Deanship of Graduate Studies

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Efficacy of Quadriceps and Gluteal Strengthening, Self-Management Education, Low-Intensity Laser Therapy Versus Education and Laser Therapy Alone on Knee Osteoarthritis Progression

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Dedication

After thanking God for His blessings and success in completing the research paper and writing it, I dedicate this achievement to the pure soul of my dear father, praying for God's mercy upon him, and to the soul of my beloved little sister, may God forgive her kind soul. I dedicate my success as a gift to my beloved mother and my dear siblings. I also grant the fruits of my labor as a gift to my work and my organization, represented by its leaders, my colleagues, and my dear team. And I mustn't forget my dear patients who participated in the research.

Finally, I give the greatest credit and dedication to my esteemed doctor and research supervisor. In addition to all the respected doctors and teaching staff.

Researcher: Wafa Salah Natsheh

Declaration

I certify that this thesis, submitted for the degree of master, is the result of my own research, except where otherwise acknowledge, and that this thesis (or any part of the same material) has not been submitted for a higher degree to any other university or institution.

Signed: 

Wafa Salah Natsheh

Date: 01.12.2025

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I appreciate God for giving me the strength and dignity to finish my scientific studies. I am grateful to my dear father and pray that God will have mercy on him. I want to thank my estimated mother for her unwavering dedication during my academic pursuits. I express my love and gratitude to my siblings for their steadfast support. I express my sincere gratitude to my respected professor, Dr. Hadeel Halawa, for her persistent and careful supervision and support during my research. And the rest of my doctors for doing their best with me. Besides, I extend my thanks to the Hebron Rehabilitation Society, represented by its president, Dr. Samih Al-Dweik, for enabling me to conduct the research application throughout my treatment period at the institution.

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Abstract

Background: Knee osteoarthritis (KOA) is a progressive degenerative disorder that reduces joint mobility and function. Although various therapeutic approaches exist, the combined effect of strengthening the quadriceps, gluteus maximus, and medius muscles in women with KOA has not been well established.

Objectives: to investigate the impact of strengthening these muscle groups on pain, strength, endurance, range of motion, and overall function in women with grade I–III KOA. A secondary aim was to determine whether low-intensity laser therapy (LILT) enhanced these outcomes.

Methods: A total of 37 women aged 45–65 with KOA were divided into an experimental Group (EG) (n = 18) and a Control Group (CG) (n = 19) for a three-month study. The EG received a structured strengthening program along with LILT and a self-management booklet (SMB), while the CG received LILT and SMB. Outcomes were measured using the Visual Analog Scale (VAS), WOMAC, hand-held dynamometry, 6-Minute Walk Test (6MWT), 30-Second Sit-to-Stand Test (30SCT), and goniometry.

Results: Participants ‘mean age of 52 ± 10 years. The EG showed statistically significant improvements compared with the CG in pain (VAS, p = .004), (6MWT, p = .004), and (30SCT, p = .002). Significant or moderate effect sizes were also observed in muscle strength, including right quadriceps strength (p = 0.017), right gluteus maximus (Cohen’s d = 0.564), and left gluteus maximus (p = 0.025). Age stratification (≤55 vs. >55 years) revealed significant differences specifically in the 6MWT (p = .012) and 30SCT (p = 0.010). However, stratification by KOA severity (grades I–III) showed no significant differences (p > 0.05) in post-intervention pain, functional mobility, or muscle strength.

Conclusion: targeted strengthening of the quadriceps and hip extensors/abductors produces superior improvements in pain, strength, and endurance compared to LILT alone, although LILT still contributes to pain reduction and functional capacity.

Keywords: knee osteoarthritis, low intensity laser, strengthening exercise, self-management program.

List of abbreviations

KOA: knee osteoarthritis

ROM: range of motion

MP: muscle power

LLIT: Laser low intensity therapy

LLLT: laser low-level therapy

EX: experimental group

CG: control group

SCT: stand chair test

VAS: visual analog scale

BMI: body mass index

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Chapter one

1 Introduction

1.1 Background

Knee osteoarthritis (KOA) is a chronic progressive disease that is considered a major cause of disability in older adults. The estimated global prevalence for patients over 40 years is 22.9% (Cui et al., 2020), in another systematic review, the prevalence was 19%-43% for patient's ≥40 years (Culvenor et al., 2019). Moreover, KOA is responsible for four-fifths of the burden of osteoarthritis worldwide, and this result is likely to increase due to several factors. (Cui et al., 2020).

Knee osteoarthritis is classified as either primary (idiopathic)(Michael et al., 2010), the prevalence rate of this type of KOA increases with getting older, it is more common in females than males, and its severity increases more rapidly in patients who are obese. Or secondary, the main etiologies of it are post-knee injury, causing damage to the knee structure, like a meniscus tear or ligament sprain, which in turn weakens the joint (Michael et al., 2010) An important factor that is considered marginal is the imbalance and weakness of the bone and muscle structure (Felson, 2006) , varus and valgus malalignment of the knee is a clear example of this; it increases the risk of lateral and medial knee OA (Cerejo et al., 2002). There are additional factors that enhance the disease like heavy work that requires lifting, and long-standing periods.

KOA passes several pathophysiological structural changes, which may not be associated with symptoms and absence of pain in stage one(mild), with minor wear and tear and bone spur growths at the end of the knee joint(Favero et al., 2015). Symptomatic KOA starts in stage two (moderate) with synovitis, increasing in bone spur through the space between the bones, which can be diagnosed through X-rays of the knee, in addition to a proteolytic breakdown of the cartilage (Stoppiello et al., 2014). Knee joint pain, a feeling of discomfort, and stiffness particularly after a period of rest, arising in the morning are the patient's main complaints (Felson, 2006). Stage three (severe) is characterized by loss of cartilage integrity by erosion to the cartilage surface between bones, the collagen fragments are released into the synovial fluid, which progresses joint inflammation and causes serious dynamic pain through functional activities (e.g., walking, kneeling, squatting)(Stoppiello et al., 2014). Finally, Stage four is considered the very severe stage where the chondrocyte morphology of the articular surfaces of the medial and lateral tibial plateaus and femoral condyles were evaluated for the extent and severity of loss of surface with decreased synovial fluid that causes friction, severe static, and dynamic pain, chronic joint inflammation, and continuous joint stiffness (Stoppiello et al., 2014). Thus, these symptoms lead the patient to the stage of disability due to difficulty in functional movement and pain, especially walking, standing, and going up and down stairs (Culvenor et al., 2019).

There are different approaches to treating KOA, conservative approaches for the first three stages, and surgical approaches to knee arthroplasty for the fourth stage (Kon et al., 2012). The conservative approach involves pharmacological and non-pharmacological therapy, pharmacological therapies which include analgesic anti-inflammatory drugs, and minimally invasive procedures involving injections of various substances aiming to restore joint mobility and reduce friction, besides dietary supplements. However, it was found that medication must be monitored to avoid adverse effects when taken for a long time, in addition to the temporary local effect on symptoms only (Kon et al., 2012). Non-pharmacological therapies include variations of Methods of rehabilitation, different sports, strengthening exercises for improving muscle strength and knee range of motion (Rannou & Poiraudeau, 2010), self-management education programs as supportive methods (Gay et al., 2018), and electrotherapy such as ultrasound, electrical stimulation, and laser high and low intensity is a safe treatment to relieve pain and improve physical function in patients with knee osteoarthritis(Paolillo et al., 2018).

Laser low-intensity therapy (LLIT) is a device used by physiotherapists to treat several musculoskeletal conditions that produce monochromatic light without heat. The main goal of using low-intensity lasers in treatment is to supply direct bio-stimulation light energy to body cells. The absorption of this energy stimulates molecules and atoms of cells in the bone steam and accelerates the bone's repair process (Ebrahimi et al., 2012), increase the microcirculation on the area that radiated, and decrease pain(Hegedus et al., 2009)Consequently, LLIT decreases pain and improves microcirculation on the treated area in KOA (Hegedus et al., 2009).

Furthermore, self-management education helps patients with KOA take care of themselves by having a reference for activities, information, and precautions that must be considered, including various aspects of life, to prevent the patient's condition from deteriorating (Kao et al., 2016),(Uritani et al., 2021). Self-management education programs may include education on osteoarthritis, cognitive behavioral counseling, pain management education, learning to perform basic exercises, control body weight, and Lifestyle Modification.(Uritani et al., 2021).

