

Regarding VAS activity scores, both the low-dose and HILT groups showed significantly lower values compared to the placebo group ($p<0.05$). However, no significant difference was found between the LILT and HILT treatment groups in terms of VAS activity levels ($p>0.05$).

The ODI scores were significantly reduced in the high-dose laser treatment group compared to the placebo group ($p<0.05$). No significant differences were found between the HILT and LILT groups or between the LILT and placebo groups ($p>0.05$).

A significant difference was observed in the change of resting VAS scores across the three groups ($p<0.05$). The HILT group showed a greater improvement in resting VAS scores compared to both the LILT and placebo groups, with the HILT group performing better overall ($p<0.05$). No significant difference was found between the placebo and LILT groups ($p>0.05$).

A significant difference was found in the change in VAS activity scores among the three groups ($p<0.05$). No significant difference was observed between the HILT and LILT groups ($p>0.05$), but the LILT group showed a significantly greater improvement compared to the placebo group ($p<0.05$).

A statistically significant difference was found in the change in ODI scores among the three groups ($p<0.05$). The HILT group showed a significantly greater improvement compared to the placebo group ($p<0.05$). However, no significant difference was observed between the changes in the HILT and LILT groups ($p>0.05$) (Table 3).

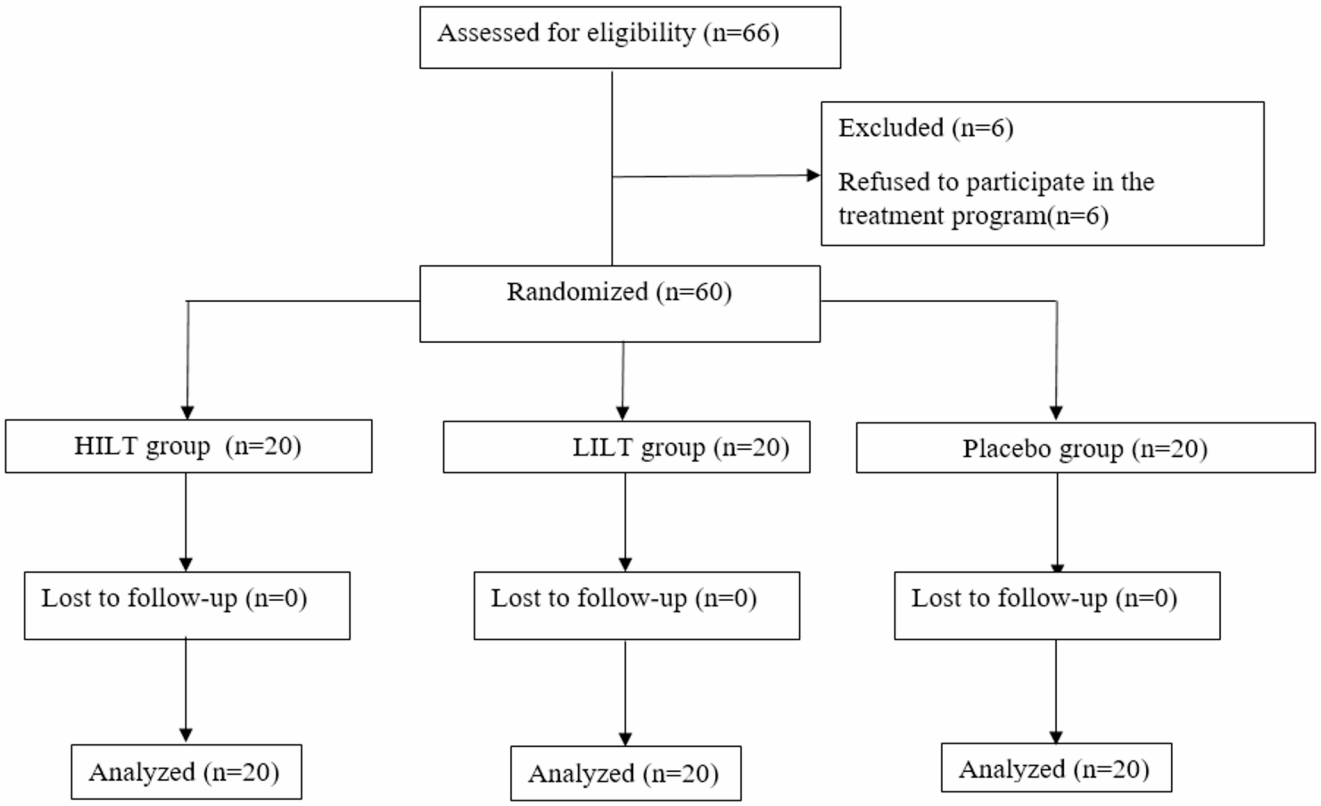

Fig. 1 Flow chart of the study

Table 1 Characteristics of participants ($N=60$)

