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Review Article

Physiotherapy Section

An Overview and Implication of High Intensity Laser Therapy in Neck Pain: A Narrative Review

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ABSTRACT

High-Intensity Laser Therapy (HILT), also known as Class IV laser, is a relatively modern type of non invasive physical electrotherapy that has been used to treat a variety of conditions. However, there has been little research conducted on this equipment. HILT can be highly beneficial for treating painful neck-related disorders, as it offers various effects including bio stimulation, regeneration, analgesia, anti-inflammatory properties, and anti-oedema properties. Many disorders that cause neck pain can be effectively treated with HILT in combination with exercise. To gather essential information on the subject, electronic databases such as PubMed, Scopus, and Google Scholar were searched. The conclusions of the review indicate that HILT is highly efficient, affordable, and innovative. However, it has received minimal academic research attention and has not been widely used in Indian clinical settings. The evidence suggests that HILT is a highly effective physical treatment technique that significantly improves pain, Range of Motion (ROM), functional status, and Quality of Life (QoL) in patients with neck pain.

Keywords: Electrotherapy, Physiotherapy, Quality of life, Range of motion

INTRODUCTION

Neck pain is the second most frequent cause of musculoskeletal disability, following low back pain, resulting from changes in occupational tasks, technological advancements, and computer use over the past few years [1,2]. The prevalence of neck pain varies widely among studies, with an average prevalence of 23.1% and a range of 0.4-86.8% in the general population [3]. Neck pain has a significant financial burden, including medical expenses, reduced performance, and work-related issues [4].

Neck pain can be categorised based on the duration of onset: acute (up to six weeks), subacute (up to three months), and chronic (over three months). Neck pain can also be classified as mechanical, neuropathic, or attributed to another cause (such as referred pain from the heart or vascular pathology) [5]. Common symptoms of neck pain include localised and/or referred pain, point tenderness, and limited cervical Range of Motion (ROM) [6]. Since the underlying pathophysiology of neck pain often remains unknown, it is referred to as non specific neck pain [7]. Various risk factors for neck pain exist, which can be modifiable or non-modifiable. These include old age, being female, having little social support, and a history of neck or lower back pain. However, other risk factors such as inactivity, perceived stress, and cognitive factors (such as attitudes, cognitive style, and fear-avoidance beliefs) have stronger evidence [8].

Neck pain can be treated using different methods. Pharmaceutical drugs, including non-steroidal anti-inflammatory medications and pain-relieving therapies, are commonly used; however, they carry serious adverse effects. Non-pharmacological therapies, such as laser therapy, massage, acupuncture, yoga, aquatic therapy, manual therapy, neck stretching, and training, have been suggested [9-12].

LASER OVERVIEW

The acronym "LASER" stands for Light Amplification by Stimulated Emission of Radiation. A laser is an optical amplifier that utilises stimulated emission of electromagnetic radiation to generate light [13]. Lasers are classified based on their ability to affect biological systems. Bio-stimulating procedures often use Class I, II, and III lasers [14]. Class IV lasers, known as high-intensity lasers, have gained prominence in scientific research and clinical rehabilitation therapy since the late 1990s. This technology allows for intensities of upto 10 W or higher, resulting in a more potent analgesic impact and biomodulation. Class IV lasers do not cause tissue damage due to their highly divergent nature. The therapeutic dosage (J/cm^2) can be significantly increased without prolonging the treatment duration, thanks to the rapid emission enabled by this technique [15].

Although HILT has become increasingly common in clinical practice, there is a scarcity of published research originating from India. The majority of laser treatment research focuses on low-intensity applications. Three Indian studies have explored the use of HILT/Class IV Laser in Physiotherapy (PT) [16-18]. One case series demonstrated the favourable benefits of using Class IV laser in the treatment of Bell's palsy, particularly when initiated early in the condition [16]. Another study found that Class IV laser, after off-pump Coronary Artery Bypass Graft (CABG), was a safe, well-tolerated, and effective therapy for managing postoperative pain, suggesting its potential use in a multimodal analgesic strategy [17]. HILT was found to be beneficial in reducing pain in athletes with proximal hamstring tendinopathy, although there was no significant difference in the improvement of hamstring isokinetic peak torque between HILT and a normal PT program [18].