Above all, there is strong evidence supporting the use of strengthening exercises in the rehabilitation regimen for patients with OA. There were improvements in strength, discomfort, function, and quality of life (QOL). The mix of joint-specific strengthening with general strength, flexibility, and functional exercises; the progression of the exercise program; and the amount of client self-reliance to sustain the program are all important components of the exercise program. There is not enough evidence that the type of strengthening (isometric, isotonic, or isokinetic) has any significant impact on program outcomes. However, evidence suggests that pain control may be the primary mechanism by which strengthening activity benefits patients with OA. Strengthening exercises alone have some effects on pain improvement (Pelland et al., 2004).

Consequently, it is found that quadriceps muscle strength is usually weaker in people with knee osteoarthritis than in healthy old adults, and quadriceps weakness is a risk factor for the onset and progression of knee OA. As a result, strengthening exercise programs increase quadriceps muscle strength and sensorimotor function, reduce neural inhibition, and improve clinical outcomes such as pain, physical function, and quality of life. Strong quadriceps are hypothesized to stabilize the knee against unwanted displacement forces and protect the knee from pathologic loadings, hence reducing structural damage during normal activities (DeVita et al., 2018). On the other hand, Hip muscle weakness has been seen in people with knee OA also, and it is believed to increase medial compartment strain on the knee joint. A recent study found substantial, high-quality evidence to promote hip muscle strengthening in the conservative therapy of people with knee osteoarthritis (OA). And recommended supporting hip muscle training in the conservative therapy of knee OA patients (Neelapala et al., 2020).

1.2 Problem Statement

Knee osteoarthritis is a chronic, progressive joint disease and a growing global health concern, driven by aging populations, obesity, and sedentary lifestyles. It causes pain, functional limitation, and disability, significantly affecting daily activities and psychological well-being, and disproportionately impacts women. Although conventional physical therapy approaches—such as quadriceps strengthening, electrotherapy, and thermal modalities—effectively relieve symptoms, they are largely knee-focused and may not adequately address the underlying biomechanical dysfunctions contributing to disease progression(Shao et al., 2024).

Physical exercise modulates inflammatory and oxidative processes within the joint, certainly strengthening and range-of-motion exercises reduce pain and improve function in individuals with KOA, even with moderate adherence. More broadly, there is growing evidence that expanding the scope of PT interventions to include strengthening exercises targeting other key muscle groups, such as the gluteus muscles, may offer superior outcomes. The gluteus muscles play a critical role in functional stability, particularly during activities such as walking and standing. When functioning synergistically with the quadriceps, strong gluteal muscles can help mitigate joint loading in the lower extremities, potentially reducing the risk of KOA progression (Tore et al., 2023) (Wilson et al., 2005).

Although quadriceps strengthening exercises are well-documented to reduce pain and disability in KOA patients (Roddy et al., 2005), a broader strengthening approach that incorporates other muscle groups, such as the gluteal, has been less explored. Previous studies have shown that strengthening exercise alone can improve pain and functional outcomes in osteoarthritis patients (Pelland et al., 2004).

However, there is a need for a structured exercise program that integrates targeted interventions for identifying optimal exercise type and dosage is a priority in KOA management. Evidence shows that combining hip and quadriceps strengthening is more effective than quadriceps exercises alone, with resistive hip exercises improving both patient-reported and functional outcomes. Reduced hip abduction strength is common in KOA, and greater strength in this direction is associated with fewer symptoms functional performance, and slower disease progression, sustainably and practically(Hislop et al., 2022).

This study aims to develop and evaluate a comprehensive strengthening exercise program that includes both quadriceps and gluteus muscles for KOA patients. By implementing approved evaluation tests, this research seeks to assess the program's efficacy in reducing pain, enhancing functional performance, and potentially slowing KOA progression. This approach represents a shift towards holistic, muscle-inclusive strategies in KOA management, addressing gaps in current PT protocols and improving patient outcomes.

1.3 Research justification

Knee osteoarthritis (KOA) is a prevalent and escalating health challenge globally, contributing to significant disability and burdening healthcare systems. Current medical and therapeutic solutions primarily address symptomatic relief rather than tackling the underlying biomechanical issues that contribute to disease progression. This gap underscores the need for innovative approaches that focus on prevention, improved functionality, and minimized progression to disability.

This study targets three key muscle groups—quadriceps, gluteus maximus, and gluteus Medius—because of their essential roles in both static and dynamic pelvic stability. Strengthening these muscles is hypothesized to redistribute loading forces away from the knee joint, thereby reducing mechanical stress and mitigating the progression of KOA. By minimizing the direct impact on the knee joint, this approach not only alleviates symptoms but also provides a preventive strategy to preserve joint integrity and function.

In addition to muscle strengthening, the study integrates low-intensity laser therapy (LILT), a modality with established efficacy in pain relief during both rest and movement. This combination of laser therapy and targeted strengthening exercises provides a dual approach to managing KOA, creating a broad scope for exploring synergistic therapeutic effects. Furthermore, incorporating patient self-management strategies, including adherence to clinical advice and lifestyle modifications, is expected to complement these interventions and enhance overall outcomes.

While KOA has been extensively studied in other parts of the world due to its significant impact on public health, there remains a lack of comprehensive research on this condition in Palestine. The increasing number of patients seeking physiotherapy for KOA in local clinics highlights the urgent need for evidence-based interventions tailored to this population. This study not only addresses this gap but also aims to establish a foundation for future research, providing valuable insights and outcomes that could improve KOA management in Palestine. By aligning clinical expertise with structured research, the study aspires to open new horizons for future studies and innovative treatment strategies in the region.

1.4 Research hypothesis

1. Strengthening exercises for the quadriceps, gluteus maximus, and gluteus medius have a significant effect on decreasing pain and improving functional activity, with KOA female patients aged from 45 to 65 years
2. Strengthening exercises for quadriceps, gluteus maximus and medius, enhancing muscle strength and gait endurance. With KOA, female patients aged from 45 to 65 years.
3. Strengthening exercises for quadriceps, gluteus maximus, and medius, increasing knee range of motion (ROM) in female patients with KOA
4. Laser low-intensity influences reducing pain and improving physical function in female patients with KOA.
5. Younger females aged 45 to 55 will progress significantly on the outcome assessment compared to older females aged 56 to 65.

1.5 Research questions

1. In females with KOA aged from 45 to 65 years, does strengthening the quadriceps, gluteus maximus, and medius affect pain and functional activity?
2. What is the effect of strengthening quadriceps, gluteus maximus, and medius on muscle strength and gait endurance in females with KOA aged from 45 to 65 years?
3. Does strengthening the quadriceps, gluteus maximus, and medius affect KROM in females with KOA aged from 45 to 65 years?
4. Does low-intensity laser therapy reduce pain and improve physical function in female patients with knee osteoarthritis?"
5. Is there a significant difference in outcome assessment progress between younger females aged 45 to 55 and older females aged 56 to 65?

1.6 Research Objectives

1. To investigate that if muscle-strengthening exercises for the quadriceps, gluteus maximus, and Medius muscles in patients with knee osteoarthritis grades one to three affect pain and functional activity in female patients from 45 to 65 years.

2. To assess the efficacy of muscle strengthening exercises for the quadriceps, gluteus maximus, and medius muscles on muscle strength and gait endurance, in female patients with KOA grade one to three aged from 45 to 65 years.

3. To evaluate the effect of strengthening exercises for quadriceps, gluteus maximus, and medius on range of motion, gait, in female patients from 45to 65 years with KOA grades from one to three,

4. To assess the mediating effect of low-intensity laser on female patients with KOA in terms of pain, physical function, ROM, muscle strength, endurance, and gait.

5. To compare the difference in progression in outcome measurement between females aged 45 to 55 and females aged 56 to 65.

1.7 Terminology

* Chondrocytes: are the cells responsible for cartilage synthesis. They are critical for the process of endochondral ossification.

* Extracellular matrix: A network of proteins and other molecules that surround, support, and provide structure to cells and tissues in the body, and play a crucial role in cell proliferation.

* Proteoglycans are extracellular matrix components that engage in adhesion, growth, receptor binding, migration, barrier development, and interaction with other extracellular matrix molecules.

* Glycosaminoglycans: Are polysaccharide molecules that give additional physical properties to the extracellular matrix, such as hydration and support, and are a vital aspect of the body's connective tissues.

*Matrix metalloproteinases: A broad family of zinc-containing metallopeptidases that degrade biological mediators and promote cell motility.

Chapter Two

2 Literature Review

2.1 Theoretical studies

2.1.1 Knee Joint Anatomy and Physiology:

The knee is a modified hinge joint that allows a broad range of movements. Its primary actions include flexion and extension in the sagittal plane, along with varus and valgus rotations in the frontal plane. Additionally, the knee permits medial rotation during flexion and lateral rotation during terminal extension in the transverse plane. This joint ensures stability and control under diverse loading conditions. It consists of two bony articulations: the femur-tibia joint, which bears most of the body's weight, and the patella-femur joint, which enables smooth force transfer from the quadriceps femoris muscle (Abulhasan & Grey, 2017).