	Placebo ($N=20$)		Low dose ($N=20$)		High dose ($N=20$)		*P*-value
	N	%	*N*	%	*N*	%	
Gender							>0.999
Male	12	60.0%	12	60.0%	12	60.0%	
Female	8	40.0%	8	40.0%	8	40.0%	
Marital status							0.820
Single	2	10.0%	3	15.0%	3	15.0%	
Married	18	90.0%	17	85.0%	17	85.0%	
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	
Body Mass Index (kg/m^2)	28.09	3.18	26.03	3.17	27.71	4.55	0.179
Age	42.00	12.10	41.60	11.90	39.85	11.18	0.828

SD: Standart deviation

Table 2 Comparison between the three groups before-after treatment ($N=60$)

	Placebo		Low dose		High dose		*P*-value*	*P*-value for post hoc test**		
	Median	IQR	Median	IQR	Median	IQR		*P*-L	*P*-H	L-H
VAS (rest) Before	6.15	1.75	6.10	2.00	6.75	1.75	0.076			
VAS (rest) After	5.00	4.50	3.50	3.75	0.00	4.00	0.004	>0.999	0.011	0.014
VAS (activity) Before	7.80	2.00	7.75	2.00	8.35	1.00	0.374			
VAS (activity) After	5.50	6.00	3.00	5.00	1.00	5.00	0.010	0.029	0.023	>0.999
ODI (%) Before	63.80	0.16	61.90	0.18	64.30	0.10	0.783			
ODI (%) After	53.00	0.42	38.00	0.35	15.00	0.43	0.021	0.749	0.017	0.320

VAS: Visual Analogue Scale, ODI: Oswestry Disability Index, * p-value is reported for Kruskal Wallis test, **p-values adjusted using Tukey's post hoc test ($\alpha=0.05$), P-L: placebo versus low dose, P-H: placebo versus high dose, L-H low dose versus high dose

Table 3 Comparison of the change after treatment between the three groups ($N=60$)

	Placebo		Low dose		High dose		*P*-value*	*P*-value for post hoc test**		
	Median	IQR	Median	IQR	Median	IQR		*P*-L	*P*-H	L-H
VAS (rest)	−1.50	3.00	−3.00	4.5	−6.00	4.75	<0.001	>0.999	0.003	0.004
VAS (activity)	−1.00	4.75	−5.50	4.75	−7.00	6.0	0.002	0.028	0.002	>0.999
ODI	−15	0.28	−27.50	0.29	−41.0	0.40	0.002	0.825	0.002	0.062

VAS: Visual Analogue Scale, ODI: Oswestry Disability Index, * p-value is reported for Kruskal Wallis test, ** p-values adjusted using Tukey's post hoc test ($\alpha=0.05$), P-L: placebo versus low dose, P-H: placebo versus high dose, L-H low dose versus high dose), IQR: Inter Quantile Range

4 Discussion

This study aimed to evaluate the effectiveness of HILT and LILT combined with exercise in patients with LDH. The findings indicated significant improvements in pain intensity at rest and during activity, as well as in disability levels across all three groups. Notably, patients in the HILT group experienced more pronounced improvements in resting pain and physical disability compared to those in the other groups.

LILT is commonly utilized in the treatment of both acute and chronic pain related to musculoskeletal conditions [14, 15]. This form of laser therapy uses a non-invasive, non-ionizing, monochromatic, and polarized light beam with high concentration. Its primary mechanism of action involves stimulating tissues, including cells, vascular structures, interstitial tissue, and the immune system, without causing a rise in tissue temperature. LILT is employed to promote tissue regeneration, reduce inflammation, and alleviate pain. While it has been shown to influence various cellular processes, the exact mechanisms of its effects are not fully understood [16].

