CAPITAL UNIVERSITY OF SCIENCE AND TECHNOLOGY, ISLAMABAD

To Determine the Efficacy of Low-Level Laser Therapy to Treat Pain in Various Body Parts for a Patient Cure

by

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Dedication to Allah Almighty, the most beneficent and merciful, Hazrat Muhammad (S.A.W.W) my father M. Nazir Usmani, my mother Amtul-rauf Usmani and my late grandfather Haji M. Yousaf Usmani, grandmother Sarwar-Jan Usmani. Whose prayers always enlightened my way throughout my life. It's also dedicated my work to my friend Junaid my brothers Majid , Muzammal, Awais Ali, my sisters Fouzia and Sobia, my nephews Umm-e-Habiba, Ahsaan, Hassam, Usman, um-e-Farwa and Muhammad and all other family members who supported me and taught me that the best kind of knowledge to have is that which is learnt for its own sake. They taught me that even the toughest task can be accomplished if it is done one step at a time.

CERTIFICATE OF APPROVAL

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(Sadaf Usmani)

Abstract

Since the development of lasers about 40 years ago, low-level laser therapy has been used to treat various diseases, including pain, inflammation, and congestion, as well as to promote wound healing, deeper tissues penetration, nerve healing and avoid tissue damage. This technology is now used in all over the world including Pakistan. Low- intensity laser therapy is used for reducing pain. It is non-invasive and non-surgical therapy in which low beam of light is emitted into the tissues and causes regeneration of the tissue cell. Low-intensity laser therapy help in increasing blood circulation which carries good nutrients and provided to the dead tissue area. It is Canadian technology, FDA approved and not harmful to the body of human. The light-based therapy method known as Bioflex Laser Therapy was created by Canadian physician Dr. Fred Kahn. Vascular surgeon Dr. Khan began to research lasers after experiencing their healing effects firsthand. He has considerable experience and exceptional talent. There are two lights used for treatment. Red light and infrared light. Red light can be seen with naked eyes and it target superficially while infrared light travel in nano-second cannot be seen and it target at deeper level. LLLT has gained popularity in recent years, particularly in the fields of physical therapy and rehabilitation. This study was designed to evaluate the effectiveness of low laser therapy for the cure of patients. Laser light is used from the ancient time and now it is the best replacement of NASIDs for reliving pain. It has no or minimum side effects but it is expensive therapy. It is assumed that the first actions of low-level laser therapy, that boost ATP generation, control reactive oxygen species, and induce transcription factors, occur in the mitochondria. Accelerated tissue oxygenation, cytokine, growth factor, and inflammatory mediator levels, as well as increased cell migration and proliferation are the results of these impacts. These biochemical and cellular modifications have positive effects on both patients and animals, including faster healing of chronic wounds, relief from carpal tunnel syndrome and sports injuries, a decrease in pain from neuropathies and rheumatoid arthritis, and lessening of heart and stroke damage as well as nerve and retinal toxicity and retinal injury.

Contents

List of Figures

List of Tables

Abbreviations

CE :	Common Era
FDA :	Food and Drug Administration
Fq :	Frequence
Hz :	Hertz
LED :	Light Emitting Diodes
LLLT :	Low- Level Laser Therapy
LPLT :	Low-power laser
MMP :	Membrane Potential
mW :	One million watts
Nm :	Nano meter
NO :	Nitric Oxide
NSAIDs :	Non-steroidal anti-inflammatory drugs
OA :	Osteoarthritis
PBM :	Photobiomodulation
RA :	Rheumatoid arthritis
ROS :	Reactive Oxygen Species
Sec :	Second
SLD :	Super Luminous Diodes
VAS :	Visual analogue scale
WALT :	World Association of Laser Therapy

Chapter 1

Introduction

1.1 Background

The term "laser" refers to light amplification through stimulated emission of radiation. A laser beam is coherent, collimated, and monochromatic [1]. Low-Level Laser Therapy (LLLT), which involves exposing a biological system to light, helps to encourage tissue regeneration, lower inflammation, and ease the pain. In contrast to other medical laser techniques that use an ablative or heat process, LLLT uses a photochemical effects which indicates that light is absorbed and changes chemically [2]. Low- level laser therapy is also used for skin treat. It is thought that the use of low light lasers can relieve pain or stimulate and promote cellular function, in contrast to laser medicine, which uses high-power lasers to cut or destroy tissue. The effects seem to be restricted to a particular range of wavelengths [3–7].

Cognitive Photobiomodulation the use of infrared or near-infrared light can encourage cell healing, according to studies on cerebral photobiomodulation [8]. The human skull and cerebral cortex can both be penetrated by near-infrared waves, which could result in the cerebral cortex receiving a small amount of energy. LLLT is an application of light that promotes the regeneration of tissue, lowers inflammation, and relieves pain. This procedure involves directly directing various low-level light outputs and wavelengths at the area that has to be treated. The body tissue

subsequently absorbs the light. There are two types of light red and infrared. Red and near-infrared light causes the damaged cells to respond physiologically, which promotes regeneration. Typical wavelengths for superficial tissue treatment vary from 600 to 700 nanometers (nm). Deeper penetration is achieved with wavelengths between 780 and 950 nm. The procedure doesn't include medication or surgery, it is a non-invasive, non-toxic, and painless treatment. It also doesn't heat or cut tissue or cause any negative effects. This Canadian technology is approved by the FDA, Canada Health, and the CE [8].

Dr. Fred Kahn, a Canadian doctor, developed the light-based treatment technique known as Bioflex Laser Therapy. Dr. Khan is a vascular surgeon with extensive expertise and outstanding talent who decided to investigate lasers after personally benefiting from their healing properties. For more than 30 years, he has been a pioneer and leader in the laser therapy industry. He is the creator of the Bioflex Laser Therapy system, which was created by physicians for clinicians with the help of Super Luminous Diodes (SLD) and Laser Diodes, the Bioflex Laser Therapy system emits light at therapeutic wavelengths for the delivery of studied treatment applications.
The Bioflex system consists of huge, flexible SLD arrays that progressively transmit red and infrared light over a vast surface area and laser diodes that deliver targeted light targeting at particular areas of tissue damage, including muscles, tendons, or joints. Red and/or infrared light therapy can be administered to tissues at varying depths using the Bioflex three-step procedure, which consists of red light, infrared light delivered by an array of SLDs, and finally red and/or infrared light delivered by laser. This allows for a thorough treatment process [9].

LLLT are identified by a number of factors. The power of first is laser (10-3 to 10-1 W), which is followed by wavelength (300 to 10.600 nm). The rate of pulse is 0 (continuous) to 5000 Hz, the pulse duration is 1–500 ms, the interpulse interval is 1–500 ms, the total irradiation time is 10–3000 seconds, and the intensity is 10–2 to 102 J/cm2 [10]. The electromagnetic spectrum of therapeutic lasers is in the visible red to near visible red range, from 630 to 980 nm. The wavelength of these lasers is the most straightforward way to classify them. LLLT use's biggest

challenge is determining the right exposure dose. The density of energy is measured in joules per cm2 that is used as a stand-in for the tissue dose. The amount of energy produced is calculated by multiplying the mill wattage of the laser by the duration of exposure in seconds (for instance, 50 mW x 40 seconds = 2000 mJ or 2J). In this case, the surface tissue dosage is 1 J/cm2 and the fluence is determined by multiplying the irradiated area of 2 cm2 by 2 J [11].

Ancient civilizations employed light treatment dating back to the ancient Egyptians and Indians, who treated illnesses and improved their health by bathing in the sun (heliotherapy). The efficiency of light-tissue penetration in human skin is mostly due to the absorption spectra of the three primary biological chromophores: water in all tissues, oxyhemoglobin, and deoxyhemoglobin in blood inside the dermis, and melanin in the epidermis. This Canadian invention allows red wavelengths (620-750 nm) to penetrate further since blood and melanin absorb less of them. Porphyrins, blood, and melanin absorb red wavelengths (435-500 nm) [11]. Because it is non-invasive, supported by research, and has no side effects, cold laser therapy for joint discomfort is quite effective. Other terms for laser therapy include LLLT or cold laser therapy is used. It helps with the repair of harmed tissues, the care of wounds, the control of arthritis, and many other medical conditions. Technology for BioFlex laser therapy. In order for articulation, the joints in the human body are joined by a variety of tendons, ligaments, cartilage, and muscles. In our clinics and medical facilities, joint soreness is one of the most frequent problems we see. There are many different ways to alleviate joint pain, but each one has certain drawbacks [10].

A type of light therapy called low intensity laser therapy that causes cellular metabolic changes. Cellular photoreceptors absorb photons, which results in chemical changes and potential metabolic advantages for the human body. With a common wavelength of between 600 and 1000 nm, low-frequency continuous laser therapy has been used for many years to treat pain. In both experimental and clinical research, photobiomodulation has been shown to have analgesic and anti-inflammatory effects [11]. Many medical practitioners, including physicians, dentists, physical therapists, and others, employ cold laser treatment. Cold

laser therapy's primary applications are tissue healing and pain and inflammation treatment.

1.2 Minor Sprains and Injuries

Low intensity laser therapy is frequently employed in sports and physical treatment settings to treat minor sprains and strains, including:

- Muscle strains
- Ligament sprains
- Tennis elbow
- Tendonitis
- Bursitis
- Neck pain
- A lower back ache
- Knee pain discomfort brought on by muscular spasms

1.2.1 Inflammation

Low-level lasers therapy are used by dentists to treat inflamed oral tissues and repair ulcerations. It is used by medical professionals to treat rheumatoid arthritis (RA) and other chronic autoimmune illnesses' inflammation.

1.2.2 Pains and Aches

Low-level lasers therapy is used in pain clinics to treat patients with acute or chronic pain brought on by ailments including fibromyalgia and carpal tunnel syndrome.

1.2.3 Skin Resurfacing

To promote skin regeneration, cold laser therapy is employed. It is used by dermatologists to treat a variety of skin issues, such as:

- Acne and its scars
- Psoriasis causes skin edema
- Swelling
- Burns
- Dermatitis
- Rashes

1.2.4 Wound Recovery

Low-level lasers therapy is also used to treat wounds that are challenging to cure, such as lesions caused by diabetes.

1.2.5 Acupuncture

For patients who are uncomfortable with needles, acupuncturists employ cold laser therapy. Although they don't pierce your skin, low-level laser beams can stimulate your acupoints in a similar way to how needles do [12–14].

1.3 Devices that are Used in Bioflex for Treatment

There is a computer used in low level laser therapy in which software shows the session's duration and the dose of laser which we adjust according to treatment. An array and probes are used for treatment [15].

FIGURE 1.1: Device used in Bioflex

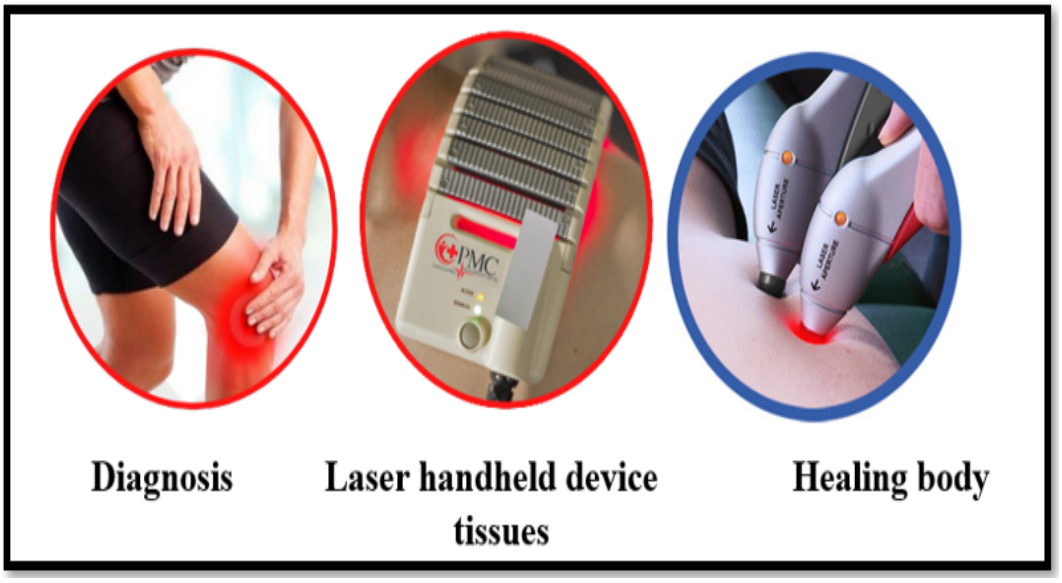


FIGURE 1.2: Bioflex Laser Therapy Systems

Back pain is also one of the most common illnesses that, if neglected, can get worse with time. 60 to 80 percent of people experience back discomfort at some point in their lives. Of those, 40% might develop persistent back pain. Back discomfort can be treated using cold laser therapy, which is non-invasive, effective, and secure. A laser beam is focused on the back, completely eliminating back ache. The treatment also helps to reduce other signs and symptoms like edema and inflammation [16]. Osteoarthritis, which becomes worse as people age, is one of the most common diseases that many people have experienced. Estimates suggest that this

illness affects 40% of individuals under the age of 65 in Britain and Australia and 14% of adults in the United States. The frequency of this condition is increasing [17]. Knee osteoarthritis (KOA) affects 13% of women and 10% of men in the US population who are over 60. KOA is an inflammatory degenerative disease that affects the entire joint. It causes pain, disability, and a decreased quality of life due to the increasing loss of cartilage (QoL). Higher pain thresholds and faster KOA disease development are linked to increased inflammatory activity [18]. One of the most common causes of functional disability in humans is osteoarthritis, a physical and motor impairment that has a significant cost impact on both the person and society [19]. Neck discomfort is a frequent and expensive illness, and there is little proof of the effectiveness or adverse effects of pharmaceutical management. Neck discomfort can be treated without surgery with low-level laser therapy (LLLT), which uses non-thermal laser irradiation to target painful areas [20].