Classification of Laser

The International Electrotechnical Commission (IEC) provides the following classification for lasers [19]:

Class I: Safe under all conceivable use scenarios.

1M: Safe to view without visual aids but may be dangerous when used with them (microscopes, binoculars, loupes, etc.,).

Class II: Visible wavelengths (400-700 nm) are safe if observed for less than 0.25 seconds.

2M: Optical seeing aids are not safe for visible wavelengths (400-700 nm).

Class IIIR: Slightly dangerous for intrabeam vision of beams larger than 7 mm.

Class IIIB: Dangerous for intrabeam gazing, causing direct but not through scattered energy harm to the skin and eyes.

Class IV: Both direct and reflected energy can harm the skin and eyes due to higher power.

How Laser Works

Laser treatment is a painless and non invasive therapeutic procedure that can be applied to various conditions [20]. The specific wavelength of a laser can be absorbed by cellular mitochondrial chains, leading to increased production of other chemical messengers (Nitric oxide, cytokines, and growth factors). This, in turn, boosts Adenosine Triphosphate (ATP) production, enhancing cellular metabolism, regeneration, and healing. Laser radiation also impacts enhanced angiogenesis, fibroblastic activity, and collagen synthesis through the proliferation of endothelial cells in the affected tissue. The suppression of inflammation is established by blocking anti-inflammatory cytokinins in the tissues. The indirect effects on pain relief are attributed to the suppression of swelling and inflammation, stimulation of endogenous opiates such as encephalin and endorphins, and a decrease in nerve fibre speed (Aδ and C) [15].

Advantage Over Low-Level Laser Therapy (LLLT)

Class IV/HILT lasers have wavelengths of more than 1000 nm and high power of 0.5 W, providing an advantage over Low-Level Laser Therapy (LLLT) as they can penetrate joints and muscles more deeply, resulting in enhanced outcomes. In acute conditions, higher power is observed to be more effective in pulsed analgesic therapy, and it also allows for the delivery of intense thermotherapy in chronic conditions [21]. The physiological effects of Class IV/HILT lasers include increased microcirculation and metabolism, reduced painful nerve impulses, and the release of beta-endorphins, resulting in decreased inflammation, collagen synthesis, stimulation of immune processes, and nerve regeneration. These effects are accompanied by photochemical effects that activate enzymes involved in the respiratory chain, DNA, ATP, and RNA synthesis [22].

HILT ensures high-energy transmission in a brief period, preventing the accumulation of temperature in the treated tissue. This allows for photothermal and photochemical actions to occur in deep tissues, where the laser light is gently absorbed by the tissue's chromophores. By controlling the release of substance P, bradykinin, histamine, and other substances from damaged tissues through peripheral nociceptor cells, HILT increases the pain threshold and slows down pain transmission [23].

Cellular Characteristics of Laser

Laser treatment has significant impacts at the molecular, cellular, and tissue levels, affecting ATP production, modulation of Reactive Oxygen Species (ROS), and induction of transcription factors [24,25]. These transcription factors, such as redox factor-1, dependent Activator Protein-1 (AP-1), Nuclear Factor kappa B (NF-κB), Activating Transcription Factor/cAMP-Response Element-Binding protein (ATF/CREB), Hypoxia-Inducible Factor (HIF)-1, and HIF-like factor, are regulated by cellular redox status [25]. These factors trigger protein synthesis, enhance tissue oxygenation, promote cell proliferation and migration, and modulate cytokines, growth factors, and inflammatory mediators [26].

Mast cells play a crucial role in inflammation, as specific wavelengths of light can trigger mast cell degranulation, leading to the release of Tumor Necrosis Factor alpha (TNF-α), increased tissue infiltration, and fibroblast proliferation [27,28]. Laser radiation also activates and enhances the proliferation of lymphocytes, allowing for faster wound closure [28,29]. Additionally, laser radiation affects the electron transport chain, increasing mitochondrial products and oxygen consumption [30]. Laser therapy also increases oxygen metabolism and activates transcription factors, leading to the upregulation of genes involved in cellular migration, proliferation, cytokines, and growth factors [31-33].