The knee joint's articular surfaces are defined by medial and lateral femoral condyles and tibial plateaus, which are crucial for stability under load. Hyaline cartilage covers these surfaces, allowing smooth movement and effective load distribution. The Chondrocytes, the primary cartilage cells, synthesize and maintain the extracellular matrix, mainly consisting of type II collagen and aggrecan, a proteoglycan that binds glycosaminoglycans. Disruption of the balance in cartilage composition and structure can impair its tensile strength and load absorption capacity, leading to biomechanical and biochemical alterations (Vaienti et al., 2017).

Menisci are fibro-cartilaginous structures, located between the femoral condyles and tibial plateaus. Distribute loads evenly, reduce joint stress, enhance joint congruity, and facilitate synovial fluid diffusion across articular surfaces. The knee's cruciate ligaments stabilize the joint by preventing tibial Antero-posterior translation, playing a key proprioceptive role, and resisting varus-valgus deviations and internal rotation, particularly between 10° and 30° of flexion. The medial collateral ligament (MCL) is a complex structure consisting of two layers (superficial and deep), its primary function is to resist valgus stress on the knee, while the lateral collateral ligament (LCL) resists varus stress and excessive internal knee rotation (Abulhasan & Grey, 2017).

The knee's musculature comprises anterior and posterior muscles, with the quadriceps group primarily extending the knee. The hamstring group flexes the knee, while the gastrocnemius and plantaris muscles contribute to flexion. The sartorius and gracilis assist in knee flexion, while the semitendinosus acts as a medial rotator. The iliotibial band, tensor fasciae latae, and popliteus stabilize and flex the knee, with the biceps femoris and semimembranosus contributing to rotation. The knee's musculature serves both mobility and stability (Abulhasan & Grey, 2017).

2.1.2 Muscle Function

The quadriceps femoris, comprising the rectus femoris, vastus lateralis, vastus medialis, and vastus intermedius, primarily facilitates knee extension, which is crucial for activities like walking, going up and down stairs, bending, and squatting. Its role in daily living activities, performance, and injury prevention involves strength, endurance, neuromuscular control, and force generation during explosive lower-limb movements. Strong quadriceps play a critical role in managing musculoskeletal conditions, including ACL reconstruction, patellofemoral pain, knee osteoarthritis, and resistance training programs(Ahsan & Alzahrani, n.d.)

The gluteal region, located at the back of the pelvis, plays a vital role in human movement and stability. It houses key muscles—gluteus maximus, Medius, and minimus—and serves as a passage for essential neurovascular structures to the lower limb. The gluteus maximus, being the largest and most superficial muscle, is significant in surgical access to the hip joint(Elzanie & Borger, 2023).The gluteus maximus is a major hip extensor and an important hip external rotator (rotating leg outward) and hip abductor (moving leg away from the body). Since the gluteus maximus is a key muscle for controlling knee valgus, it follows that the stronger and more functional the glutes are, the less inward rotation they can prevent (Contreras & Cordoza, 2019).

The gluteus Medius is a key pelvis stabilizer that maintains frontal plane alignment during walking and functional activities, besides helping to prevent excessive knee valgus during weight-bearing activities(Frigotto et al., 2019). When the gluteus Medius becomes Weak and dysfunctional, it allows the thigh to rotate and pull inward abnormally, causing what is called a "collapsing kinetic chain."This abnormal position of the thigh can put excessive stress and strain around the knee joint and kneecap, which increases lower extremity injuries and gait abnormalities, such as Trendelenburg gait, iliotibial band syndrome, patellofemoral pain syndrome, and ACL injuries. (Daniel et al., 2017). Another study shows that hip abduction strengthening exercises are commonly used in lower extremity rehabilitation programs due to their functional impact on daily activities and potential benefits for hip injuries and knee problems. Strengthening the hip abductor muscles is a crucial strategy for people with knee osteoarthritis (Lubahn et al., 2011).

Biomechanically, the lower extremity functions as an integrated kinetic chain, where the pelvis, hip, and knee influence each other during weight-bearing activities. Pelvic orientation affects hip mechanics by altering muscle length and leverage, while hip strength and control influence knee alignment. Poor hip control can contribute to inward knee collapse, also known as dynamic knee valgus (DKV), which increases stress on knee structures. Conversely, hip stiffness may transfer excessive rotation to the knee. Conversely, abnormal knee mechanics can alter pelvic posture to maintain balance, highlighting the interdependent nature of lower-limb biomechanics(Jamaludin et al., 2024).

Dynamic knee valgus, characterized by femoral adduction and internal rotation, tibial external rotation, knee abduction, and ankle eversion, is associated with non-contact knee injuries such as ACL tears, PFP, and patellar dislocation, especially in females during cutting and pivoting tasks; hip strength is therefore critical for controlling DKV and mitigating injury risk. Patellofemoral pain is abnormal knee mechanics common in women, traditionally linked to quadriceps weakness, recent evidence emphasizes proximal factors, including hip muscle function and movement patterns. Gluteal weakness altered hip mechanics, and DKV have been associated with PFP, suggesting a biomechanical contribution to patellofemoral joint loading. Hip-strengthening interventions improve pain and function (dos Anjos Rabelo & Lucareli, 2018). Moreover, abnormal stress distribution and lower-limb malalignment also contribute to knee osteoarthritis. Patellar maltracking disrupts load distribution, promoting pain and joint degeneration. Optimal patellar alignment and morphology are closely linked to knee kinematics and kinetics and may support biomechanical function and inform KOA management(Y. Wang et al., 2024).

2.1.3 Knee osteoarthritis

Knee osteoarthritis, commonly known as degenerative joint disease of the knee, is primarily caused by wear and tear and progressive loss of articular cartilage, osteophyte production, subchondral sclerosis, and a variety of biochemical and morphological alterations in the synovium and articular cavity The incidence of OA is continuously growing due to population aging, improper diets, altered lifestyles, and increased obesity (Wang et al., 2022).

There are two forms of knee osteoarthritis: primary and secondary. Primary osteoarthritis is defined as articular deterioration with no evident underlying cause. Secondary osteoarthritis is caused by an excessive concentration of force across the joint, such as post-traumatic reasons, or defective articular cartilage. Osteoarthritis is a degenerative illness that can eventually lead to disability (Hsu & Siwiec, 2024). Mechanical damage, hereditary factors, and aging can all trigger pathophysiological mechanisms contributing to OA. Initially, a hypertrophic healing phase may occur, softening the articular cartilage (Favero et al., 2015).

Articular cartilage, composed of type II collagen, proteoglycans, chondrocytes, and water, maintains equilibrium to prevent cartilage deterioration. In osteoarthritis, matrix metalloproteases (MMPs) are overexpressed, disrupting the balance and causing collagen and proteoglycan loss. Chondrocytes release tissue inhibitors of MMPs (TIMPs) to enhance proteoglycan production, but this is insufficient, leading to a decrease in proteoglycans, increased water content, and disordered collagen pattern, ultimately leading to cartilage loss(Hsu & Siwiec, 2024).

The Osteoarthritis Research Society International (OARSI) scoring method classifies early OA as having a grade of 1-3 based on the extent of degradation in the articular cartilage. Grade 1 is distinguished by articular cartilage swelling, but minor fibrillation in the superficial zone may also occur. In grade 2 cartilage surface loss occurs, fissures deepen, and chondrocytes cluster. In grade 3vertical cracks have expanded into the middle zone, causing chondrons to develop. Changes in early OA only influence the cartilage's superficial and intermediate zones (Favero et al., 2015).

2.1.4 Knee osteoarthritis management

Several methods and protocols have been proposed in the literature to reduce pain and improve independent daily living activities, including pharmacological and non-pharmacological treatment, physiotherapy techniques, physical therapeutic exercise, and knee arthroplasty (Selten et al., 2017).

Knee OA is a common condition affecting the knee joint, often affecting mobility; The first-line treatments for this condition include education, self-management, exercise, weight loss for overweight or obese patients, and OA rehabilitation. These strategies have been proven to decrease pain and improve joint function. Adjunct therapies, such as thermal modalities, laser therapy, therapeutic ultrasound, and manual therapy techniques are often used to complement core knee OA treatments to maximize patient outcomes. These therapies aim to improve joint function and mobility (Dantas et al., 2021).