According to a 2016 study, 116 million Americans have musculoskeletal discomfort every year, which results in $635 billion in medical expenses, lost productivity, and missed work or school days [21]. Any treatment technique may have benefits, but it also includes potential drawbacks and hazards. Currently, modalities, immobilization, medications, chiropractic care, physical therapy, behavioral counseling, injections, and/or surgery are used to manage musculoskeletal pain. Only two of the specific risks and side effects of these conventional medicines are peptic ulcers and gastrointestinal bleeding . The typical path of chronic pain includes escalating dysfunction, impairment, and potential disability. The "International Association for the Study of Pain" has the following definition of pain: Pain is defined as "an unpleasant sensory and emotional experience associated to, or characterized in terms of, current or potential tissue damage [22].

Most of the time, eliminating the irritating stimulus instantly reduces pain. There are instances where pain persists even after the stimulus has been removed and the body has healed, though. Furthermore, pain can arise even in the absence of a cause, disease, or injury. Acute pain is characterized as lasting less than thirty days, whereas chronic pain is defined as "pain that goes beyond the ordinary period of healing" and lasts more than six months. The three major types of pain

are nociceptive, neuropathic, and central. Different pain pathways are targeted by the current medical therapy of pain or the use of analgesics. Nociceptive and neuropathic pain can be effectively treated with low level laser therapy (LLLT), but central pain cannot. When therapeutic lasers were first utilized in dermatology for wound healing more than 20 years ago, the principles of biostimulation were first established. Genovese contends that biological effects brought on by low level lasers are the result of low energy being deposited into tissues, where the deposited energy has primary, secondary, and all-around therapeutic effects. This enhances healing by having analgesic and anti-inflammatory properties. Various low-level light outputs and wavelengths are applied directly to the targeted area during this process. In turn, the body tissue takes in the light. When red and near-infrared light react with damaged cells, a physiological response occurs that encourages regeneration. Common wavelengths used to treat superficial tissue range from 600 to 700 nanometers (nm). Wavelengths between 780 and 950 nm are employed for deeper penetration. The laser instrument will feel like it is touching your skin, but the process is painless and noninvasive. You won't hear or feel any noises, vibration, or heat. Usually, each treatment only lasts a few minutes [23].

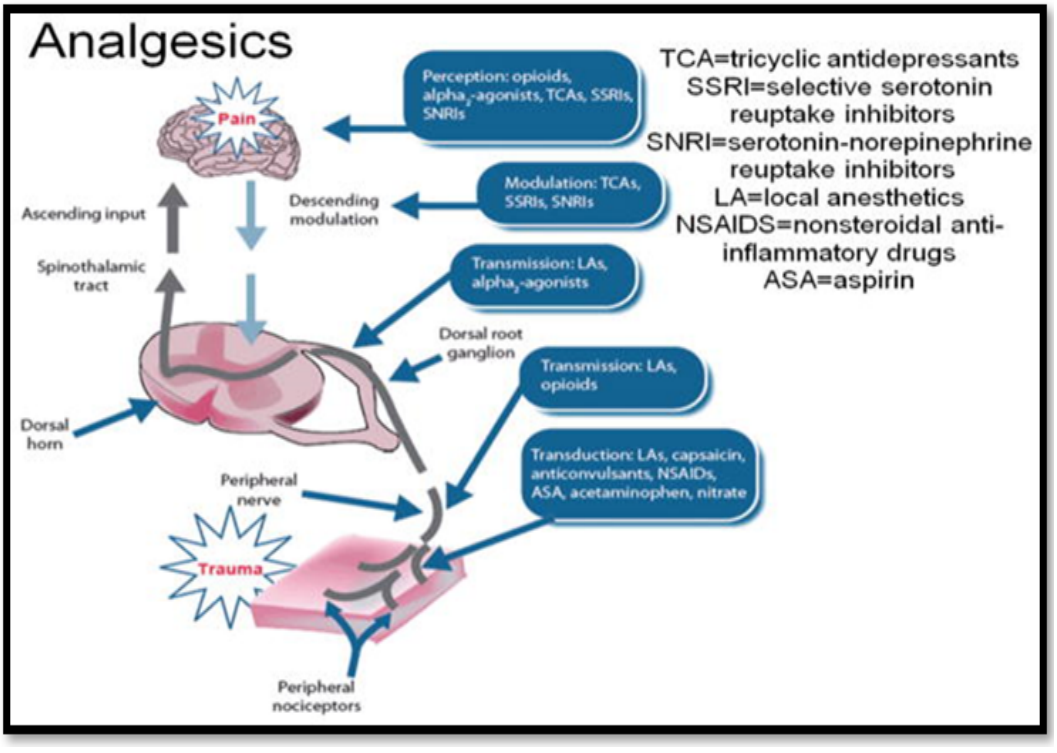


FIGURE 1.3: Site of analgesic action on the pain pathway

1.4 Light Spectrum in Laser Therapy

The action spectra of the target photo acceptors (like cytochrome c oxidase), which determine the favorable biological responses like increased metabolism, cellular regeneration, and immunomodulation, can be used to characterize the efficiency of light wavelengths with respect to photobiomodulation therapy. The red (630–680 nm) and near-infrared spectra have the widest range of wavelengths that are clinically useful (810-840 nm). Wavelength is one of the most important light-related parameters, along with dosage or energy density (J/cm2), treatment duration, and light delivery in pulses (cycles per second or Hz), in influencing the effectiveness of absorption, depth of penetration, and ultimately the clinical effects. The cumulative effects of photobiomodulation may become apparent clinically right away or over the course of many days [24].

1.4.1 Red Light

The advantages of red light wavelengths (= 630–680 nm) as well as in situ and in human investigations have been shown. Since the development of the He-Ne laser (632.8 nm) in the 1960s. Cytochrome c oxidase, one of the final enzymes in the electron transport chain that produces ATP, absorbs a lot of these wavelengths. Due to increased ATP generation and cellular metabolism brought on by exposure to these red wavelengths, damaged or unwell cells and tissues will heal and recover much more quickly.

Other photo acceptors in the skin, such as hemoglobin and melanin, also absorb red wavelengths to some extent, limiting the effective penetrating deep into it to the subcutaneous parts the body (approximately 5-10 mm). With the exception of treating superficial skin diseases like acne, other wavelengths like violet and blue are not employed in laser therapy since they are so intensely absorbed by skin photo acceptors that they scarcely penetrate the skin (1-2 mm).
The treatment of relatively superficial illnesses including subcutaneous bursitis, skin problems like acne, psoriasis, hair loss, and eczema, as well as wounds and

chronic ulcers, is greatly aided by red wavelengths, particularly those mostly in the 630–680 nm range. The extensive network of capillaries in the subcutaneous area will also absorb red wavelengths, which will cause the activated white blood cells, stem cells, and platelets to have a potent immunomodulation impact. This is known as a systemic or remote impact, because it creates a healing and anti-inflammatory response that is disseminated to anti-inflammatory response that is disseminated to diseased and wounded tissues far from the treated location via activated white blood cells. Red light cannot penetrate deeply, yet it can still be a very potent therapeutic wavelength for deeper tissues if certain conditions are met.

The capacity of red wavelengths to induce analgesia and provide the patient with instant pain relief is their final advantage. Higher doses of light energy, particularly those with red wavelengths, can suppress superficial nociceptors (pain nerve fibres), which inhibits the central transmission of pain, according to study by Roberta Chow and colleagues. Axonal flow, cytoskeleton structure, and reduced ATP in pain-transmitting neurons are all impacted by photobiomodulation. These researchers noted that there are no adverse effects or nerve injury and that the effects are reversible [24].

1.4.2 Infrared Light

Near Cytochrome c oxidase and other photoreceptors are known to absorb infrared wavelengths, which has a beneficial impact on cellular physiology. In order to determine the photo absorption spectra of these photo acceptors and the wavelength ranges that produce the best photobiomodulation, Tina Karu was one of the essential researchers. For deeper lying injuries and conditions related to musculoskeletal disorders, she found near infrared wavelengths between 810 and 840 nm were most active. Hemoglobin and other photo acceptors, which prevent light from penetrating more deeply, absorb far less of these near infrared wavelengths. Since they can penetrate several centimeter's deeper than other wavelengths utilized in photobiomodulation therapy, light in the 810–840 nm range is thought to

be the most transparent. The real clinical effective depth of penetration varies depending on the kind of skin, the density of the tissue, the power, the length of the treatment, and the use of contact technique. The amount of light that can efficiently pass through and accumulate to a dosage high enough to have a photobiomodulation impact varies amongst tissues such bone, tendon, muscle, adipose, and ligament. Near infrared wavelengths (810–840 nm) are the "go to" wavelength range to cure these deeper tissues since they are the most effective at directly photobiomodulation these kinds of tissues. One method to accelerate the dose rise in these deeper tissues is to use additional force. The possibility of a thermal effect that inhibits performance, however, grows with power. Naturally, more power also means faster treatment times, which results in less stimulation of target photo acceptors. Longer illumination periods have a better therapeutic impact, according to research. The effectiveness of Infrared Laser treatment has been established. is useful in treating a variety of musculoskeletal disorders and deeper lying tissues [25].

1.4.3 Pulsed Light

One of the least understood factors in photobiomodulation therapy, pulsing light has been found to have an impact on therapeutic efficacy. A diode's output of light can be either a continuous wave, which is a steady stream of light, or it can be modulated by pulses that occur at a fixed frequency between one and hundreds of cycles per second (Hz). According to a large body of research, pulsed light can be used to increase therapeutic responsiveness [25].

It has also been demonstrated to have advantages, such as:

- Increasing the bio stimulatory impact
- Increased light penetration into tissues at deeper levels
- Reduce the possibility of phototoxic effects when treating deeper tissues
- Decrease in the molecule's local transient heating

- Focus on particular cells according to their ATP consumption and mitochondrial activity.

1.5 Aims

The aims of my research were following:

1. The purpose of current study is to investigate the analgesic efficacy of low-level laser therapy in patients with different sessions for the cure.
2. To evaluate the performance and analgesic efficiency of low-level laser therapy in patients with different body parts, particularly with knee osteoarthritis in 60 patients.

1.6 Objectives

The objectives of my study were:

1. To evaluate a number of sessions performance successfully or unsuccessful (Increase of unsuccessful, increase the number of sessions).
2. To determine the percentage of effectiveness of low-level laser therapy in body parts
3. Recommendation of the treatment for masses
4. To provide safe therapy to the specific patients

Chapter 2

Review of Literature

2.1 History of Laser

Dr. Nils Finsen received the Nobel Prize in Medicine in 1903 in recognition of his work using focused light radiation to treat various illnesses, including lupus vulgaris [26]. Professor Maiman TH constructed the first operational red ruby laser in 1960, but Mester E et al. were unable to show the phenomenon of "laser bio stimulation" until 1967. The work of Whelan H. et al. on the medicinal uses of light emitting diodes (LED) for the NASA space station was presented in 1999. Over 400 Phase III randomised, double-blind, placebo-controlled trials and over 4,000 LLLT laboratory investigations have now been published [27]. At the Semmelweis Medical University in Hungary, Endre Mester made the discovery of Low-level laser therapy (LLLT) in 1967.

Mester was attempting to replicate an experiment initially carried out by Paul McGuff in Boston, USA, who successfully treated malignant tumors in rats using the newly discovered ruby laser. The history of LLLT began in 1967, a few years after the first functional laser was created, when Endre Mester at Semmelweis University in Budapest, Hungary, decided to investigate if laser radiation can induce cancer in mice. After shaving their dorsal hair, he divided them into two groups and gave one of them a low-powered ruby laser (694 nm) treatment. They did not

develop cancer, and to his amazement, the treated group's hair grew back faster than the untreated group did. The first instance of "laser biostimulation" was this. Since that time, medical therapy using coherent-light sources (lasers) or non-coherent light sources (light-emitting diodes, LEDs) has matured. Low intensity laser therapy is commonly referred to "cold laser," "soft laser," "biostimulation," and "photobiomodulation," is currently used in several countries as a component of physical therapy. In fact, light therapy is among the oldest therapeutic modalities utilized by mankind (in the past, Egyptians used solar therapy, and later, Nils Finsen received the Nobel Prize for UV therapy) [28]. The following development in technology is evolution of light treatment, thousands of people utilize every day across the globe. Zlatko Simunovic, M.D., F.M.H., the director of medicine at the Pain Clinic and Laser Center in Locarno, Switzerland, writes: "Laser therapy [LLLT] is a natural and biological therapy since man has believed that the sun's light is what keeps him healthy since ancient times. Human beings simply cannot exist without light, as the diseased cell's obvious lack of light demonstrates. Such a sick cell can be made healthy again by laser light [29]. The terms Low Level Light Therapy (LLLT), Laser Biostimulation (also known as laser biostimulation), Laser Phototherapy (also known as low-level laser therapy), Low-Power Laser Irradiation (also known as low-power laser therapy), and Photobiomodulation Therapy are accepted as alternate terms under the medical subject heading Low Level Light Therapy. Industry experts believe that the phrase "Photobiomodulation therapy" is the most appropriate [30]. A laser is a device that produces light by an optical amplification method based on the electromagnetic radiation's stimulated emission. The International Engineering Consortium defines four primary categories of lasers (IEC standard 60825.) These categories show the radiation's potential for causing eye damage [30].

1. Class 1
2. Class 2
3. Class 3B
4. Class 4

2.1.1 Class 1

The power output of few LED red light therapy items is now higher. One thousand of a watt, or 1 mill watt, is maximum output power allowed for class 2 lasers. As an illustration, consider the NovoThor red therapy bed [31].