Techniques of Application [34]

The application techniques for laser therapy are simple, and generally, two methods are used:

1. **The grid method:** The handheld probe is placed parallel to the target spot, in close contact with the skin. Each area of the target (1 cm^2) is treated for a specified period.
2. **The scanning method:** There is no contact between the laser probe and the patient's skin, and the probe is held at a distance of 5 to 10 mm. The laser probe is moved mechanically or manually over the region to be treated after measuring the overall size of the target tissue.

LASER Measurements [35]

1. Size of the Area to Treat:

Treatment Area (cm^2)=length (cm)×width (cm)

2. Target Dosage:

Typical dosages range from 6-12 joules per centimeter.

Total Energy=Target Dosage (J/cm^2)×Treatment Area (cm^2)

Treatment Time (s)=Total Energy Delivered (J)/Average Output Power (W)

HILT in Various Neck Pain Conditions

Cervical spondylosis: Cervical spondylosis is a common pathological condition that causes neck pain. The pain typically refers to a large area and worsens with neck movements. Plain radiographs of the cervical spine may show a loss of the typical cervical lordosis and other signs of degenerative disease. The development of osteophytes and involvement of nearby soft tissue structures indicate the onset of degenerative changes in the intervertebral discs. However, imaging findings can be misleading as significant pathological abnormalities can also be found in asymptomatic individuals on Computed Tomography (CT) and Magnetic Resonance Imaging (MRI) scans [36].

Cervical disc herniation: Cervical disc herniation most commonly occurs between the C5-C6 and C6-C7 vertebral bodies when the nucleus pulposus protrudes through a tear in the annulus fibrosus. Mechanical compression can cause microvascular damage ranging from mild venous flow blockage, leading to congestion and oedema, to severe compression that can result in arterial ischaemia. The annulus fibrosus is weaker in the posterolateral region, making herniations more likely in that area. When a herniation pinches the cervical nerve root as it escapes, it can cause radiculopathy in the associated dermatome. The most common subjective complaints include axial neck pain and unilateral arm pain, numbness, and tingling in the affected dermatomal distribution [37].

Chronic Neck Pain (CNP): Neck pain, also known as cervical pain, is an unpleasant sensory and emotional experience caused by actual or potential damage to cervical tissues. CNP is a primary condition that is not attributed to a single cause and lasts for more than three months, resulting in functional limitations and emotional impact. With a prevalence of over 30% and significant socio-economic costs, neck pain is one of the leading causes of disability worldwide [38]. Women tend to experience more neck pain between the ages of 35 and 49, particularly after the age of 45. The risk of developing neck pain is associated with physical and psychosocial factors and may be influenced by factors such as inactivity, prolonged postures, and office work. However, the cause of neck pain is often non specific [38].

Trapezius myofascial pain syndrome is one of the main causes of persistent neck pain. It is characterised by one or more myofascial trigger points and deep, severe pain in the skeletal muscles and their fascia. Only one-third of individuals with neck pain report complete relief of symptoms. Patients with neck pain typically experience point tenderness, localised pain, and limited cervical ROM [39].

Whiplash injury: Whiplash injury is a common post-traumatic condition caused by the overstretching of muscles, tendons, and capsular tissues. While whiplash recovery typically takes 2-3 months, 10-30% of patients continue to experience neck pain and headaches even two years later. Additionally, 6% of patients do not return to work even after a year [40]. The pathophysiology underlying the symptoms is still unknown, but it is believed to involve strain on the myofascial and tendon components, altered nociceptors, and excessive stretching of the cervical facet capsule ligaments [40].