2.1.5 Role of Physiotherapy in KOA

Physical therapy is the most generally recommended nonpharmacological and nonsurgical treatment for osteoarthritis. Physical therapy for OA aims to alleviate pain, enhance joint function, and advance the patient's physical condition, allowing the patient to move freely in daily activities. Physical therapy for OA mostly consists of aerobic and neuromuscular strengthening exercises. Other beneficial physical therapies, such as low-intensity laser, and pulsed ultrasound treatment, can alleviate pain and enhance joint function. Notably, in most cases, a combination of physical therapy modalities is required for optimal therapeutic efficacy (Wang et al., 2022).

The physiological impacts and medical applications of laser low-intensity treatment as described in previous research have shown that laser low intensity promotes fibroblast and osteoblast proliferation, collagen formation, and bone regeneration. In addition, LLI increases alkaline phosphatase activity and calcium levels. Furthermore, Pathological changes can cause diminished circulation in joint vessels, cartilage, and bone metabolism. According to this evidence, results indicate that LLI decreases pain in KOA and increases microcirculation in the affected area (Hegedus et al., 2009).

Evidence suggests that increasing knee extensor strength reduces the chance of developing symptomatic knee OA in women. Stability at the knee joint necessitates internal forces large enough to offset external pressures operating on the knee. The quadriceps muscle absorbs loads and maintains dynamic stability. Weakness in the quadriceps can affect local contact stress in a way that harms articular cartilage; it may also result in greater impulse loading, which has been linked to knee pain and may predispose to knee arthritis. Proprioception, which includes joint position perception, helps to maintain dynamic knee joint stability by synchronizing the quadriceps, hamstrings, and other muscles (Aaboe et al., 2014).

Hip extensors, particularly the gluteus maximus, are vital for many functional activities of everyday life, such as transitioning from sitting to standing, ascending stairs, and keeping an upright posture while walking. Because the muscle fibers, particularly the deep sacral fibers of the gluteus maximus, are perpendicular to the sacroiliac joint, gluteus maximus contraction increases sacroiliac joint stability. During ambulation, it contributes to forced transfer from the lower extremity to the pelvis. There is evidence that skill training and helping individuals understand better biomechanics during movement, i.e., during gait in addition to strength training, improves gluteus maximus activation and leads to developing a biomechanics strategy to reduce loading of the knee joint(Barton et al., 2013).

Moreover, hip abductor muscle strength is crucial for reducing knee adduction moments by counteracting pelvic drop in the contralateral swing limb during the single-limb stance phase of gait. A pelvic drop intensifies forces on the medial compartment of the stance limb's knee, contributing to joint stress. Theoretically, greater hip abduction strength reduces knee adduction moments, potentially lowering pain and improving function in knee osteoarthritis patients. This highlights the importance of hip abductor strengthening in managing OA symptoms and enhancing joint stability(Yuenyongviwat et al., 2020).

2.2 Similar studies

Numerous studies in the literature examine various strengthening training programs in a variety of settings. The first study was a randomized controlled trial (RCT) that assessed the efficacy of two parallel home exercise programs that included several (stretching and strengthening) exercises for the hip and knee muscles in the intervention group. And there were 52 individuals, with 28 in the intervention group and 24 in the control group. The study lasted for four weeks. The study's findings demonstrated a substantial effect in the multiple exercise group in terms of joint flexibility and muscle strength (Suzuki et al., 2019).

The second RCT attempts to determine if quadriceps in combination with hip abductor training improves function and reduces pain in KOA patients more than quadriceps alone. 80 subjects were divided into two groups: group one trained the hip abductor and quadriceps, whereas group two trained simply the quadriceps. After 6 weeks, the study found that Group 1 improved more in balance and flexibility than Group 2 (Xie et al., 2018).

The third study is a blind randomized trial with 128 people over 50 years old, medial KOA, and a BMI of ≥30 kg/m2. The intervention consisted of 12 weeks of non-weight-bearing (NWB) quadriceps strengthening at home versus weight-bearing (WB) functional activity. There was no change in pain or function between the two groups after the intervention; however, the WB exercise group improved their quality of life more (Bennell et al., 2020)

The fourth study is a randomized controlled trial. The purpose of this study was to compare the effectiveness of neuromuscular exercise to pharmacological treatments (analgesic and anti-inflammatory medicines) in the daily lives of patients with early KOA for long-term treatment. After 12 months of follow-up, no improvement in daily life activities was seen. However, the neuromuscular exercise group alleviated knee problems more significantly, with half of the patients reporting clinically relevant improvements. The study concluded that neuromuscular training could be a better long-term therapy option for reducing symptoms such as edema, stiffness, and mechanical problems. On the other hand, it prevents the adverse effects of medications (Holsgaard-Larsen et al., 2018).

The fifth study is a randomized clinical trial with 377 KOA subjects divided randomly into three groups, all of whom are over 50 years old and have a BMI ranging from 20 to 25. Group One: intensity training with 127 individuals; Group Two: low-intensity training with 126 participants; and Group Three: control with 127 participants. The study's findings did not support the effectiveness of high-intensity training over low-intensity or control in people with KOA, with no significant reduction in pain or knee function force at 18 months of intervention (Messier et al., 2021).

Regarding the laser low-intensity effects on knee OA study, there are several studies explaining this effect. This study aimed to explore the pain-relieving effects of LLLT and potential microcirculatory changes in patients with knee osteoarthritis (KOA). Patients were randomly assigned to either LLLT or a placebo LLLT. Treatments were administered twice weekly for four weeks using a diode laser in skin contact. The placebo control group received an ineffectual probe. Thermography was performed before, during, and after therapy, and joint flexion, circumference, and pressure sensitivity were also assessed. The study found that LLLT significantly improved pain pressure sensitivity and flexion in the irradiated area with the intervention group, while the placebo group did not show significant changes. Thermographic measurements showed a 0.5°C increase in temperature, indicating improved circulation. However, no significant changes occurred in the placebo group (Hegedus et al., 2009).

In another similar study, this RCT study aims to investigate the impact of low-level laser therapy (LLLT) and static stretching exercises on pain, quality of life, function, mobility, knee range of motion (KROM), and hamstring shortening in knee OA patients aged 50-75. The trial will involve 145 participants in five groups, group one (LLLT+stretching exercise), Group 2 (LLLT placepo+stratch), group 3(stretching exercise), Group 4(LLLT), group 5 control group with a treatment frequency of three sessions per week for all active groups. Although exercise therapy is a beneficial treatment for knee osteoarthritis patients, it is unclear which exercise methods are most suited to this population. LLLT has been utilized to enhance the effectiveness of physical therapy (Ferreira de Meneses et al., 2015).

The goal of this review was to look into the effectiveness of LLLT plus Exercise Therapy (ET) on pain, range of motion, strength of muscles, and performance in KOA right away following therapy, and see if the benefit of LLLT plus ET could be maintained during follow-up (4 - 32 weeks). The results suggest that LLLT combined with ET might be used to relieve pain in the KOA. LLLT decreases pain at 4-8J with a wavelength of 640-905nm per point when used for 10-16 sessions at a frequency of twice a week. An exercise therapy program with a specified dosage that targets the main muscle groups may be beneficial. However, LLLT + ET is no more effective than a placebo in improving ROM, muscle strength, and function in KOA (Malik et al., 2023).

In addition, a study concentrating only on patients with OA in the same joints is required to explain the impact of self-management programs, as persons with knee OA face physical and psychological challenges that are distinct from those experienced by those with other arthritic conditions. Furthermore, past research has found a diverse range of delivery techniques for self-management education packages. This systematic review aimed to assess the effectiveness of group-based and face-to-face self-management education programs delivered by health professionals that focused solely on self-efficacy for knee OA. The total score on the Arthritis Self-Efficacy Scale was also determined. Some studies have found that group-based and face-to-face self-management education programs improve self-efficacy for pain and symptom management and self-regulation in knee osteoarthritis. However, the included research yielded inconsistent outcomes (Uritani et al., 2021).

Another study evaluates the effectiveness of self-management for knee osteoarthritis using a meta-analysis of 13 randomized controlled trials (RCTs). The main outcomes included pain, knee function, stiffness, WOMAC (total), physical function, arthritis self-efficacy (ASE-pain), arthritis self-efficacy (ASE-other symptoms), mental health, and quality of life. The meta-analysis showed differences in pain, knee function, stiffness, ASE-pain, ASE-other symptoms, mental health, and quality of life between self-management and control groups. Four outcomes were highly heterogeneous, with evidence of quality ranging from very low to moderate. The study concluded that self-management might improve pain, knee function, stiffness, ASE, mental health, and quality of life in patients with KOA, but had no significant effect on WOMAC (total) and physical function (Wu et al., 2022).