2.1.2 Class 2

For residential use, class 1 devices are readily available because they cannot hurt the eyes. In order to be classified as a low power laser, red light therapy LED equipment's power output typically can increase up to 500 mW. Our patients can use a variety of Class 1 home use lasers, such as the Handy Cure Laser and the B Cure Laser, between visits to the clinic [32].

2.1.3 Class 3

Most clinical Low Level Laser equipment utilized by the medical community in the field of Photobiomodulation uses Class 3b Laser (PMBT). Class 3b laser does not produce a thermal effect, thus it does not burn, but if it is shone directly into the eyes, it may cause eye injury. Protective goggles are always worn, and a therapist with formal training delivers the treatment. Clinical experiments and research in the field of laser therapy use the Class 3b Laser, which is thought to be the most effective Red Light Therapy currently available. Depending on the particular medical problem or type of treatment, Laser Medicine employs a number of probes with varying wavelengths and power output [32].

2.1.4 Class 4

The skin can be burned by laser systems with output powers greater than 500 mW. If the manufacturer says that this type of laser should be used for low-level laser — photobiomodulation therapy, such assertion is false [32].

Although his low-power laser beam failed to eliminate any tumors, he did notice that the rats he surgically implanted with tumors had faster hair development and better wound healing. This was the first proof that low-level laser light (instead of powerful thermal lasers) might have some useful medical uses [28, 29].

In order to encourage tissue regeneration, Low-level laser treatment (LLLT) uses light to be administered to a biologic system to reduce swelling and ease the pain. In contrast to other medical laser techniques, LLLT uses an impact of photochemistry, which implies that Light is taken in and results in a substance modification, rather than an ablative or heat mechanism [30].

This process involves applying various low-level light outputs and wavelengths directly to the region being treated. A light of laser is then absorbed by the bodily tissue. Red and near-infrared light cause a physiological reaction in the wounded cells that promotes regeneration. Common wavelengths used to treat superficial tissue range from 600 to 700 nanometers (nm). Wavelengths between 780 and 950 nm are employed for deeper penetration. The process is painless, non-invasive, and non-toxic, has no side effects, does not heat or cut tissue, and does not call for medication or surgery. The FDA, Canada Health, and CE have all authorized this Canadian technology [31]. The most prevalent joint condition in older people, (OA) of the knee is linked to severe physical disability. Pain relief is the major goal of treatment for knee OA. Although non-steroidal anti-inflammatory medicines (NSAIDs) are osteoarthritis frequently used to treat the pain and stiffness brought on by knee OA, their usage may be constrained due to the high occurrence of significant upper gastrointestinal adverse effects [32], [33]. To avoid or to reduce the side effects associated with NSAIDs, physical therapy agents such as ultrasound, transcutaneous electrical nerve stimulation therapy and muscle strengthening exercises are frequently used. Low-power laser therapy has been used to control pain in different musculoskeletal conditions [34]. Low back discomfort, also referred to as lumber-sacral pain, has recently become so frequent that it has epidemic proportions. 70% to 85% of people worldwide will have this prevalent musculoskeletal illness at some point in their lives [35]. Low-level laser therapy (LLLT) has been successfully utilized to treat low back pain and other

musculoskeletal pains. Patients from adjacent hospitals made up the experimental (32) and control (26) groups in the current study. For a total of three weeks straight, each group underwent LASER + exercises (Arm 1) and heat therapy + exercises (Arm 2), respectively. At both the beginning and the completion of the intervention, tests were done for pain and AROM (lower back forward flexion, extension, and right and left side flexion). Using a two-way repeated measure MANOVA with significant at the 5% significant level with a 95% confidence interval, the data were evaluated throughout time, between the two groups, and at baseline, midpoint, and end of the intervention. It may be stated that LLLT is a successful therapeutic option for NSCLBP [36–38].

In March 2006 a study was organized to examine the evidence that is both sufficient in terms of quality and quantity regarding to the effectiveness of LLLT in improving wound healing. To regarding the current situation published in cellular simulations, studies on live animals and humans. Some papers exploring the effects of LLLT on cell cultures in vitro report an increase in cell proliferation and collagen formation using specific and somewhat arbitrary laser settings with the helium neon (HeNe) and gallium arsenide lasers The method by which LLLT may be working, whether photo thermal, photo chemical, or photo mechanical, is not discussed in any of the research that are currently available. Nevertheless, these results no longer are replicated in animals with skin that is more like to that of living beings, such as pigs. Some research, notably individuals who use HeNe lasers, suggest benefits provides a rodent model for the recovery of surgical wounds.

Larger investigations having not confirmed the positive influence on the surface wound healing that were observed a few cases in a sequence in humans. There is a need for high-quality clinical research that link cellular impacts and biological operations in order to more clearly comprehend the role that LLLT plays role in the healing of carious lesions. Future research should focus on well-controlled investigations with logical laser and treatment parameter selection. The research does not currently seem in order to the LLLT is widely used in healing process in the absence of such investigations. Contradictory research in the literature have restricted the use of low-level laser therapy (LLLT) in the United States is used

investigational only, despite the extensive use and well-established uses for 10–100 W high-energy lasers [39].

However, low power laser treatment is clinically widely used elsewhere, including in Europe, Asia, and Canada to treat a range of dermatologic, chiropractic, and neurologic conditions. Reviewing the LLLT studies that, to date, have prevented the Food and Drug Administration from approving several of these technologies in the United States is helpful in understanding this gap. The main issue is whether there is enough data to back up the use of LLLT.

An estimated 83 per 100,000 people are reported to experience acute neck discomfort with cervical radiculopathy each year, and the disorder is more prevalent in people who are in their fifth decade of life (203 per 100,000). The study was conducted in the Rehabilitation Clinic of the Medical School, University of Belgrade, Serbia, between January 2005 and September 2007 [39].

The Bioflex laser, a low-energy photon therapy device, was the subject of a pilot research to determine its effectiveness in treating carpal tunnel syndrome (CTS). Over the course of 12 treatments, measurements of pain and strength were kept track of. Seven patients with confirmed CTS underwent tests using hand dynamometry and visual analogue scales (VAS) both objectively and subjectively at the beginning and after 12 sessions with the Bioflex laser and appropriate manipulation/soft tissue therapy. At the 12th session, a testing revealed that five out of seven patients (71%) were pain-free. By the fifth, seventh, and tenth treatments, three individuals had no longer any pain. This pilot study demonstrates the Bioflex laser's effectiveness in treating unilateral CTS. Twelve treatments yielded a success rate of 71%, making this therapeutic strategy quite affordable [40].

In a controlled, randomised experiment, we looked at how laser irradiation affected the way that surgical incisions on rabbits healed. Since the way LLLT is applied to the human body is similar to how similar physiologic structures are applied to animal tissue, this research has been expanded to include people. The Achilles tendon, epicondyles, shoulder, wrist, and interphalangeal joints of the hands, both unilaterally and bilaterally injured, were among the anatomical areas

studied clinically on 74 patients. Prior to LLLT, every patient underwent surgery. For the treatment of trigger points (TPs), an infrared diode laser (GaAlAs) 830 nm continuous wave was utilized. For the scanning operation, a HeNe 632.8 nm mixed with a diode laser 904 nm pulsed wave was used. Both were used in the current clinical research as monotherapy. Redness, heat, soreness, swelling, and loss of function were the clinical parameters used to evaluate and measure the outcomes before they were put on hold for statistical analysis using the chi2 test. The following findings were reached after comparing the healing processes of two patient groups: In the group of patients receiving LLLT, wound healing was noticeably sped up (25%–35%). Patients receiving LLLT experienced much greater pain reduction and functional improvement than those receiving no treatment. The main benefits of LLLT for postoperative sports- and traffic-related injuries are quicker wound healing in addition to pharmacological side effects prevention, dramatically accelerated functional recovery, earlier return to work, training, and sport participation, and cost savings [41].

The World Association for Laser Therapy's treatment recommendations were used to subgroup the studies study by dose after they had been synthesized using random effects meta-analyses. The risk-of-bias tool from Cochrane was employed. Meta-analysis was performed on 22 trials (n=1063). Bias risk was negligible. Both at the conclusion of treatment (14.23 mm VAS; 95% CI 7.31 to 21.14) and during follow-ups 1–12 weeks later (15.92 mm VAS; 95% CI 6.47 to 25.37), LLLT significantly reduced pain compared to placebo. According to the subgroup analysis, the indicated LLLT doses significantly reduced pain when compared to placebo at the conclusion of treatment (18.71 mm; 95% CI: 9.42 to 27.99) and during follow-ups 2–12 weeks later (23.23 mm; 95% CI: 10.60 to 35.86).

The prescribed LLLT doses resulted in the greatest pain relief during follow-ups 2–4 weeks following the conclusion of therapy (31.87 mm VAS, substantially greater than placebo (95% CI 18.18–45.56)). Additionally, LLLT statistically significantly decreased disability. Negative incidents were not reported. At 4-8 J with a 785-860 nm wavelength and at 1-3 J with a 904 nm wavelength per treatment location, LLLT decreases pain and impairment in KOA [42]. A study was carried out

in 2017 to evaluate the long-term effects of low-level laser treatment (LLLT) combined with strengthening exercises in patients with knee osteoarthritis. Follow-up findings from a previously reported randomised, double-blind, placebo-controlled experiment at three and six months. There were 40 patients with knee osteoarthritis in grades 2-4 on the Kellen-Lawrence scale, aged 50 to 75. The LLLT group had an eight-week supervised strengthening training programmed after receiving 10 LLLT treatments with an invisible infrared laser (904 nm, 3 Joules/point) over the course of three weeks. The infrared laser output was inhibited for the placebo LLLT group, but they received the same care. The severity of osteoarthritis as determined by the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) and Lequesne Index, as well as pain on a visual analogue scale and paracetamol use.

All outcomes were steady, according to the additional data collected during the follow-up period, and there were no significant differences between the groups at three and six months. However, the LLLT group used significantly less rescue analgesics (paracetamol) on a daily basis during the follow-up period, with a group difference of 0.45 vs. 3.40 units (P 0.001) at six months of follow-up. We come to the conclusion that the previously reported improvement following LLLT with exercise was maintained for a period of six months within the constraints of this short trial. The end result was that the six-month maintenance of the immediate post-intervention gains from LLLT plus strengthening exercises [43].

Low light therapy is a powerful treatment method for adults suffering from musculoskeletal conditions, in 2017 a systematic study and meta-analysis showed. The dosages used by the World Association of Laser Therapy (WALT) . In December 2014 the study was carried out to establish the impact of combined with low-level laser treatment an exercise regimen on patients pain associated with osteoarthritis of the knee, functioning, movement range, muscle strength, and quality of life.
A trial that is randomised, double-blind, and placebo-controlled, with patients being assigned to various treatment groups in turn. There were 40 participants, both sexes, osteoarthritis of the knee, 2-4 levels of osteoarthritis, between the ages of 50 and 75. Randomization was used to assign participants to either the group

of laser, which received 3 J of low-level laser therapy combined with exercises, or the control group. During three distinct intervals—baseline, three weeks following the conclusion of laser therapy. Then following the completion of the exercises, the Lequesne questionnaire was used to assess functionality and a visual analogue scale (VAS) was used to assess pain, muscular power was measured with a dynamometer and an all-purpose goniometer, Physical activity were assessed using the WOMAC questionnaire from the Western Ontario and McMaster Universities. Significant activity differences across the groups were as well discovered (P = 0.03). There are no more noteworthy variations. (P >0.05) are discovered from the other factors. When compared to baseline, participants in the laser group significantly improved on activity (P = 0.001), functioning (P = 0.01), range of motion (P = 0.001), and discomfort (P = 0.001). (P 0.001), according to intragroup analysis. The placebo group showed no discernible improvement. According to this research exercising and using low light treatment can help individuals with osteoarthritis of the knee experience pain alleviation, improved function, and increased activity [44].

In August, 2000 a study was conducted in which many people are affected by osteoarthritis (OA) and rheumatoid arthritis (RA). About ten years ago, low level laser therapy (LLLT) was developed as a noninvasive alternative to conventional RA and OA treatments, but its efficacy is still debatable. We evaluated LLLT's efficacy in the management of OA and RA. The Cochrane Collaboration's techniques were followed in a systematic review, which was carried out by adhering to an a priori methodology. The Cochrane Controlled Trials Register, Medline, and Embase searches of the literature turned up the trials. Only randomised controlled studies using LLLT for individuals with a RA or OA medical assessment were considered applicable.

There was 13 studies total, 68 individuals each received an active laser treatment and a placebo treatment, 212 individuals were randomly assigned to treatment of laser and a laser placebo was administered to 174 individuals. 4 to 10 weeks of treatment were required. There were just 2 trials that reported follow-up for up to 3 months. LLLT improved mobility from point the palm by 1.3 cm (95% CI -1.7 to -0.8) and reduced morning stiffness by 27.5 min (95% CI -52.0 to -2.9) in

RA patients when compared to a separate control group. In functional evaluation and movement, there was no difference in local swelling between groups for other outcomes. Based on the dosage of LLLT, the wavelength, the application site, or the duration of the treatment, there were no appreciable changes between the subgroups. There was no difference swelling between the control and treated hands in RA when compared to a control group utilizing the opposite hand, although almost everyone's pain level decreased. Alleviation and progression of disease.197 participants in all were randomised for OA. Three trials were used to gauge pain. Despite the statistically significant findings heterogeneity ($p > 0.05$) standardized mean difference -0.2, 95% CI -1.0 to +0.6), the averaged analysis revealed no impact on pain.). Joint strength, joint mobility, and other results were not statistically significant. Since LLT has low adverse effects, it should be taken into consideration for the temporary reduction of pain and morning stiffness in RA [45].