DISCUSSION

This review highlights the importance of HILT in PT, an area that has not been extensively explored. Some recent studies have investigated the use of HILT and have shown its effectiveness in various musculoskeletal conditions, such as low back pain, chronic back pain, lumbar disc protrusion, fibromyalgia, shoulder pain, carpal tunnel syndrome, Grade-2 and 3 knee osteoarthritis, lateral epicondylitis, osteopenia, plantar fasciitis, children with juvenile rheumatoid arthritis, and wound healing in postburn, axillary node dissection of breast cancer, foot ulcers, and refractory wounds [41-43]. These studies compared HILT with other PT interventions and consistently concluded that HILT was more effective in reducing pain, disability, and promoting wound healing. It appears that HILT may enhance the effects of laser therapy by incorporating both thermal and non thermal agents. Different mechanisms play a role in managing acute and chronic pain, suggesting that chronic pain situations may benefit from more intense laser therapy. The treatment area of the scanner lasers was found to be more crucial than the size of the probe in determining the effectiveness of the lasers. When applying laser therapy, it is important to consider the aetiology and diagnosis of the condition [42].

Seven studies were found that used HILT to treat painful neck conditions. These studies varied in their approach, with some using both stationary and scanning applications, while others used scanning exclusively [12,23,36,39,40,44,45] [Table/Fig-1,2]. In Table/Fig-2, The Physiotherapy Evidence Database (PEDro) scale was applied to do a qualitative analysis of the study that was listed. An 11-item scale was developed to assess the reliability and methodological quality of randomised clinical trials [46]. Pulsed mode HILT was predominantly used in the trials. HILT helps reduce pain by inducing photothermal and deep tissue photochemical reactions, which stimulate collagen synthesis, improve blood flow and cellular metabolism, and block pain signals [36]. With its long wavelength, HILT is able to penetrate deep tissues and reach hard-to-reach areas, providing stimulation to the targeted area [47]. HILT plays a significant role in reducing pain, improving the ROM, functional status, and QoL in patients with neck pain. When combined with an exercise program, HILT has even greater benefits for patients with neck pain. The studies mentioned above have concluded that HILT is sufficient to observe noticeable improvements in patients with cervical spondylosis, cervical disc herniation, CNP, and whiplash injuries, as opposed to conservative interventions.

Author/year	Objectives	Condition	Participants	Findings	Conclusion
Kenareh R et al., 2021 [12]	To evaluate the efficacy of HILT and ultrasound PT in terms of pain, disability, and cognition	Chronic, non specific neck pain	HILT group: 30 US group: 30	Both groups had a decrease in pain, cognition, and functional score, but the HILT group showed greater improvement	HILT performs better in the treatment of chronic non specific neck pain than the ultrasound group.
Venosa M et al., 2019 [36]	To compare HILT and an addition of US and TENS on pain, ROM, and functional activity	Cervical spondylosis	HILT group: 42 US+TENS group: 42	Both groups had a decrease in pain, and increased ROM and functional scores, but these were more significant in the HILT group	HILT+Ex performs better than US+TENS+Ex.
Yilmaz M et al., 2020 [23]	To compare HILT and an addition of US and TENS on pain, ROM, and functional activity	Cervical Disc Herniation (CDH)	HILT group: 20 US+TENS group: 20	In individuals with CDH, both therapy modalities showed analgesic effects and enhanced function	Both are equally effective in treating CDH.
Alayat MS et al., 2016 [44]	To evaluate the effect of HILT on cervical ROM, pain, and functional activity	Chronic neck pain	HILT group: 30 Placebo group: 30	Both groups had a decrease in pain, cognition, and functional score, but the HILT group showed greater improvement	HILT+EX performs better than the PL+Ex group.
Dundar U et al., 2015 [39]	To evaluate the efficacy of HILT in terms of pain, CROM, disability, and QoL	Chronic myofascial pain of the trapezius muscle	HILT group: 38 Sham group: 38	Both groups had a decrease in pain and increased ROM, QoL, and functional score, but the HILT group showed greater improvement	Individuals with chronic myofascial pain of the trapezius muscle can benefit from HILT as a therapy approach.
Haładaj R et al., 2017 [45]	To assess the cervical mobility and analgesic effectiveness following traction therapy using the Saunders device and HILT	Cervical spondylosis	Traction group: 88 HILT group: 86	Following therapy, significant results were seen in both groups, but in long-term follow-up, HILT had positive effects	In terms of long-term follow-up, HILT proved more efficient than the Saunders procedure.
Conforti M and Fachinetti GP, 2013 [40]	To assess the efficacy of HILT in comparison to traditional simple segment physical therapy	Whiplash injury	HILT group: 84 PT group: 51	The HILT group had a more significant decrease in pain and a quick recovery and return	HILT is more successful at treating whiplash injuries than simple segmental physical therapy.