Chapter Three

3 Methods and procedure

3.1 Study design

Multicentric prospective randomized double-blinded study, with pre-, mid-, and post-tests. Using an experimental methodology is suitable for this study to compare the effectiveness of the applied interventions on female patients from 45 to 65 years radiographically diagnosed with KOA, unilateral or bilateral, degree one to three according to Kellgren-Lawrence (KL) classification system.

3.2 Study setting

Participating physiotherapy and orthopedic clinics are found within hospitals and rehabilitation institution in Hebron City, Palestine. The researcher obtained approval from the appropriate authorities to recruit patients who attended these clinics within the last six months the hospitals and institution are AL-Ahli Hospital, AL-Meezan Hospital, Red Crescent Hospital, and Hebron Rehabilitation Society. The selected sample of patients was referred for testing and therapeutic intervention for the study which included (pre-test, mid-test, post-test, and intervention programs) to Hebron Rehabilitation Society, where the researcher collaborated with her assistant colleagues to conduct the study.

3.3 Study sample

3.3.1 Sampling methods

Random sampling was conducted systematically through patient's x-ray, radiologist reports and doctors' referrals in the orthopedic and physical therapy clinics affiliated with hospitals and Hebron Rehabilitation Society, an initial sample of patients were recruited based on the diagnosed KOA, all patients have X-ray images taken within six months prior to enrollment, accompanied by a radiologist's report assessing the degree of KOA grade using the

Kellgren–Lawrence grading system. Degree of arthritis (first, second, and third degree) through radiologically diagnosed, age (from 45 to 65 years), and gender (female), all patients who met the inclusion criteria were contacted and invited to participate in the study. The patients who initially agreed to participate from all clinics met the inclusion criteria (n=41). The researcher's next step was dividing the participants into two groups randomly.

3.3.2 Sampling size

Following the collection of demographic and medical data, 41 female KOA patients who met the inclusion criteria. The sample was subsequently divided into two clusters: female patients aged 45–55 and female patients aged 56–65, then numbering the patients in each cluster separately on an Excel sheet and selecting the odd numbers from the two clusters to form the first group (experimental group) and the even numbers for the second group (control group).

The first group (n=21) received treatment (strengthening exercises, laser low intensity, self-management) and the second group (n=20) received LLI and self-management. Because no statistics are available on the prevalence of KOA in Palestine, the sample size could not be calculated based on population estimates. Therefore, similar studies on KOA management were reviewed to assess the appropriateness of the sample size, and several studies with comparable sample sizes were identified.

3.3.3 Inclusion criteria

- Subject with the radiological diagnosis of KOA grade one, two, or three according to Kellgren-Lawrence grading system.
- There is no medical contraindication to practicing strength and fitness exercises
- Subjects are female patients from 45 to 65 years old.
- Subject's body mass index (BMI) $\leq 30 kg/m^2$.

3.3.4 Exclusion criteria

- Subjects with major uncontrollable conditions, such as uncontrolled hypertension, post-stroke, cardiopulmonary, and cardiovascular disease at a serious level.
- Subjects who underwent total knee arthroplasty (TKA).

3.4 Data collection

3.4.1 Tools of data collection

- **Demographic information** from each participant, including age, address, weight, height, educational level, occupation, and marital status were gathered. In addition to medical history, lifestyle (sedentary, average, active, very active), number of family members, living floor, and the grade of KOA and its side, all this information was gathered from their medical records and subjective interviews with participants.

- **Body mass index (BMI):** a measure based on weight and height. It is calculated by dividing a person's weight in kilograms by their squared height in meter, this estimates a healthy body weight based on a person's height, rather than measuring body fat percentages (Bipembi et al., 2015).

- **A hand-held dynamometer (HHD**) from Muscle Meter Company Australia (MAT): is an instrument employed to evaluate isometric muscle strength (Garcia et al., 2021).The findings indicate that hand-held dynamometry can be a reliable assessment technique when performed by a single competent tester (Bohannon, 1986).

  Using a consistent methodology and patient instructions, this hand-held dynamometer demonstrated good relative and moderate absolute reliability, making it a feasible tool for study in the senior population (Buckinx et al., 2017).

  In contrast to traditional manual muscle testing (MMT), which utilizes a break test requiring the patient to exert maximum voluntary effort against an increasing counterforce used by the examiner to exceed or break the isometric force generated by the patient. HHD is preferred as it involves the patient exerting maximum voluntary effort against fixed resistances provided by the examiner. This assessment necessitates that the subject exerts maximum isometric force while the dynamometer remains stationary (Buckinx et al., 2017).

  Standardized Procedure for Isometric Muscle Strength Testing Using a Handheld Dynamometer. Before testing, the patient should be appropriately positioned and the dynamometer securely adjusted for each target muscle group:

  - Quadriceps: The patient is seated at the edge of the examination table with feet suspended, not touching the floor. The dynamometer is affixed to the mid-portion of the anterior lower leg.
  - Gluteus Maximus: The patient lies prone with the knee of the tested limb flexed to 90 degrees. The dynamometer is positioned at the midpoint of the posterior thigh.
  - Gluteus Medius: The patient assumes a side-lying position on the non-tested side. The dynamometer is placed at the mid-lateral aspect of the tested leg.
  - During testing, the examiner stabilizes the dynamometer while the participant exerts maximal voluntary isometric contraction against the device. The examiner provides resistance to match the participant's force and delivers standardized verbal encouragement, such as: *"Push as hard as possible"* and *"Push, push, push, push"*, to elicit maximal effort.
  - Each trial consists of a 3–4 second isometric hold. A total of 2–3 trials are conducted per muscle group. The peak force from each trial should be recorded, and both the average force and the highest individual value should be reported.

Measurements may be expressed in either kilograms or pounds(Contributors, n.d.).

- **Six-minute Walk test (6MWT):** The 6-minute walk is a reliable and valid measure of physical endurance in older adults, it is currently one of the preferred tests when administering a functional walk test in clinical or research settings (Enright, 2003). The test protocol stated that participants should walk for the entire 6 minutes of the test, but might take pauses if needed. Patients can use an assistive device during both walking tests if necessary. During the walking test, the total distance walked during the test is to be recorded (Chen et al., 2017). The test required participants to walk a 15-meter track back and forth within the exercise room for six minutes. The time was recorded using a stopwatch, the distance was calculated by recording the number of laps and then calculating the total distance.

- **The Western Ontario and McMaster Universities Arthritis Index (WOMAC):** WOMAC as an outcome assessment tool has been utilized in research for decades. It tests three domains (pain, stiffness, and function) for osteoarthritis patients mainly hip and knee osteoarthritis (Gandek, 2015). WOMAC is a valid and reliable instrument for assessing the severity of OA of the knee (Salaffi et al., 2003). Patients are asked to describe their pain, stiffness, or functional activities in the last 48 hours. There are five response options, ranging from 'none' to an extreme response of 'none' rated as zero, mild as one, 'moderate' as two, 'Severe' as three, and 'Extreme' as four. The pain, stiffness, and physical function subscale scores are obtained by adding the values from each area. The WOMAC is rated on a best-to-worst scale, with lower subscales suggesting less pain, stiffness, or better physical function. The entire WOMAC scores are summed across three domains: Pain (5 items, max 20), Stiffness (2 items, max 8), and Physical Function (17 items, max 68). The total raw score (max 96) is often normalized to a 0–100 scale. to facilitate interpretation and comparison with other studies. Higher scores indicate worse symptoms (0 = no symptoms) and are widely used in research to assess treatment effects in osteoarthritis (Ackerman, 2009).

- **A goniometer:** is a valid and reliable tool used to measure the range of motion in joint angle (Riddle et al., 1987). Evidence suggests that goniometric measurements of the knee joint are reliable and valid (Gogia et al., 1987). The measurement procedure was as follows:

  - **Knee Flexion (Bending):** With the patient prone, place the goniometer’s fulcrum at the lateral femoral condyle, align to greater trochanter the arms with the fibula align to the lateral malleolus, bend the knee fully, and record the degrees of flexion.
  - **Knee Extension (Straightening):** With the patient supine and the ankle supported, use the same goniometer alignment, straighten the knee fully, and record the angle of full extension result.

- **30-second chair stand test (CTS):** Also known as the 30-second sit-to-stand test was designed to assess mobility, functional lower extremity strength, and endurance in individuals (WIRIYATUMJAROEN & Chinkulprasert, 2023). Sit-to-stand (STS) power was linked to functional performance in both male and female patients with advanced knee OA. Moreover, CTS power should be measured in individuals with advanced knee OA(Jørgensen et al., 2024).The 30CTS is a valid and reliable, practical tool for use in a general elderly population with reduced levels of function(Jørgensen et al., 2024). Participants sit on an armless chair and repeatedly stood up and sat down without using their arms; the total repetitions completed in 30 seconds were recorded using a stopwatch.