The outcomes for OA are erratic between trials and may vary depending on the LLLT's application strategy and other characteristics. Applications and the LLLT device's properties methods should be regularly reported by clinicians and researchers. Use of standardized, validated outcomes should be used in new LLLT trials. Despite some encouraging results, this metaanalysis lacked information on how the four parameters of frequency at the time of treatment, dose and area of application near the nerves as opposed to the effectiveness of low intensity laser therapy. The efficiency of LLLT for OA and OA has to be studied to determine the effects of these variables in randomised controlled clinical trials [46].

In September 2018 a study was conducted the aim of this study was to provide an overview of the potential advantages of LLLT for pain management. Coherent light with a wavelength between 600 and 1000 nm is used in cold laser therapy in the hopes of photo-stimulating the tissues and promoting and accelerating healing. This is demonstrated by the similarity in absorption spectra between oxidized cytochrome c oxidase and action spectra from biological reactions to light. In clinical studies and laboratory experiments, LLLT has been shown to result in pain alleviation and fibroblastic regeneration by utilizing the qualities of coherent light. It is believed that LLLT is able to relieve pain by lowering the level of biochemical

indicators, oxidative stress, and the development of edema and bleeding. LLLT has also been observed to considerably reduce pain in the acute situation. In both experimental and clinical research, photobiomodulation has been shown to have analgesic and anti-inflammatory effects. According to this studies, using LLLT for osteoarthritic diseases and pain management may be a complimentary approach used in clinical practice to provide symptom control for patients with osteoarthritis and chronic pain [47].

In 2015 a study was completed to assess the effectiveness of low-level laser therapy (LLLT) for the treatment of knee osteoarthritis (KOA). Selected papers were then subjected to meta-analyses. EMBASE, ISI, and Databases were searched from January 2000 to November 2014, we frequently searched the Cochrane Library and Web of Science databases. Research that contrasted LLLT with sham laser in KOA patients diagnosed in accordance with Rheumatology American College recommendations, were randomised controlled trials (RCTs), and were written in English. The Pedro scale was used by two impartial reviewers to rate the quality of the studies. From the available pooled data, meta-analyses were conducted to determine therapy efficacy. The criteria for nine randomised tests (7 double-blind, 2 single-blind) were met. Data from 518 patients were extracted, including 264 from the groups of treatment and 254 in the group of controls. An average age of the patients ranged between 51, 83 and 64, 27 years, and their Kellen-Lawrence grade was 2. Based on a Pedro score of 7, all included studies had good methodological quality.

The data on pain measured through the VAS scale immediately following treatment were supplied by seven trials. Following therapy, the treated and control groups did not vary significantly in terms of the VAS pain score's standardized mean difference (S I-squared = 666%, MD=-0.28 (95% CI=-0.66, 0.10). No discernible change by laser treatment status was revealed by subgroup analysis depending on whether the investigations were carried out in accordance with the requirements of the World Association Laser Therapy (WALT) [48].

Additionally, a further analysis of subgroups depending upon the degree failed to of OA detect any differences that were statistically significant (SMD -0.28, 95%CI

-0.66, 0.10) between the two groups. The advantage of LLLT against a placebo at this time point was not supported by the assessment of the combined data from the five studies with VAS pain data at the 12-week point. Once we examined the aggregate results of the WOMAC tests for stiffness, pain, and function, conclusions were identical (5 and 3 studies had outcome data right after and 12 weeks after therapy respectively). Results shows most recent evidence, This is based on research using sham laser control therapy and refutes the value of using light therapy as a treatment for KOA patients. A study was published in 2008 of September about Juvenile spondyloarthropathy (jSpA), often called enteritis-related arthritis, affects children (Era), typically have both enteritis and arthritis. Children with JIA have not been thoroughly researched for the therapeutic effectiveness of low-energy lasers for enteritis [49]. During this test trails, we present 20 kids that have jSpA who were investigated by using the ILAR and ESSG standards and who received LLLT added to conventional NSAID treatment. They worked with a laser powered by gallium-aluminum-arsenide. The typical treatment sites were AC joints, infrapatelar and Achilles tendon insertions. Using the patient's reported pain before and one month after the therapy, the effects of the treatment were assessed. Typical Treatment included 10 days of 10-minute sessions [50]. Here were 8 boys and 12 girls, with a median age of 11.4 years (range 7–17). The mean of VAS was 6.1 before to therapy (interval 4-8), and it was 1.3 one month afterwards (range 0–4). Depending on where the enteritis was, a dose of 2.5 to 3 J/m3 was often administered. Tissue effects with LLLT on inflammation, swelling analgesia, and edema have a bio stimulating effect. Laser treatment with Ga-Al-As appears to be a beneficial supplement to the existing conventional treatment techniques for treating Children with jSpA have enteritis discomfort and swelling [51].

In 2017, a review titled "Effective treatment options for musculoskeletal pain in primary care:
A systematic overview of current evidence" came to the conclusion that there was insufficient evidence to determine whether laser therapy was effective for treating neck pain, either acute or chronic, or shoulder pain. Exercise and/or surgical treatment for knee discomfort may benefit more from low-powered laser treatment [52].

The use of LLLT to alleviate pain resulting from various musculoskeletal diseases has gained popularity recently. Despite being widely utilized, its therapeutic results have been reported in a variety of ways. Additionally, there are conflicting findings when using it on individuals with non-specific chronic low back pain (NSCLBP). This study investigated the efficacy of LLLT for the treatment of NSCLBP by a literature review and meta-analyses of particular trials [53].

The Cochrane Library and Web of Science were routinely between January 2000 and November 2014 was searched. The study includes randomised controlled trials (RCTs) contrasting LLLT with a placebo in individuals with NSCLBP. The efficacy effect magnitude was assessed using the weighted mean difference (WMD). We performed a conventional random-effects meta-analysis and used the I-squared index to measure consistency [54].

One triple-blind, four double-blind, and one single-blind RCT were conducted, and without specifying. Out of 221 studies satisfied the criteria for inclusion, including a total of 394 patients. Based on five investigations, the LLLT group's post-treatment WMD pain outcome score was substantially lower than the control group's (WMD = -13.57 [95% confidence interval (CI): -17.42, -9.72], I (2) = 0%] on the visual analogue scale (VAS). For outcomes related to spinal range of motion or disability scores, no discernible treatment impact was found [55].

According to our research, LLLT works well for treating NSCLBP discomfort. However, there is currently a lack of data to support its influence on function [56, 57].

2.2 Mechanism of Action of Low-Level Laser Treatment

Non-thermal irradiation of photons is used in LLLT, Photobiomodulation, or phototherapy to change biological activity. When performing LLLT, light sources are either coherent (lasers) or non-coherent (filtered lamps, LEDs, or occasionally a

combination of both), such as both. Reduced pain and swelling, more effective tissue healing, promoted the regrowth of various tissues and nerves, and prevention of tissue injury in circumstances where it will probably happen in the main medical applications of low-level laser therapy (LLLT) [58]. The primary biomechanical

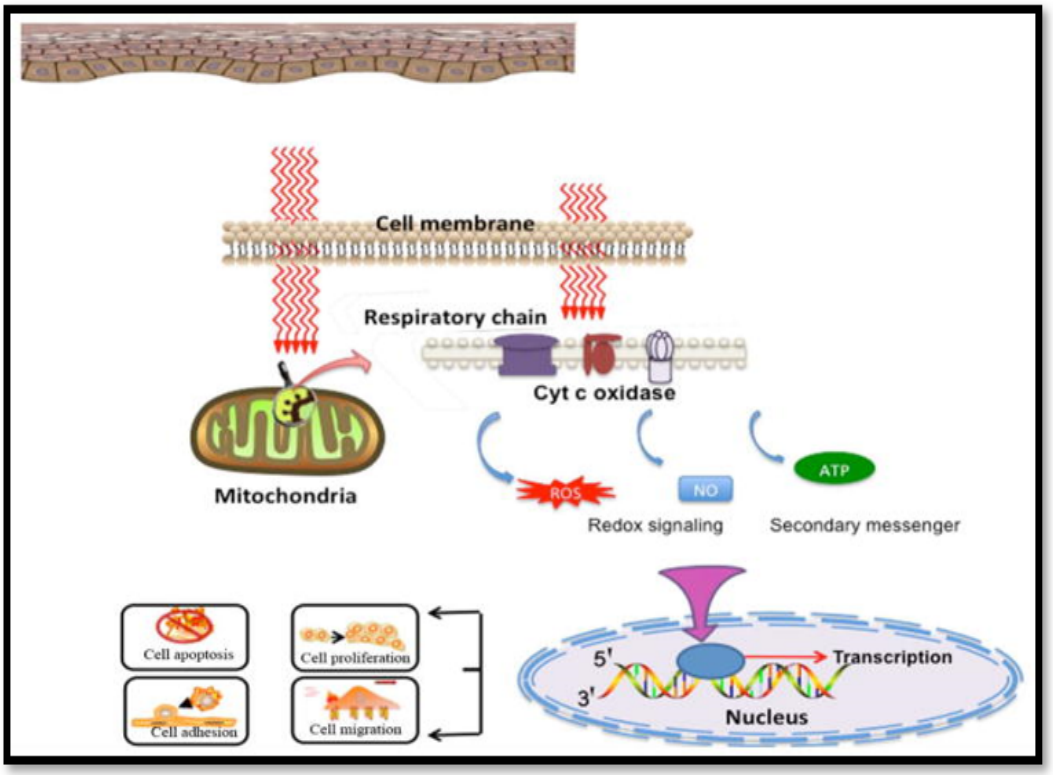


FIGURE 2.1: Low-level laser therapy's mechanism of action

process effects the low light and are hypothesized to be caused by mitochondrial chromophores, especially cytochrome c oxidase, which absorb red and NIR light (CCO) and a component of the respiratory chain inside the mitochondria [59]. Low-power visible or near-infrared light cannot affect a biological system unless the photon is absorbed via electronic absorption bands linked to a photon acceptor or chromophore [60]. Chlorophyll, haemoglobin, myoglobin, cytochrome c oxidase, other cytochromes, flavin, flavoproteins, or porphyrins are examples of molecules (or subunits of molecules) that give substances colour [61]. By using red and near-infrared wavelengths a tissue's "optical window" is a band of wavelengths where light can enter the tissue most effectively [62].

The ideal wavelength is thought around 810 nm. Our mitochondrial cell is also known as "the cellular power plants," use oxidative phosphorylation to turn food

molecules and oxygen into energy (ATP). In human cells, cytochrome c oxidase may serve as the primary photo-acceptor for the red-NIR wavelength range (COX) [63].

Hypoxic cells produced in the mitochondria, in particular in damaged nitric oxide, can restrict respiration by binding to COX and displacing oxygen. The concept is that low intensity light therapy can photo-dissociate NO from COX and reverse the inhibition of mitochondrial respiration brought on by excessive NO binding [64].

2.3 Low-Level Laser Therapy for Pain Management

Sprains, strains, whiplash, muscular back pain, cervical or lumbar radiculopathy, tendinitis, and tendinopathy are acute Orthopaedic diseases, also in chronic conditions like fibromyalgia, chronic regional pain syndrome, frozen shoulder, neck and back pain, epicondylitis, carpal tunnel syndrome, and rheumatoid arthritis. Treatment with LLLT is effective for treating dental pain disorders such as third molar surgery, dentine hypersensitivity, and orthodontic procedures [65]. This treatment is also available for neuropathic pain syndromes such as diabetic neuropathy, trigeminal neuralgia, and post-herpetic neuralgia. One could assume that numerous processes can act to relieve pain given the large range of diseases [66].

The epidermis houses the peripheral nerve ends of nociceptors, which are made up of unmyelinated, slow-conducting C fibers and sparsely militated filaments. This complex network changes unpleasant stimuli into potentials of action. Additionally, due to of their very superficial nature, these nerve terminals can be quickly absorbed by the LLLT wavelengths.

The neuron cell bodies are located in the dorsal nerve root ganglion, while the neurons' expanded cytoplasm (axons) extends to the exposed nerve endings on the skin's surface. After LLLT, nerves in subcutaneous tissues, sympathetic ganglia, and the neuromuscular junctions within muscles and nerve trunks are also

impacted. LLLT initially directly to affects the epidermal neural network. When low-level laser therapy is administered with enough strength, it inhibits action potentials, resulting in a 30 percent within ten to twenty minutes, neural blockage of administration and reversing itself in about 24 hours [67].

2.4 Low-Level Laser Therapy Parameters

The wavelength, power density, pulse parameters, energy density, energy, and duration are the irradiation parameters that must fall within specific ranges in order for LLLT to be effective. When the surface density is 5W/cm2 and the beam power is 1 Watt, the best penetrated wavelengths in the 760–850nm range may achieve a light density of 5mW/cm2 at a depth of 5cm.For LLLT, there are four clinical targets:

- The damage encourages healing, remodeling, and inflammation reduction.
- To lessen swelling and irritation, lymph nodes
- Analgesia is induced by nerves
- Using trigger points, you can relax tense muscles and lessen soreness

An average treatment lasts between 30 seconds to 1 minute each spot. for simple instances can be treated at one point, but more severe dysfunctions like cervical or lumbar radiculopathy can be addressed at up to 15 points [68]. At the North American Association for Laser Therapy conference in 2010, a consensus discussion on safety and contraindications was organized. Their primary suggestions were:

1. Eye: Aiming laser beams away from the eyes is prohibited, and everyone in the room should wear protective eyewear
2. Cancer: When chemotherapy is being administered to the patient, LLLT can be therefore utilized to decrease the negative impacts of microsites that

do not treat over the site of any known primary carcinoma or subsequent metastasis. But for palliative relief, LLLT may be an option for cancer patients who are near the end of their lives

3. Pregnancy: Avoid applying treatments directly to the growing fetus

2.5 Epileptics

Patients who are photosensitive and have epilepsy need to be informed a seizure could be brought on by low-frequency pulsed visible light which is 30Hz. According to reports, the side effects of LLLT are identical similar to those that patients who utilized placebo devices in clinical studies have experienced.