[Table/Fig-1]: The effect of HILT on various neck pain conditions [12,23,36,39,40,44,45].
TENS: Transcutaneous electrical nerve stimulation; HILT+Ex: HILT combined with exercise; US+TENS+Ex: Ultrasound therapy combined with TENS and exercise; PL+Ex: Placebo Laser with exercise; QoL: Quality of life; ROM: Range of motion; PT: Physiotherapy

Authors	Country	Dosage	PEDro score
Kenareh R et al., 2021 [12]	Iran	Two phases. The first phase lasted for three minutes at 10 Watt, 25 Hz, and 15 J/cm^2, and the second phase lasted for six minutes at 7 W power with 100 J/cm^2. Total time: 10 sessions spread over two weeks, each lasting 9 minutes.	5/10
Venosa M et al., 2019 [36]	Italy	1,060 J total energy is given across three phases per session. First phase: rapid manual scan of a trapezius muscles (100 cm^2/30 s) with a 500 J total energy dosage. Second phase: 10 J with 6 seconds at each trapezius trigger point for a total of 60 Joules. The third phase consisted slow manual scan of a trapezius muscle for an amount of energy of 500 J at a rate of 100 cm^2 every 60 seconds. Total: 15 minutes per session. Over the course of three weeks, HILT was administered once each day for 15 days.	4/10
Yilmaz M et al., 2020 [23]	Turkey	One session's total energy delivery is 1850 joules. 1.02 minutes with an energy of 8.0 W, a frequency of 25 Hz, a dosage of 5 J/cm^2, and a total energy of 125 joules are applied to each 25 cm^2 of sore tissue. Twenty therapeutic sessions of 15 minutes each, held five days a week for four weeks.	5/10

Alayat MS et al., 2016 [44]	Saudi Arabia	2250 J total energy in three phases in a single session. First Phase: A total of 1025 J of quick manual scanning. Second phase: 200 J for 14 s of given HILT (25 J) with the fluency of 510 mJ/cm^2 for each trigger site. The third phase is similar to the first phase's slow manual scanning. Total time: 15 min, 12 sessions twice a week for 6 weeks.	4/10
Dundar U et al., 2015 [39]	Turkey	1,060 J total energy is provided over three phases per session. First phase: 100 cm^2 over 30 seconds, with a 500 J total energy dose. For a total of 60 J, the second phase is equal to 10 J with a time delay of 6s for each trigger point. Third phase engaged (100 cm^2/60 s, 500 J total energy). Total time: 15 sessions spread over 15 minutes each of 3 weeks.	8/10
Haładaj R et al., 2017 [45]	Poland	Total energy for analgesia=195 J with pulse mode at 25 Hz, wavelength at 980 nm, and radiation power density at 600 mW in 3.5 minutes and 5 J/cm^2 is the energy density. For Biostimulation application, power density of P=300 mW at a wavelength of 980 nm, 6.5 minutes of operation time, and 1250 J of supplied energy, the average energy density (Ed) is 50 J/cm^2. Ten times in one series, analgesic and biostimulation treatments were used (1 per day, 5 times a week for 2 weeks).	5/10
Conforti M and Fachinetti GP, 2013 [40]	Italy	Pins=12,0 Watt±10%, power density P=6, 5 Watt/cm^2±10%, triple wavelength radiations: λ=780÷1100 nm, emission time=8 and 40 seconds.	5/10

[Table/Fig-2]: Presentation of articles according to authors, country, and dosage of HILT with PEDro scoring [12,23,36,39,40,44,45].

The precise laser parameters were not reported in the articles mentioned above. The duration of laser treatment depends on the size of the area being treated and typically lasts only a few minutes to prevent the risk of burns. This is why the treatment is divided into three different phases to avoid excessive heating.

CONCLUSION(S)

With proper dosage assessment, supervision, and implementation, HILT may emerge as a game-changer in therapeutic settings. It can be applied to treat several neck pain conditions. HILT has multiple applications and is a revolutionary piece of electrotherapy equipment for a new wave of PT.

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