- **A visual analog scale (VAS)** is a one-dimensional scale that measures the degree of pain. It is often used in clinical and epidemiological research to track how patients' pain changes over time and to quantify the intensity or frequency of different symptoms. The score is based on the distance (mm) on the 10-cm line between the "no pain" anchor and the patient's mark, which gives a score between 0 and 10. A higher score means that the pain is worse. The following cut points on the pain VAS have been suggested based on the pain distribution and VAS scores:(0) no pain, (1–4 mm) mild pain, moderate pain (4–7 mm), and severe pain (7–10 mm).VAS is a valid and reliable score for assessing pain progression(Begum & Hossain, 2019).

3.5 Study procedure

The researcher in collaboration with her colleagues at Hebron Rehabilitation Society applied the clinical program to the two groups for three months, two sessions per week, where the first group (the experimental group), firstly received a low-intensity laser to the affected knee, the second implement a training program focusing on strengthening training exercise for the quadriceps combined with gluteus maximus and gluteus Medius muscles and finally providing patients with self-management booklet that explains everything that a patient needs to take care of themselves.

The second group (control group) received the same self-management booklet and had the laser applied with the same parameters twice a week for three months.

There were three examination tests pre-test, a med test was applied after a month and a half of applying for the intervention programs, and a post-test was applied at the end of the program. At the end of the study, the results of all tests were compared between the experimental group and the control group, to measure the changes in pain, gait, muscle strength and endurance, and functional activities.

3.6 Suggested program

- Both research groups (the experimental group and control group) received low laser intensity with the same parameters**,** twice a week for three months**.**

Table 3.1: Laser low-intensity parameters in each session (Hegedus et al., 2009).

Wavelength	830 nm	80% wave
Power density	35mw/0,35mm2	in skin contact
Dose	9.00J/cm2	Time:1m for each point
Size of the point	1.00cm2	In the focus of the laser light
Frequency	10.0HZ	
The points that were irradiated	- Medial and lateral epicondyles of the Tibia and Fibula - Medial and lateral knee joint gap - Popliteal ditch	

➢ Both research groups received a Self-management booklet: which contained Self-management education programs on osteoarthritis of the knee in the following sections.

*Education: about osteoarthritis knee, its causes, how it occurs, how it progresses, and how it affects joints can better manage their expectations and take necessary action (Uritani et al., 2021)

*Cognitive behavioral counseling: teaching women how to reframe negative views about pain and disability can help them cope more effectively. Stress Management: Practices such as deep breathing or relaxation techniques help alleviate stress, but often aggravate pain perception (Wu et al., 2022)

*Pain management:

- Heat and Cold Therapy: Using heat or cold on the affected knee might help relieve pain and stiffness.
- Medications: Under physician supervision, nonsteroidal anti-inflammatory, analgesic, lotions, and gels can be used as part of a short-term pain treatment regimen(Coleman et al., 2012)

*Exercise is essential for managing osteoarthritis, improving joint health, and lowering stiffness. Encourage daily 20-minute walks on a straight road or treadmill at a slow speed. Quadriceps strengthening workouts can help stabilize and protect the knee joints (Chiu et al., 2012).

*Body weight control:

- Excess body weight puts additional strain on the knee joints, worsening the symptoms of arthritis. Focus on healthy weight control through diet. A balanced diet with anti-inflammatory foods including fruits, vegetables, whole grains, and omega-3 fatty acids from fish or flaxseeds can lower inflammation (Wu et al., 2022).

- Emphasize the value of portion control and mindful eating.
- Consult a healthcare provider about the potential advantages of nutritional supplements such as glucosamine (Wu et al., 2022).

*Lifestyle modification:

- Providing knowledge of daily activities that may need to be reduced, removed, or modified to avoid detrimental effects on the knee joint. Avoid high-impact activities that strain the knee joint (e.g., running or leaping) and instead incorporate more joint-friendly activities such as walking.
- Proper footwear: Wear shoes with strong arch support and shock absorption for less knee stress.
- Encourage house modifications, such as installing railings or employing assistive tools, to lessen the risk of falls (Yan et al., 2022).

  ❖ Note: The booklet prepared by the researcher is attached to Appendix 4

A meeting was held for the participants before the assessment and therapeutic intervention began. They were given the booklet, its contents were explained, and an educational seminar was conducted about KOA, and their questions were answered to ensure that everyone had sufficient information and a good understanding of how to implement the self-management program. Accordingly, to measure the extent of the participants' adherence to the self-management program. A calendar has been prepared by the researcher, including key points: first, pain management to determine their ability to manage their pain using prescribed medications, exercises, compresses, etc. Second, healthy nutrition to ensure an overall healthy lifestyle; and third, lifestyle modifications, such as wearing appropriate orthopedic shoes, avoiding lifting heavy objects, avoiding prolonged standing and excessive stair climbing, and ensuring she engages in short daily walks. The fourth point was positive guidance behavior, aimed at ensuring the participant's adaptation to her situation, her acceptance of it, and her ability to develop life plans that align with her physical capabilities. The fifth and final point was behaviors to avoid, summarized in ten points in the booklet. Further on, to assess commitment and adherence, a self-management weekly calendar was prepared by the researcher, and scores of the calendar were assigned: 0 = never committed, 1 = sometimes committed, 2 = often committed, and 3 = always committed. The maximum score for these five points is 5 x 3 = 15, which represents 100%. This score was used for all participants, and the total percentages were then divided by the total number of participants to arrive at an average commitment rate of 80% to the Self-Management Program.

❖ Note: the self-management weekly calendar is attached to Appendix 5

➢ Training program:

- The half-hour training program was organized twice a week over three months for the experimental group. It aimed primarily to strengthen the quadriceps, gluteus maximus, and Medius muscles. This was in addition to applying a low-intensity laser during the same treatment session.

- Training was separated into three types of exercises:

  - First, undertake five minutes of aerobic exercises to boost blood circulation, warm up, and improve muscle performance.

  - Second, 20-minute strengthening exercises that serve as the foundation of training and are aimed at improving muscle strength and endurance.

  - Finally, five minutes of stretching and breathing exercises to relax, with the goal of maintaining muscle health and increasing the range of motion in the knee joints.

The training pace was systematically increased, starting with strength exercises without any added external resistance for the first two weeks, at a rate of two sets for each exercise and 10 repetitions for each set, without using weights such as sand weights or resistance bands. Subsequently, there was a gradual increase in resistance relative to sand weight, starting from one kilogram until we reached three kilograms, with an increase in the number of sets to three and 10 repetitions per set. This was done approximately every two weeks until the end of the therapeutic intervention period.

Table 3.2: Aerobic exercises for the Experimental group.

Type	**Name**	**Duration**	**Rest**
First exercise	Walking: - forward and backward - steps right and left steps	5min, 5 rounds	20-seconds after two rounds
Second exercise	Dancing exercise (Zumba) with gentle and slow steps	5 minutes	20-seconds in the middle
Third exercise	Cycling (on a static bike)	5 minutes	20-second rest in the middle
Fourth exercise	Marsh in-place exercise	5 minutes	20-second rest in the middle

Table 3.3.A: Strengthening Exercises for the Experimental Group.

Type	Name	Duration	rest	progression
First exercise	Straight leg exercise	Starting with sets=2, repetition (rep)=10	20 Seconds(S) after each set	Endurance: increase the number of sets and reps Power: increase resistance by using a sand weight
Second	Clamshells exercise	Starting with sets=2, rep=10	20 S after each set	Endurance: increase the number of sets and rep Power: increase resistance by using a band
Third	Reverse flutter exercise	Starting with sets=2, rep=10	20 S after each set	Endurance: increase the number of sets and rep Power: increase resistance by using a sand weight

Table 3.3.B: Strengthening Exercises for the Experimental Group.

Type	Name	Duration	rest	progression
Fourth exercise	Squatting exercise	Starting with: sets=2, rep=5	20 S after each set	Starting with support by hands for holding part of body weight endurance: increase number of sets and rep. Power: decrease in the support level and increase the level of descent through exercise.
Fifth	Bridging and half-bridging exercises	Starting with: sets=2, rep=10	30 S after each set	Endurance: increase the number of sets and rep Power: Adding a band for resistance decreases the stability of the ground.
Sixth	Step-up exercises anterior lateral	Starting with: sets=2, rep=5, with support by hand holding a bar to shift weight	10 S rest after each set	Endurance: increase the number of sets and rep Power: increase the height of the step, decrease the level of assistance resistance using sand weight.
Seventh	Bird dog exercise	Sets=2, rep=10	Hold =5 S, rest=2 S	Endurance: increase the number of sets and rep Power: increase time of holding using sand weight and a band.
Eighth	Standing Single-leg Raise exercise	Sets=2, re=5	Hold= 5 S, rest=2 S	Grab something steady at first to prevent falling. Endurance: increase the number of sets and rep Power and stability: stand without support and increase hold time.