2.6 Orthopedic Outcomes

For the most part, clinical and laboratory investigations had been shown that low intensity laser treatment has a favorable impact on both acute and persistent musculoskeletal pain, according to more than 4000 papers available on pub.med.gov. Every single study has not been good because of the diversity of demographics, interventions, and comparison groups. The complicated state of pain manifests in many different ways and is influenced by a number of mechanical, physiological, psychological, and socioeconomic aspects. Comparing LLLT to other treatments is exceedingly difficult, because LLLT regimens are confounded by varying treatment durations and the lack of standardization of wavelengths and dosages.

LLLT has not yet been subjected to any long-term clinical investigations on humans. Low power light therapy might be beneficial for people having muscular discomfort, according to the majority of positive short-term clinical studies and robust laboratory research. Orthopedic surgeons' of American Academy has not recommended opposed the using of LLLT, however insurance companies have classed it as experimental/investigational after taking into account evidence-based

therapy research (BCBSKS 2013). The FDA's approval of a treatment for momentary relief of joint and muscular pain highlights the need for additional, carefully planned clinical research [68].

2.7 How Long does a Laser Therapy Session Last?

The typical length of treatment for any given ailment of the patient is 15 minutes to an hour. Patient after treatment will easily go home, can drive normally and do their routine work.

2.8 How Long does it Take for the Patient to Experience the Benefits of Low-Laser Therapy?

You might respond to laser therapy extremely fast depending on your particular illness, or your recovery might take longer.

2.9 Who is not an Ideal Candidate for Low Intensity Laser Therapy?

If you are fit any of the following descriptions, you are not eligible for low-intensity laser therapy:

- Individuals taking photoactive medications
- Pregnant women in their first trimester
- People suffering from any form of benign cell growth, including cancer and patients may experience any hemorrhaging or uncontrollable bleeding

- Those patients who are sensitive to light, either naturally or as a result of using photosensitive medications

2.10 Comparison of the Classes

The comparison of the classes 1, 2, 3 and 4

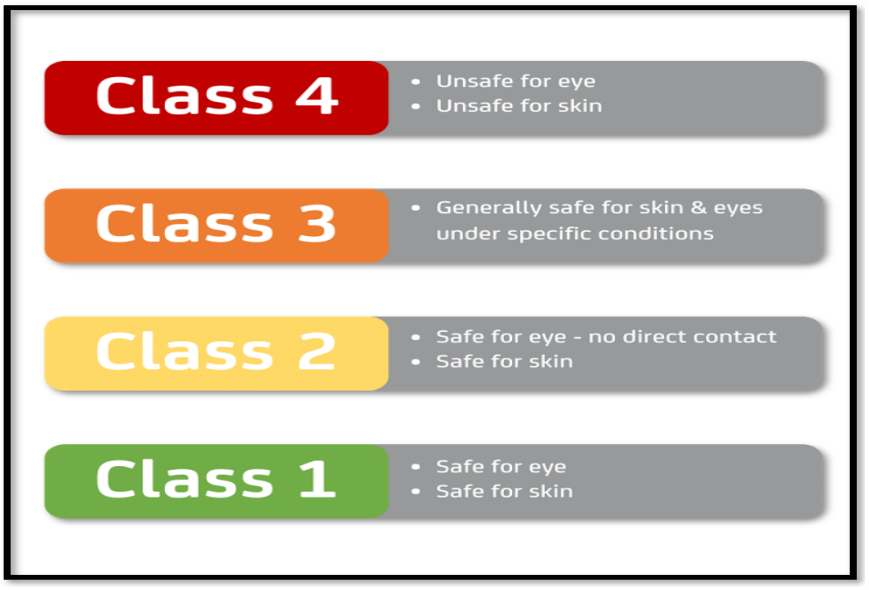


FIGURE 2.2: Flow chart of comparison.

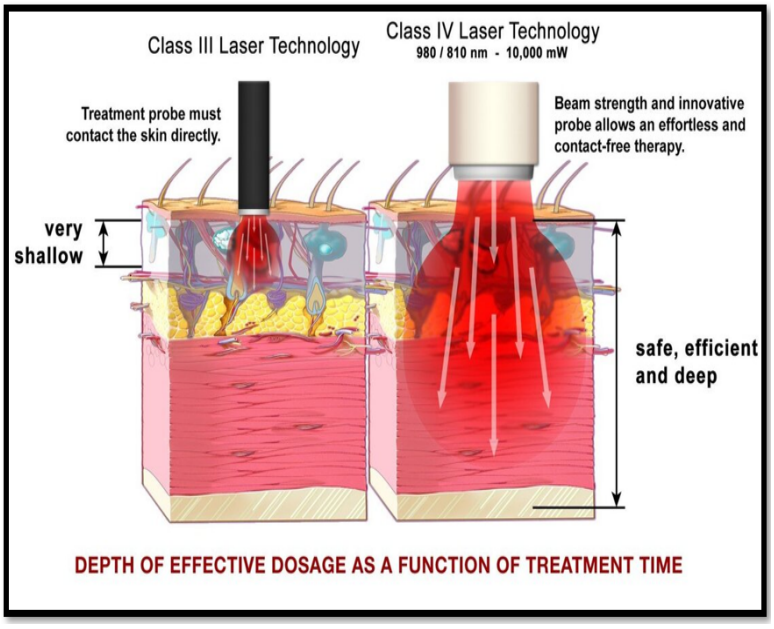


FIGURE 2.3: Comparison on depth.

2.11 Treatment Conditions

The treatment conditions were suggested :

- Syndromes of shoulder impingement
- Arthritis rheumatoid
- Herniated disc
- Knee, hip, and ankle osteoarthritis
- Tendonitis
- Neuropathic pain
- Sciatica
- TMD & Bursitis of the hip or shoulder
- Degeneration of the low back discs & Toe plantar fasciitis
- Tennis elbow & Volume reduction and pain relief in lymphedema

2.12 Benefits of Low-Intensity Laser Therapy

The benefits of the low intensity laser therapy were that it is a non-invasive and non-surgical treatment, it is painless and non-toxic, the successful rate is more than 95%, easy to use and no known side effects [69].

2.13 Contraindications

The contraindications were:

1. Pregnancy

2. Tumor
3. Hemorrhage
4. Pacemaker
5. Thrombosis

Chapter 3

Research Methodology

3.1 Study Area

The current research work was held at the Bioflex Pakistan clinic which is in the twin city Rawalpindi and Islamabad.

3.2 Sample Collection

The samples were collected from those patients who had pain in many body parts with the help of low-level laser therapy procedures

1. First, a history of the patient.
2. Is pain either chronic or acute?
3. Disease status of a patient.
4. Age.
5. Gender.
6. Body Mass.
7. Color & Pain condition.

3.3 What does Low Light Therapy do?

Low-intensity cold laser treatment used amounts of light and a low-intensity laser to promote healing. The low light levels used in the procedure don't produce enough heat to affect the tissue in our bodies, it is known as low light therapy. Comparing laser therapy with other forms of treatment, like those used to coagulate tissue and eliminate malignancies, the light level is minimum [70]. This process involves applying various low-level light outputs and wavelengths directly to the region being treated. The light is then absorbed by the bodily tissue. The red and near-infrared light causes a physiological reaction in the wounded cells that promotes regeneration.

Common wavelengths used to treat superficial tissue range from 600 to 700 nanometers (nm). Wavelengths between 780 and 950 nm are employed for deeper penetration. Lasers used in the surgical and aesthetics treatment. The cold laser therapy does not, as its name implies [71].
Other names for cold laser therapy include:

- Low-level lasers (LLLT)
- Low-power laser (LPLT)
- Photobiomodulation using soft laser biostimulation [72].

3.4 Different Ways that Pain is Introduced

Different types of pain acute or chronic pain, superficial or deep, somatic or visceral pain [73].

3.4.1 Chronic Versus Acute Pain

Chronic and acute pain are various clinical traits, acute discomfort is a self-limiting type of pain that is brought to a specific illness or wound, but it has a biological

function and is connected to spasm of muscles and activation of sympathetic nervous system. On the other hand, if a disease or injury is present, Diseases include prolonged pain condition in which pain persists for a longer period of time than is typical for recovery. Chronic pain has no known biological function and no clear endpoint [74].

3.4.2 Secondary Versus Primary Pain

A location of the pain's source might perhaps to be known from the site where it is felt. If the pain originates in the injured structures, it is primary pain; if it originates somewhere else, it is secondary pain [75].

3.4.3 Superficial Versus Deep Pain

Skinny, soft - tissue pain is a type of superficial pain that is localizable, measurable, and connected to time, place, and intensity. On the other hand, discomfort brought on a deeper muscular and visceral activation occurs more frequently and is less susceptible to stimulus [76].

3.5 Pathways of Pain

The signals are transmitted to the upper centers via a two-plot route before the pain is experienced at the site of the injury [77]. Neospinothalamics and palaeoospinothalmic pathways.

- Delta-type pain fibres, which convey less heat and physical discomfort, send impulses through the Neospinothalamics tract, which transports these signals.
- The neurotransmitter chemical released glutamate which is present at the tips of a delta nerve fibres in the spinal cord.

- Pain is mostly transmitted via the palaeoospinothalmic pathway by type C slow-chronic peripheral nerve fibres.

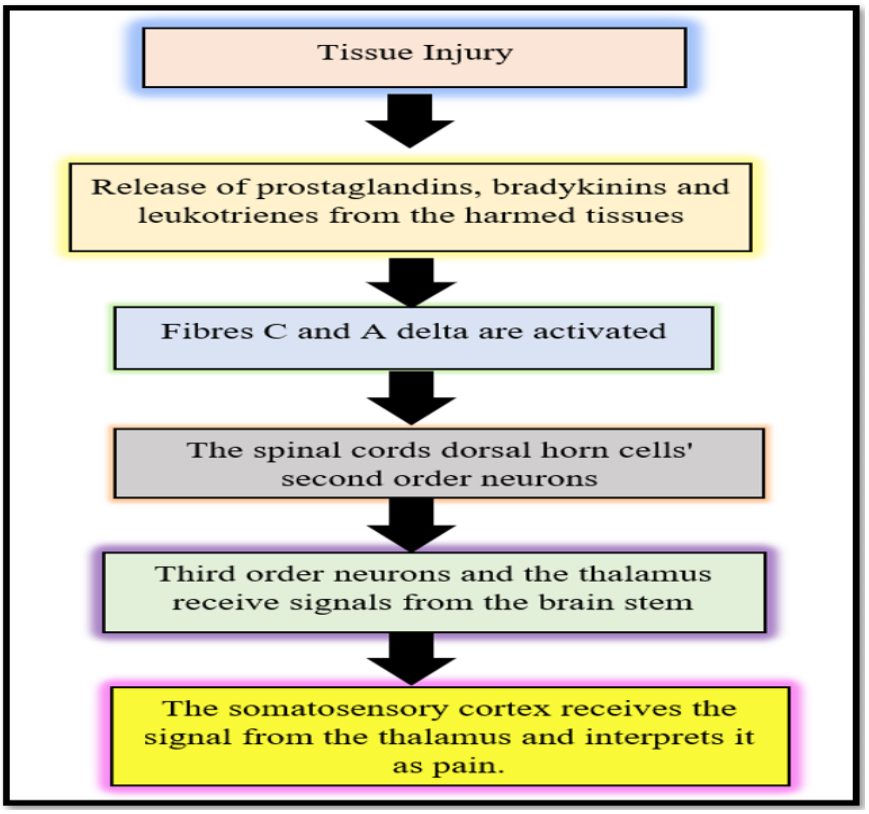


FIGURE 3.1: This flowchart displays the pain pathway from the site of tissue damage to the part of the brain where pain is felt

3.6 Procedure Take Place as Following Ways

The procedure take place during the process were [79]:

- Cold laser therapy is delivered using a small portable device
- It is non-invasive procedure
- It can harm your eyes to look directly into the laser, so you may be required to use goggles
- The physician will hold the hand-held device near your knee or touch it for 30 seconds to a few minutes. The duration is based on the dose and the surface area of the treated area

- The energy of light will travel through the skin and into your tissues, where it will be absorbed.
- The luminous energy helps to reduce inflammation and promotes the regeneration of damaged tissues.
- It generally takes more than a single treatment to feel better
- The number will depend on how much you have pain
- You may have to return several times a week for a couple of weeks or months

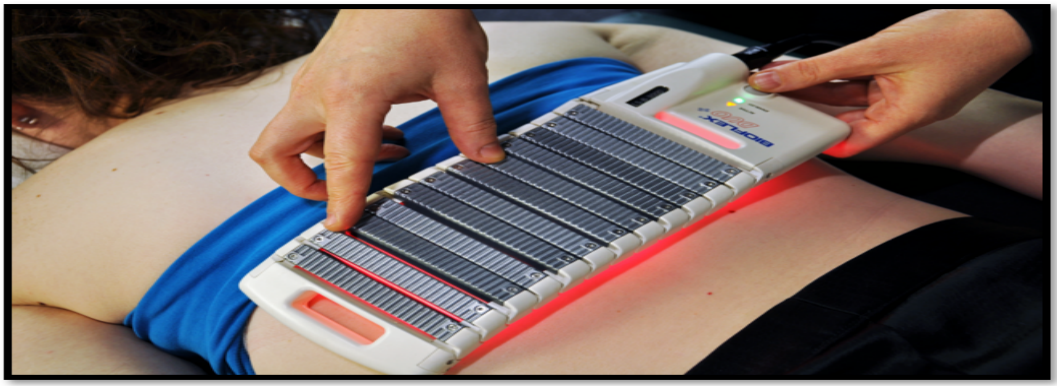


FIGURE 3.2: An array is placed on the back for treatment

FIGURE 3.3: Laser probe is using for pain treatment

3.7 Response of the Patient After Applying the Equipment

The different response of the patient after applying the equipment were [80]:

1. You may feel a slight tingling sensation, but you will feel neither warmth nor cold
2. It is a painless procedure
3. There is no recovery time, so you may return home immediately

3.8 Right Candidate for this Treatment

Low light therapy can be used to treat pain from injury or aging, like knee osteoarthritis It may also be used to cure [81]:

- Arthritis in other joints
- Carpal tunnel syndrome
- Fibromyalgia
- Muscle pain
- Tendonitis

3.9 What is the Prognosis?

Cold laser therapy can temporarily alleviate osteoarthritis of the knee, but it doesn't work for everyone. This is an alternative medicine, and further research is required to determine its effectiveness. Successful treatment varies from person to person [82].