HILT has become a promising treatment option due to its ability to deliver higher laser energy in a shorter duration, offering deeper tissue penetration compared to low-intensity laser therapy [17, 18]. This results in enhanced biostimulatory and anti-inflammatory effects. The key distinction between high-intensity and low-intensity lasers lies in the power of the beams, with high-intensity lasers (>500 mW) capable of reaching deeper and larger tissue structures that low-intensity lasers cannot access. The higher wavelength of high-intensity lasers also reduces their absorption by melanin and hemoglobin, facilitating deeper penetration into soft tissues, which allows for the stimulation of larger areas [19, 20].

Abdelbasset et al. [13] reported that 12-week HILT and LILT were effective in pain improvement in individuals with chronic non-specific LBP. They also concluded that HILT and LILT were not superior to each other in improving pain [13]. Gür et al. [21] divided individuals with chronic LBP into 3 groups. They applied exercise alone to the first group, LILT alone to the second group, and combined exercise and LILT to the third group. As a result of the study, they concluded that the improvement in the groups in which LILT alone and LILT combined with exercise were applied to reduce the severity of pain was better than the group in which exercise alone was applied [21]. Dündar et al. [22] stated that HILT application was effective in pain improvement in patients with lateral epicondylitis. Chen et al. [23] reported that two weeks of HILT application was effective in reducing pain intensity in patients with lumbar disc herniation. In our study, in parallel with the literature, we concluded that there were significant improvements in rest and activity pain intensity in all three groups. We also concluded that the amount of improvement in rest pain was the highest in the HILT group and the lowest in the placebo group, but HILT and LILT were similar to each other in terms of the amount of improvement in activity pain. We attribute these results to the fact that the laser accelerates tissue metabolism, enhances mitochondrial activity, promotes cell proliferation and differentiation, and inhibits apoptosis, which helps to improve tissue structure and alleviate pain [24].

The analgesic effect provided by laser treatment may vary between individuals. The fact that high-dose laser does not provide an additional advantage in reducing pain may be due to the variability in pain perception of individuals. Furthermore, since mechanisms such as central sensitisation are involved in chronic pain, the pain threshold may not always directly parallel biomechanical or neurophysiological changes.

Boyraz et al. [25] concluded that HILT application was effective in improving the level of disability in patients with lumbar discopathy. Fiore et al. [7] reported that 3 weeks of HILT application caused a significant improvement in disability in individuals with chronic LBP. Conte et al. [26] divided the patients with LBP into two groups: those who were referred to low back school only and those who were referred to HILT application in addition to low back school. As a result of the study, they reported that the laser-treated group showed higher improvement in disability and pain severity scores and also concluded that laser caused fewer side effects compared to other pharmacological treatments. Alayat et al. [27] concluded that 4-week HILT application combined with exercise significantly improved the disability level of patients with chronic LBP, but the improvement effect decreased in the long term. In another study, Taradaj et al. [28] reported that HILT and LILT had similar effects

on disability in patients with lumbar disc degenerative changes. According to the results of our study, the level of disability decreased significantly in all three groups, and the amount of improvement in the HILT group was significantly higher than the placebo laser group, wHILTe it was similar in the LILT group. This result can be explained by the fact that HILT application may have a more positive effect on disability in individuals with chronic LBP because it produces stronger energy than LILT application, shows effects in deep tissues, and accelerates healing processes.

This study has several limitations. No blinding was applied, and the same researcher conducted both the interventions and assessments, which may have introduced bias. The severity of disc herniation was not evaluated, although it could have influenced outcomes. The follow-up period was short (3 weeks), so future studies should include longer-term follow-up. In addition, only subjective measures (ODI, VAS) were used; incorporating objective assessments (e.g., MRI or functional tests) in future research would improve the validity and generalizability of the findings.

5 Conclusion

As a result, in this study, it was concluded that HILT application in addition to exercise therapy was more effective than LILT application in reducing resting pain intensity in patients with lumbar disc herniation. We also concluded that both HILT and LILT applications were effective on activity pain intensity and disability level, but neither treatment was superior to the other.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s40846-025-00989-6.

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Declarations

Conflict of interest The authors declare no conflict of interest.

Patient Consent Written informed consent was obtained prior to theenrolment of every study participant. That all partici-pants in our study were adults who provided their owninformed consent to participate. Therefore, parent orguardian consent was not applicable or required for thisstudy.

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