Table 3.4: Stretching exercise for the Experimental group.

Type	Name	Duration	Rest	Description
First exercise	Band-assisted quad stretch	Starting with sets=2, rep=5	5 S hold for each rep. Hold 2 S rest	Flexibility: increase range of motion and hold time, beside increase the number of sets and rep
Second	Lying hamstring stretch with band	Starting with sets=2, rep=5	5 S hold for each rep. Hold 2 S rest	Flexibility: increase range of motion and hold time, beside increase the number of sets and rep
Third	Adductor stretch lying	Starting with sets=2, rep=5	5 S hold for each rep. Hold 2 S rest	Flexibility: increase range of motion and hold time, besides increasing number of sets and rep
Fourth	Seated twist exercise	Starting with sets=2, rep=5	5 S hold for each rep. Hold 2 S rest	Flexibility: increase range of motion and hold time, besides an increased number of sets and rep
Fifth	Knee to chest exercise	Starting with sets=2, rep=5	5 S hold for each rep. Hold 2 S rest	Flexibility: increase range of motion and hold time, besides increasing number of sets and rep

Note: Appendix 2 contains exercise images that were applied in research.

3.7 Statistical analysis

Statistical analysis was performed using the Statistical Package for the Social Sciences (SPSS) package, version 23 (SPSS Inc., Chicago, IL). Data was analyzed using descriptive statistics and inferential statistics, including means and medians. Descriptive statistics were used to characterize the sample. Parametric (T-tests) and nonparametric tests (Mann-Whitney) and ANOVA were applied to measure the differences between groups in pre- med and post-tests in inferential statistics. Paired sample T test was applied to compare the difference between pre- and post-test in the same group. Statistical significance will be set at $P < 0.05$.

3.8 Ethical consideration

- Ethical approval was obtained from the institutional ethics committee at Al-Quds University (Appendix # 6, Ref. #:497/REC/2025).
- Approval was obtained from the administrations of hospitals and rehabilitation institutions, and the sample was selected from the clinics located there, in addition to permission to view patient files.
- The participants were informed about the study objectives and procedures, and the data were processed confidentially. Participants had the right to refuse participation or withdraw from the study at any time without any restrictions.

Chapter Four

4 Results and data analysis

4.1 Recruitment

As depicted in Figure 4.1, an initial assessment was conducted on a randomized sample of female patients diagnosed with knee osteoarthritis. The total sample comprised 48 women, of whom seven were excluded for failing to meet the predetermined inclusion criteria. The remaining 41 participants were allocated into two groups: Group 1 (experimental), which intervention was laser therapy in combination with therapeutic exercises (n = 21), and Group 2 (control), which intervention was laser therapy alone (n = 20).

4.2 Descriptive Statistics

Table 4.1 illustrates the distribution of demographic variables, specifically marital status, occupation, and lifestyle, presented as frequencies and percentages for each group. All participants were recruited from Hebron city and its surrounding suburbs. The findings reveal that the majority of women (89%) were married, nearly half (48.6%) reported an active lifestyle, and 43.2% were identified as housewives.

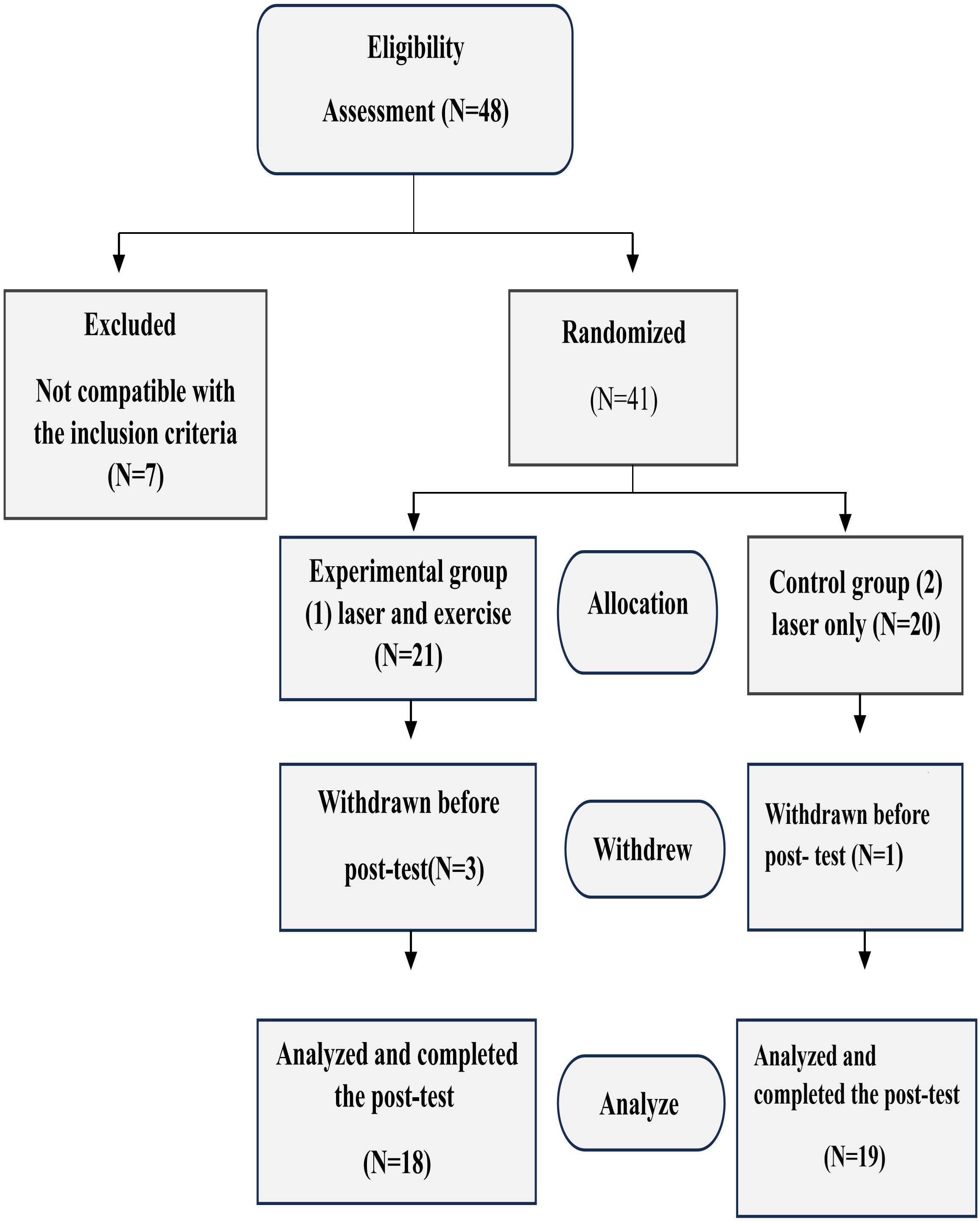

Figure 4.1: Recruitment of participants' flow chart.

Table 4.1: Demographic and clinical characteristics of the participants.

Variables	Categories	Experimental group (laser=exec) N=18		Control group (laser) N=19		Total N=37	
		N	(%)	N	(%)	N	(%)
Marital status	Married	17	94.4	16	84.2	33	89.2
	Widow	1	5.6	1	5.3	2	5.4
	Single	0	0	2	10.5	2	5.4
Life style	Average activity	8	44.4	8	41.9	16	43.3
	Active	9	50	9	47.5	18	48.6
	Very active	1	5.6	2	10.6	3	8.1
Occupation	Fulltime	4	22.2	5	26.3	9	24.3
	Part time	6	33.3	1	5.3	7	18.9
	Retired	3	16.7	2	10.5	5	13.5
	housewife	5	27.8	11	57.9	16	43.2

N = frequency, P%.

Figure 4.2 shows that housewives represented the largest proportion of participants (29.73% in the laser group), followed by part-time workers (16.22%) in the laser and exercise group, indicating that most women were not engaged in full-time employment.