3.10 Efficacy of Low Intensity Laser Therapy

Low intensity laser therapy has been used by doctors on patients looking for efficient and non-conventional pain management techniques for many years. The

number of clinical trials published globally since 1967 is around 2,500. Cold laser therapy has been demonstrated to be an effective way to relieve pain in numerous double-blind, placebo-controlled studies [83].

TABLE 3.1: Detailed information of laser treatment therapy

Gender	**Age**	**Type of pain**	**Disease health status**	**Number of sessions**	**Recovery %**
F	60	Moderate	Chronic	30	50-60%
F	44	Mild	Chronic	7	30-40%
M	53	Severe	Chronic	7	10-15%
F	67	Severe	Chronic	7	20-30%
F	60	Moderate	Chronic	10	80-85%
F	47	Moderate	Chronic	20	60-70%
F	63	Moderate	Chronic	30	70-80%
F	52	Moderate	Acute	10	80-90%
F	54	Severe	Chronic	7	30-40%
F	55	Severe	Chronic	15	10-15%
F	45	Severe	Chronic	20	40-50%
M	41	Moderate	Chronic	15	40-50%

TABLE 3.1: Detailed information of laser treatment therapy

Gender	**Age**	**Type of pain**	**Disease health status**	**Number of sessions**	**Recovery %**
F	53	Severe	Acute	30	40%
F	80	Severe	Chronic	30	50-55%
F	38	Moderate	Chronic	25	80-85%
M	70	Severe	Chronic	20	5-10%
F	52	Severe	Chronic	15	55-60%
M	44	Severe	Chronic	25	20-25%
M	52	Severe	Chronic	15	50-60%
F	60	Severe	Chronic	10	5%
F	25	Severe	Acute	15	60-70%
F	63	Moderate	Chronic	10	20%
F	78	Severe	Chronic	25	70-80%
M	58	Mild	Chronic	10	30-40%
F	60	Severe	Chronic	7	30-40%
F	53	Moderate	Acute	10	80-90%

TABLE 3.1: Detailed information of laser treatment therapy

Gender	**Age**	**Type of pain**	**Disease health status**	**Number of sessions**	**Recovery %**
F	52	Severe	Chronic	25	50-60%
F	72	Severe	Chronic	10	40-50%
F	63	Severe	Chronic	10	10%
M	63	Severe	Acute	7	35-40%
M	31	Moderate	Acute	10	50-55%
F	76	Severe	Chronic	25	20-30%
M	40	Moderate	Acute	7	20%
F	42	Moderate	Acute	10	10-15%
F	66	Severe	Acute	25	60-70%
M	73	Severe	Acute	10	40-45%
F	75	Severe	Chronic	20	5-10%
F	51	Moderate	Acute	10	60-70%
M	59	Severe	Acute	7	70-80%

TABLE 3.1: Detailed information of laser treatment therapy

Gender	**Age**	**Type of pain**	**Disease health status**	**Number of sessions**	**Recovery %**
F	55	Moderate	Chronic	20	40-45%
M	73	Severe	Chronic	7	20-30%
M	24	Moderate	Acute	7	30-40%
M	54	Severe	Chronic	10	10-15%
F	53	Moderate	Acute	10	50-60%
F	64	Moderate	Acute	7	40-50%
M	57	Severe	Acute	7	10-15%
M	33	Moderate	Acute	7	20-30%
M	62	Severe	Chronic	20	5-10%
F	43	Severe	Chronic	10	40-50%
M	65	Moderate	Acute	20	60-70%
F	33	Severe	Acute	10	50-60%
F	32	Moderate	Acute	20	80-85%
F	40	Severe	Acute	10	10%

TABLE 3.1: Detailed information of laser treatment therapy

Gender	**Age**	**Type of pain**	**Disease health status**	**Number of sessions**	**Recovery %**
F	53	Moderate	Acute	7	20-30%
M	67	Moderate	Chronic	20	70-80%
F	66	Moderate	Acute	10	70-75%
M	62	Mild	Chronic	20	50-60%
M	52	Moderate	Chronic	20	10%
F	37	Moderate	Acute	10	10-20%
M	70	Moderate	Chronic	10	40-50%

3.11 The Concept of Clinical Laser Practice

- Rather than treating the condition that is causing the sense of pain, laser therapy aims to eliminate it.
- Treatment should start after a diagnosis has been made and the patient has been informed of the protocols and expected results
- It is possible to order investigative procedures at any time, but doing so shouldn't prevent treatment from being started based on a valid diagnosis.
- The patient should be given a thorough explanation of each day's therapy as necessary and be urged to stick with it until beneficial effects are seen.

3.12 Length of Individual Treatment

1. The duration of the first therapy sessions will be under 40 minutes
2. Most conditions require between 20 and 40 minutes of standard treatment
3. A one-hour treatment period may be used for back pain and pathological disorders with a wider range and deeper severity

3.13 Parameters

3.13.1 Frequency (Hz)

The number of times (cycles) per second the waveform repeats when the system is in operation is described by frequency

3.13.2 Duty Cycle (%) (Width of the pulse)

Duty cycle explains the proportion of time the waveform is active when the system is modulating

3.13.3 Power Density (mW)

Power density (measured in milliWatts per square centimeter, or mW/cm2) indicates how much light is given across the treatment area. For instance, if a 60Watt (=60,000mW) light illuminates a 10cm2 region entirely

3.13.4 Energy Density (J/cm2)

shows the power split by the area and time multiplied. The unit of measurement is Joules per square centimeter (J/cm2). For instance, if a 60Watt light emits all of its light into a 10 cm2 region for 10 seconds, the power density is 60 J/cm2

3.13.5 Duration (sec)

How long the treatment will last

Stage One:

Table 3.2: This table shows stage 1.

Treatment Head	Frequency	Duty Cycle	Duration (Minutes)
LS-R 750	CW	20-70	6/6
LS-I 1500	10-20	-	7/7
LD-I 75	CW	-	6-10

Stage Two:

Table 3.3: This table shows stage 2

Treatment Head	Frequency	Duty Cycle	Duration (Minutes)
LS-R 750	100	90	6/6
LS-I 1500	50	50-90	7/7
LD-I 75	CW		6-10

Stage Three:

Table 3.4: This table shows stage 3

Treatment Head	Frequency	Duty Cycle	Duration (Minutes)
LS-R 750	250-1000	90	6/6
LS-I 1500	50-250	80-90	7/7
LD-I 75	CW or 100	90	6-10

Chapter 4

Results and Discussions

4.1 Sample Collection

In this study, samples are collected from 60 patients who visited with complaints of pain at Bioflex clinic Rawalpindi Pakistan from January 2022 to July 2022. The patients who have acute and chronic pain and have mild, moderate or severe type of pain with other commodities are included in this study. Among these patients, 38 (63.3%) were females and 22 (36.7%) were male. Their age group from 20 to 80 years. The adult's patients are 10 (16.6%) and older are 50 (83.33%) Figure 4.1, 4.2.

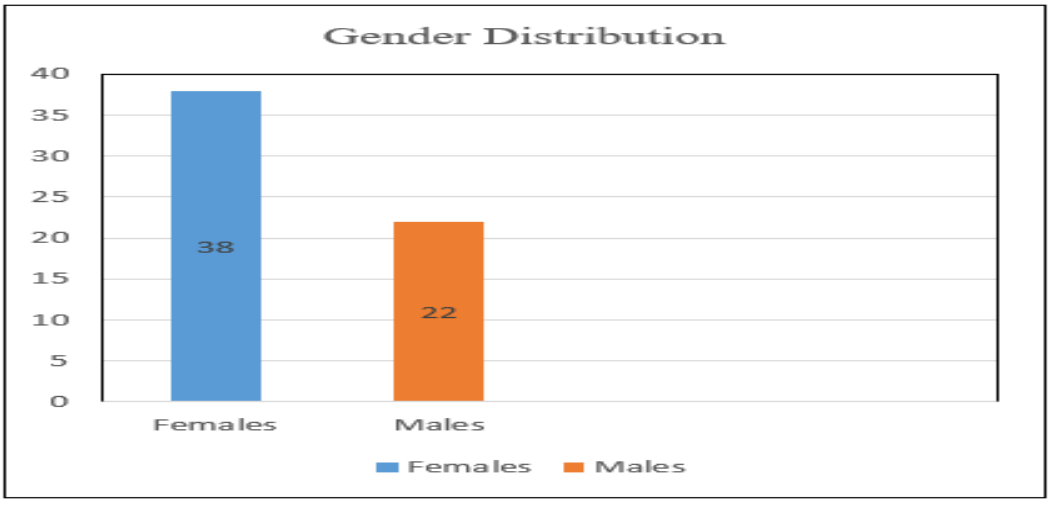


FIGURE 4.1: Gender Distribution

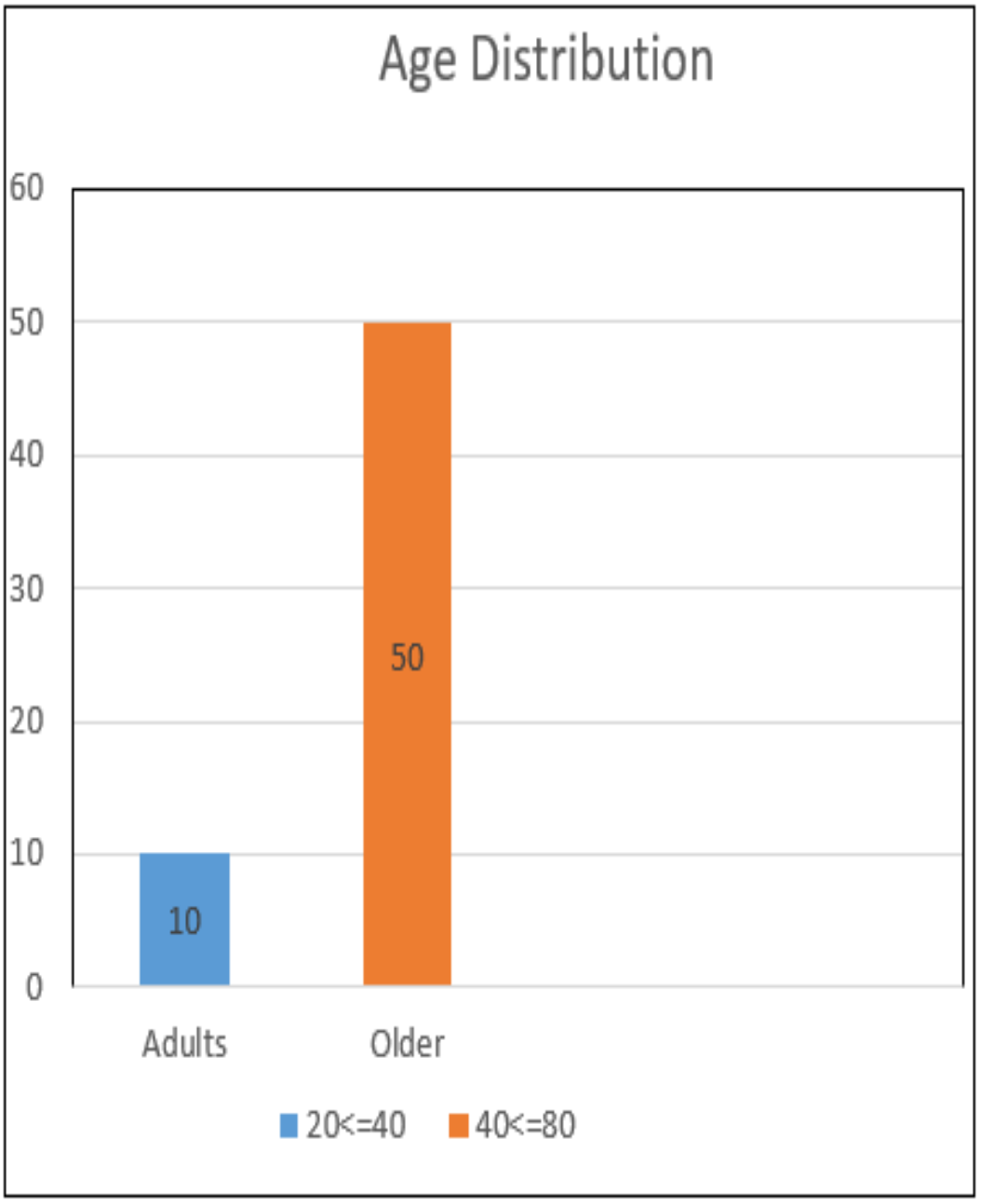


FIGURE 4.2: Age Distribution

The above figure 4.2 shows the graphical representation of the age distribution.

4.2 Type of Pain

There are three types of pain. Mild, moderate and severe. In this study 60 patients were present, from whom 30 (50%) reported severe pain, 26 (43.33%) had

moderate pain, and three (5%) had mild pain. Figure 4.3.

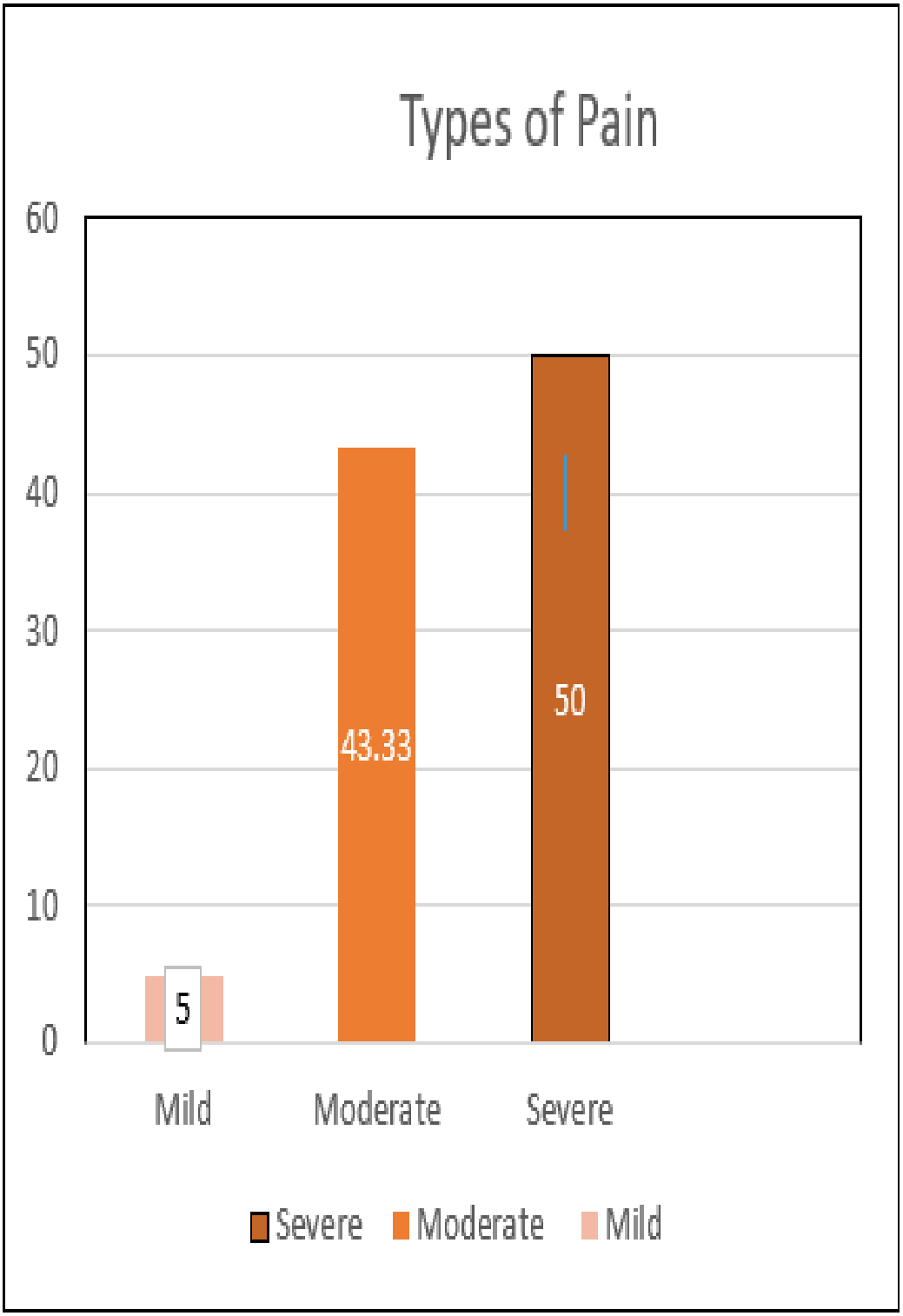


FIGURE 4.3: Types of Pain

The above figure 4.3 shows the graphical representation of types of pain.

4.3 Disease Health Status

The health status of an illness refers to whether it is acute or chronic in nature. 60 individuals were involved, 24 (40%) of whom had acute pain and 36 (60%) had chronic pain. Figure 4.4.

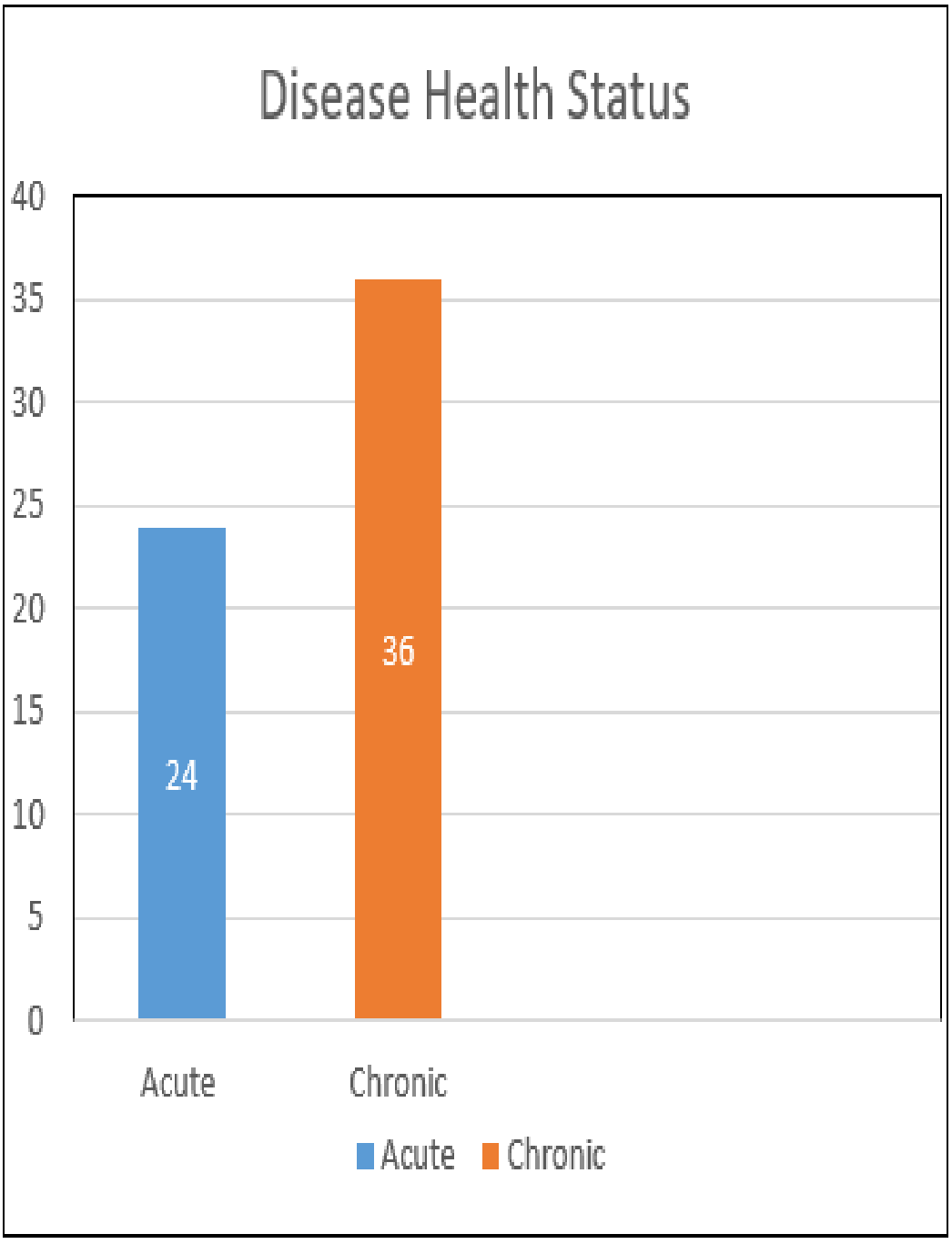


FIGURE 4.4: Disease Health Status

The above figure 4.4 shows the graphical representation of disease health status.

4.4 Number of Treatment Sessions

The number of sessions depends on the type of patient's pain and other problems. So, in the above data we will find the best number of sessions for treatment and the result will discriminate among different BioFlex clinics for better treatment. Sessions in the treatment plan are decided after patient examination and pain history. According to the examination treatments are divided into different numbers of sessions i.e. 7, 10, 15, 20, 25, 30. 60 patient's data was taken for these researches out of which 14 patients were prescribed 7 sessions, 20 patients prescribed 10 sessions, 5 patients prescribed 15 sessions, 11 patients prescribed 20 sessions, 6 patients prescribed 25 sessions and 45 patients prescribed 30 sessions. Figure 4.5.

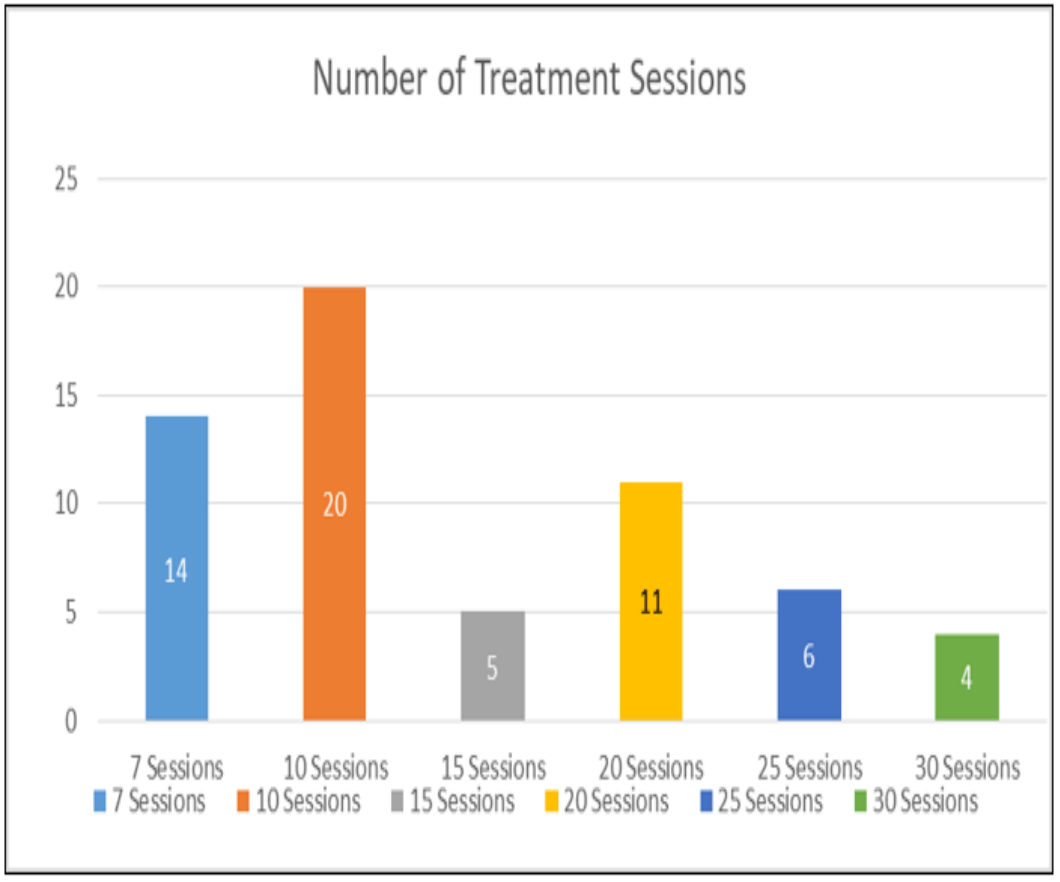


FIGURE 4.5: Number of treatment sessions

The above figure 4.5 shows the graphical representation of number of treatment session.

4.5 Statistical Analysis

Statistical Analysis of data was performed by using MS Excel. Data was entered and organized in MS Excel spreadsheet. The entered data was segregated in number of sessions and percentage.

The below table: 4.1 shows the correlation between gender, age and pain condition. Sample size is of 60 patients in which 22 are male patients and 38 are female patients. They both are divided into two age groups adult and older. Adult patients are "between" (20-40), and olders are (40-80).

TABLE 4.1: Correlation between gender, age and pain condition

Gender	**Age**	**Pain Condition**		
		Mild	**Moderate**	**Severe**
Male (Total 22)	Adult (20-40 Years)	0	4	0
	Older (40-80 Years)	2	5	11
Female (Total 38)	Adult (20-40 Years)	0	3	3
	Older (40-80 Years)	1	14	17

- Out of 22 males in adults 0 patient has mild pain condition, 4 have moderate and 0 has severe pain condition.
- While in older 2 patients have mild condition of pain, 5 patients have moderate and 11 patient have severe pain condition.
- In females out of 38 patients 0 has mild pain condition, 3 have severe and 3 have severe condition of pain.

- While same in older 1 patient has mild pain, 14 patients have moderate pain condition and 17 patients have severe condition of pain.

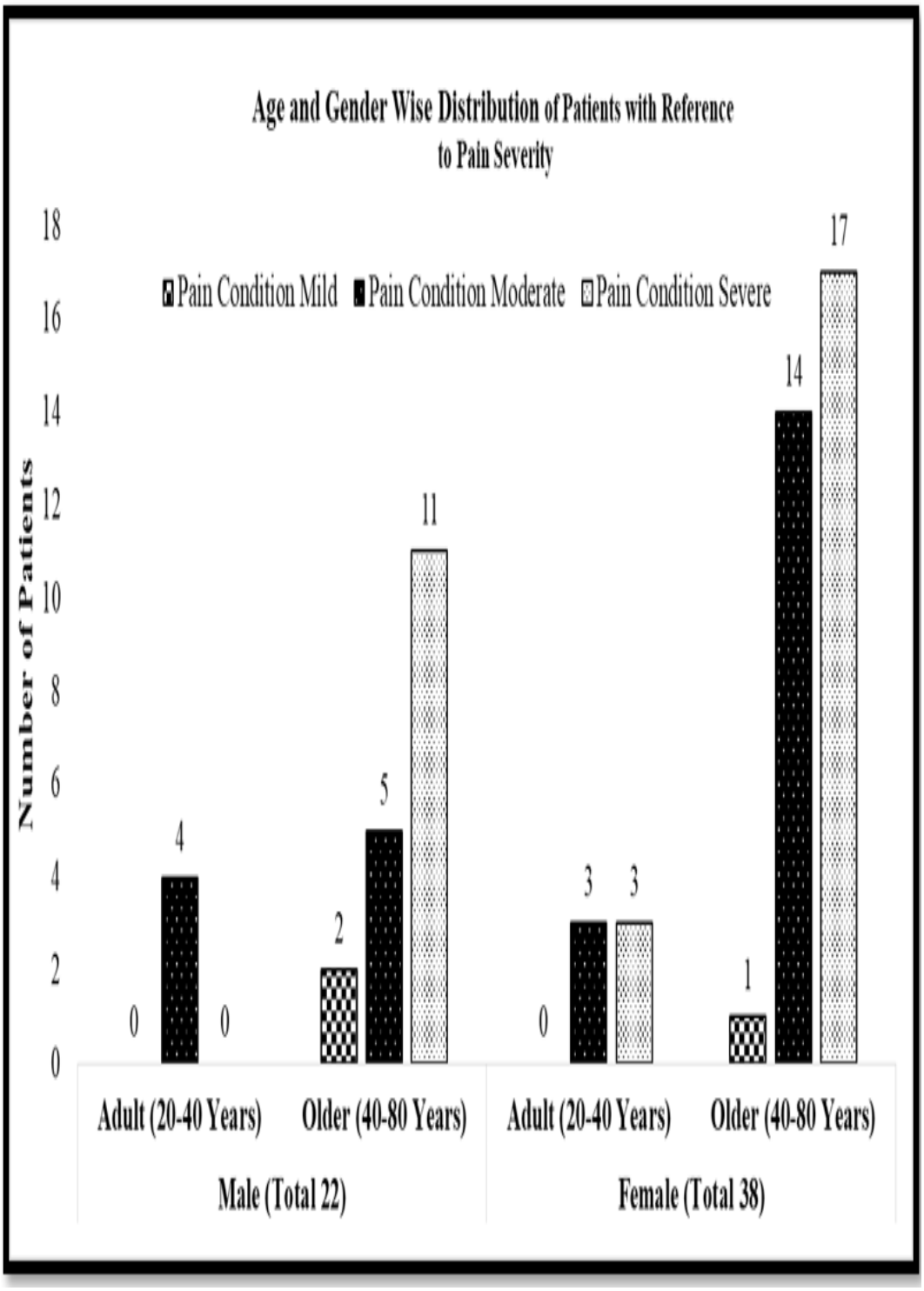


FIGURE 4.6: Correlation between gender, age and pain condition

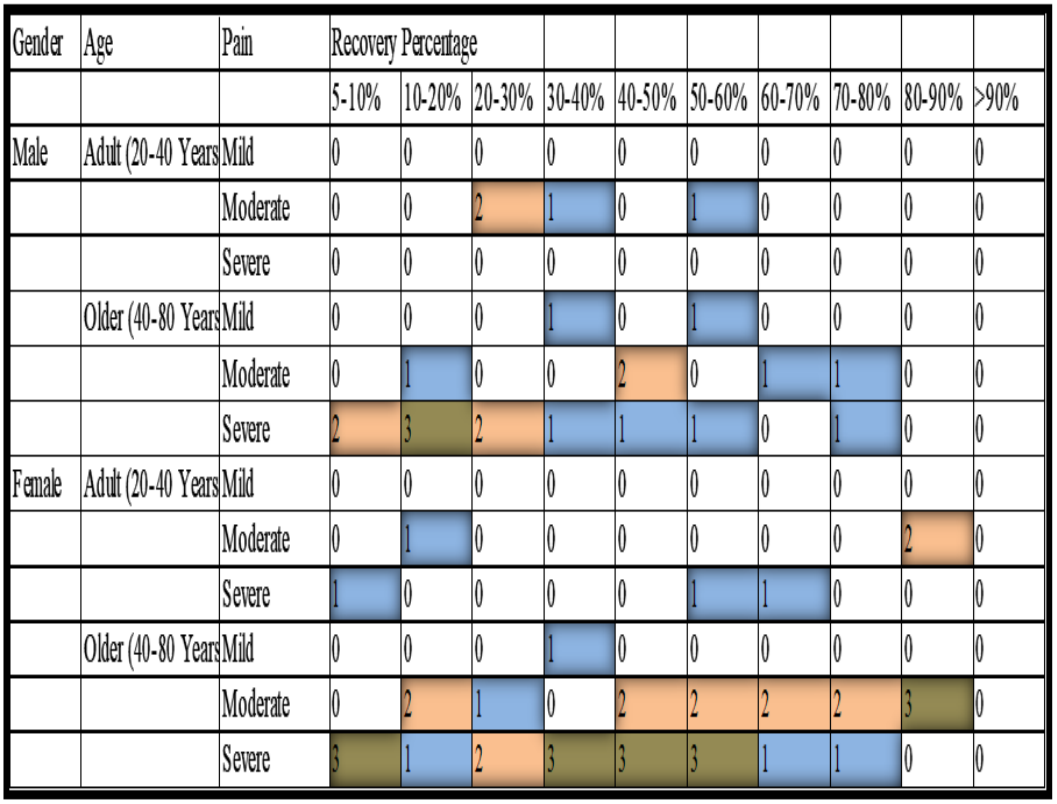
The above figure 4.6 shows the graphical representation of number of correlation between gender, age and pain condition.

TABLE 4.2: Number of sessions

Gender	**Age**	**Pain**	**Number of Sessions**					
			7	**10**	**15**	**20**	**25**	**30**
Male	Adult (20-40 Years)	Mild	0	0	0	0	0	0
		Moderate	0	0	2	1	0	1
		Severe	0	0	0	0	0	0
	Older (40-80 Years)	Mild	0	0	0	1		1
		Moderate	0	1	0	0	2	0
		Severe	2	3	2	1	1	1
Female	Adult (20-40 Years)	Mild	0	0	0	0	0	0
		Moderate	0	1	0	0	0	0
		Severe	1	0	0	0	0	1

TABLE 4.2: Number of sessions

Gender	Age	Pain	Number of Sessions					
			7	**10**	**15**	**20**	**25**	**30**
	Older (40-80 Years)	Mild	0	0	0	1	0	0
		Moderate	0	2	1		2	2
		Severe	3	1	2	3	3	3



Gender	Age	Pain	Recovery Percentage									
			5-10%	10-20%	20-30%	30-40%	40-50%	50-60%	60-70%	70-80%	80-90%	>90%
Male	Adult (20-40 Years	Mild	0	0	0	0	0	0	0	0	0	0
		Moderate	0	0	2	1	0	1	0	0	0	0
		Severe	0	0	0	0	0	0	0	0	0	0
	Older (40-80 Years	Mild	0	0	0	1	0	1	0	0	0	0
		Moderate	0	1	0	0	2	0	1	1	0	0
		Severe	2	3	2	1	1	1	0	1	0	0
Female	Adult (20-40 Years	Mild	0	0	0	0	0	0	0	0	0	0
		Moderate	0	1	0	0	0	0	0	0	2	0
		Severe	1	0	0	0	0	1	1	0	0	0
	Older (40-80 Years	Mild	0	0	0	1	0	0	0	0	0	0
		Moderate	0	2	1	0	2	2	2	2	3	0
		Severe	3	1	2	3	3	3	1	1	0	0

FIGURE 4.7: Recovery percentage

The above figure 4.7 shows the graphical representation of recovery percentage.

4.6 Discussion

The study objectives to determine the effectiveness of low-level laser treatment in curing patients' pain in various body parts. This study also aims the analgesic efficiency of LLLT various body components in patients. Strong basic science data and a lengthy history to the use of low light therapy in the treatment of pain. An elderly can handle it without experiencing many negative effects. Whether in soft tissue or bone, structural deficiencies or instabilities cannot be resolved by a laser or LED. Additionally, individuals with neuropathic pain and neurologic impairments should only use LLLT as a complementary therapy for pain management. Similar to all medical management successful outcomes depend on strong clinical abilities coupled with knowledge of the type of harm, swelling, healing, discomfort, and how laser and LED effects work [84] to [88].

In this study, 60 samples of patients were collected and analyzed by using low-level laser therapy was used.60 patients I have considered has been to evaluated and determine the health and disease status. I have divided all these patients into three categories based on their pain like mild, moderate and severe. There are various types of pain, ranging from 0 to 10. Pain levels range from zero (no pain) to one to three (mild pain), four to seven (moderate pain), and eight and higher (severe pain). We have treated all of them according to standard operating procedure. In low level laser therapy two types of light used red and infrared. Red light seen by necked eyes while infrared light not seen. In first two sessions red light was used these sessions are the warm up sessions for body after second session red and infrared both lights were used. The patients whose color is fair, they absorb more light, and maybe their pain will increase while those whose skin color is normal will heal soon. Those patients who had mild pain or moderate pain they have recovered soon from the disease were acute while severe pain and chronic disease patients were time taken [89].

The International Association for the Study of Pain claims, pain is "a painful sensory and emotional experience related to existing or potential tissue damage, or defined in terms of such harm." [90]. In 1968 Mester et al introduced for the

first time low-level laser therapy by exposing a biological system to light, LLLT decreases inflammation, encourages tissue regeneration, and eases discomfort. In contrast to other medical laser techniques that use an ablative or heat process, LLLT uses a reaction of photochemical indicating that light is absorbed and a chemical change occurs as a result. Low light laser therapy is a pain-free, non -toxic and non-invasive, non-surgical therapy. It is FDA-approved. It's easy to apply. The effects of phototherapy are understood to be time-dependent [91] to [96]. Its Cure rate is greater than 95%. But it is the most expensive and time is taken to process for the relief of pain. The study was published on 15 December 2015, Pain in the lower back and neck that lasts longer than a month is known as NSCLBP. NSCLBP is a complicated, multifaceted disorder that may or may not impair the patient's range of motion (ROM). It suggests that LLLT is an effective treatment for people with NSCLBP and low back pain. However, the currently a lack of evidence that it is effective in enhancing functioning results [97] [98].

Chapter 5

Conclusions and Recommendations

5.1 Study Outcome

Laser is a device that amplifying light via optical, which is based on the principles of electromagnetic radiation stimulated emission, to produce light. A system of light-based therapy is called Bioflex Laser therapy.

Dr. Fred Kahn MD, a medical professional located in Canada, created the light-based treatment technique known as Bioflex Laser Therapy. Dr. Khan is a vascular surgeon with extensive expertise and outstanding talent who decided to research lasers after personally benefiting from them. For more than 30 years, he has been a pioneer and leader in the field of laser therapy. He is the creator of the Bioflex Laser Therapy system, which was created by physicians for clinicians. With the help of Super Luminous Diodes (SLD) and Laser Diodes, the Bioflex Laser Therapy system emits light at therapeutic wavelengths for the delivery of studied treatment applications. The Bioflex system is made up of huge, flexible SLD arrays that transmit red and infrared light in succession over a vast surface area and laser diodes that deliver targeted light aimed at particular areas of tissue damage, including muscles, tendons, or joints.

The Bioflex laser therapy system produces light in therapeutic wavelengths using both Super Luminous Diodes (SLD) and Laser Diodes to deliver studied treatment applications. The Bioflex system is made up of huge, flexible SLD arrays that progressively emit red and infrared light over a sizable surface area and laser diodes that emit concentrated light directed to certain tissue injury sites, such as muscles, tendons, or joints. There are more and more comprehensive research investigations being conducted on the impact of low-energy laser irradiation on biological function. Although many tests demonstrate pain relief, the caliber of the studies, the sample size, and the variety of procedures frequently prevent statistical validation. In summary, the result of this study indicates that low light laser therapy give a significant role in which patient who had mild or moderate type of disease with acute condition give good result Patient felt improvement after on third or on forth session. Age, color and body fat play important role.

Result of low-level laser therapy are time taken. Some patient did not feel better and they skip their sessions. But those patients who took proper session with their passion they get good results.

5.2 Recommendation

The study is conducted to determine whether low-level laser treatment is effective for healing of body aches. The calculated results provided the comparative effectiveness of low power laser therapy. I have found in the application that the given treatment is better than routine medications because of no or minimum side effects on the patient health.

- Moreover no doubt it is a kind of expense therapy but if we discriminate the benefit of this kind of treatment than maximum patient will try to adopt this type of treatment.
- And definitely the prices of treatment goes down which would be a good sign of better treatment.

5.3 Future Perspective

Future Market Insights estimates that the global LLLT market will increase at a CAGR of 4.4% from $104.0 million in 2020 to $165.4 million in 2031. Drivers include the rising incidence of chronic diseases, the surge in demand for noninvasive devices to manage chronic pain, technological advancements, and a rising sense of optimism about obtaining quicker regulatory approvals for novel goods. The use of laser therapy to relieve pain appears to have a bright future. According to athlete testimonials, laser therapy is ideal for treating sports injuries since it is quick, efficient, noninvasive, and free of the side effects associated with conventional drug-based therapies.

Low-intensity laser therapy is a non-invasive, non-surgical, and painless procedure. It has no or minimum side effects. Additional clinical trials, in our opinion, are required for the awareness of laser its advantage for patient cure.

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