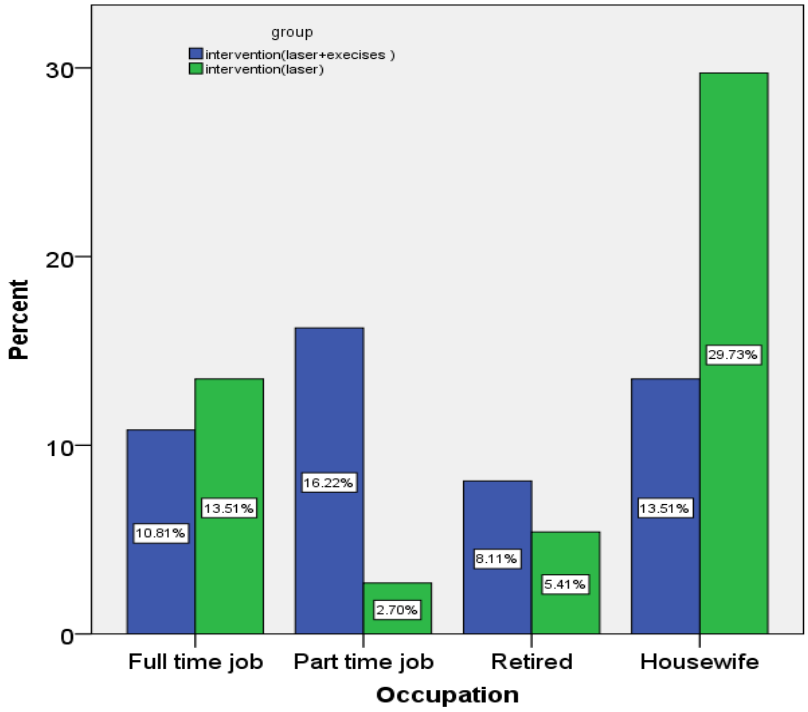

Figure 4.2: Percentage of participants' occupation.

Table 4.2 presents the distribution of participants based on the floor of residence and family members. The findings indicate that over 50% of the participants reside on the second floor, while 37% live on the first floor. Regarding family members, the majority of participants reported a family size ranging between two and five members, representing the highest average among the study sample.

Table 4.2: Distribution of participants according to living floor and number of family members.

Variable		Experimental (laser+execs) N=18		Control(laser) N=19		Total N=37	
		N	%	N	%	N	%
Living floor	1	9	50	5	26.3	14	37.8
	2	9	50	10	52.6	19	51.4
	3	***	***	3	15.8	3	8.1
	4	***	***	1	5.3	1	2.7
Family member	1	1	5.6	***	***	1	2.7
	2	5	27.8	2	10.5	7	18.9
	3	1	5.6	4	21.1	5	13.5
	4	2	11.1	3	15.8	5	13.5
	5	2	11.1	4	21.1	6	16.2
	6	5	27.8	2	10.5	7	18.9
	7	2	11.1	3	15.8	5	13.5
	8	****	****	1	5.3	1	2.7

Table 4.3 presents a summary of statistics for variables related to age, body mass index, and baseline pain assessment for participants in each group. The results, which include the mean, standard deviation, and p-value for these variables, showed no significant difference between the two groups at baseline. Notably, the participating age range was from 45 to 65 years, and the body mass index ranged from 20 to 32.

Table 4.3: Variable characteristics of the participants.

Variables	Experimental group (laser+exercise) N=18	Control group (laser) N=19	
	Mean ± S. D	Mean ± S. D	P .value
Age	54.05± 6.760	53.3 ± 5	0.706
Body mass index	28.2 ± 2.96	28.7 ± 3.6	0.645
Visual analog scale1	6.5 ± 1.4	6.4 ± 2	0.889

SD: standard deviation

The results presented in Table 4.4 demonstrate the distribution of OA severity among the participants. (23 out of 37) were classified as having moderate osteoarthritis (grade II), representing the largest proportion across both groups. This was followed by severe cases (grade III) with (9) participants, and mild cases (grade I) with (5) participants. Furthermore, the table indicates that all participants exhibited bilateral knee joint degeneration.

Table 4.4: Knee osteoarthritis grades of participants.

Variables	Categories	Experimental (laser +exec) N=18	Control (laser) N=19	Total N=37
osteoarthritis grade	mild	4	5	9
	moderate	11	12	23
	severe	3	2	5
Osteoarthritis sides	bilateral	18	19	37

N: number

Participants in both groups were classified with grade II knee osteoarthritis (32.43% in the experimental group and 29.73% in the control group), as illustrated in Figure 4.3.

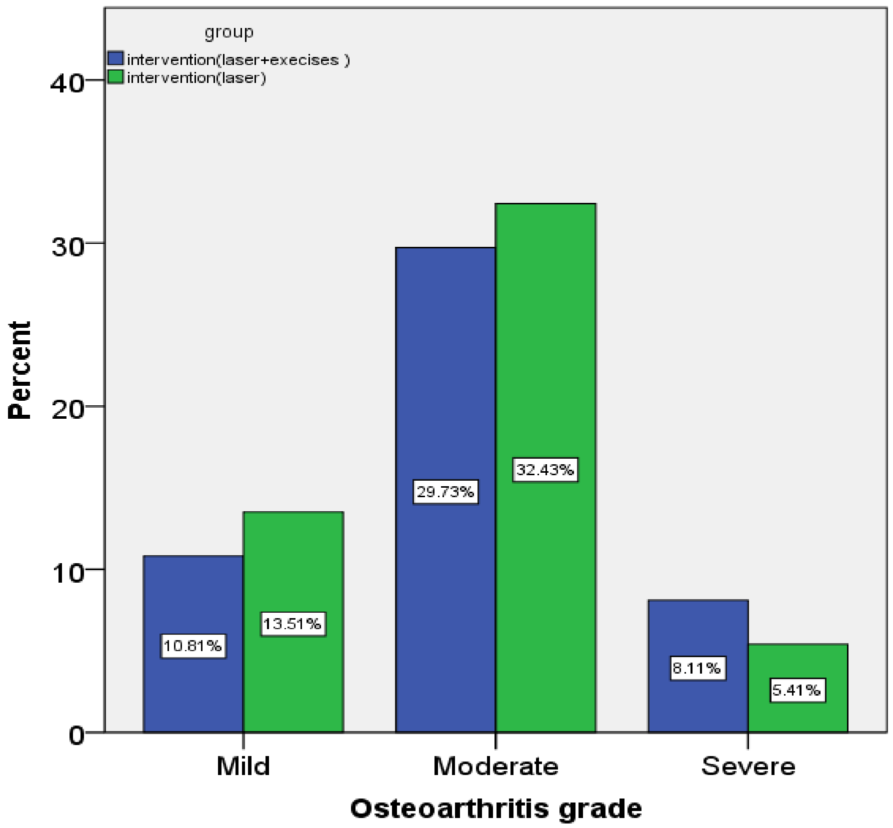

Figure 4.3: Percentage of participants distributed across osteoarthritis grades.

4.3 Descriptive Analysis for the Western Ontario and McMaster Universities Osteoarthritis Index

Descriptive analysis of WOMAC scores in Table 4.5 showed improvements in both groups across pain, stiffness, and physical function domains, with greater gains observed in the experimental group. By post-intervention, a higher proportion of participants in the laser + exercise group reported no or slight symptoms (e.g., 50% with no walking pain and 83.3% with no difficulty putting on socks). In contrast, the control group retained more cases of moderate to severe, particularly in stair climbing and heavy domestic duties. These findings indicate that combining laser therapy with exercise yielded more pronounced functional and symptomatic improvements than laser therapy alone.

Table 4.5.A: WOMAC descriptive analysis.

Womac categories		**Experimental group (laser+excs) (N=18)**					**Control group (laser) (N=19)**				
Pain		NO	S	M	V	E	NO	S	M	V	E
1. Walking	Pre	5	5	6	2	0	4	10	4	0	1
	Med	8	9	1	0	0	9	6	4	0	0
	post	9	7	2	0	0	7	8	4	0	0
2. Stair climbing	Pre	0	1	7	9	1	0	5	6	6	2
	med	0	8	8	1	1	2	5	10	2	0
	post	1	7	9	1	0	2	6	6	5	0
3. Nocturnal	pre	2	7	3	5	1	8	1	5	5	2
	Med	7	6	4	1	0	14	2	0	2	1
	post	9	5	4	0	0	13	3	3	0	0
4. Rest	Pre	4	5	8	1	0	6	9	2	2	0
	med	6	8	3	1	0	6	7	5	1	0
	post	12	4	2	0	0	9	6	3	1	0
5. Weight bearing	Pre	1	1	8	8	0	3	7	6	2	1
	Med	4	4	7	3	0	4	11	3	1	0
	post	2	11	4	1	0	4	6	6	2	1
Stiffness											
1. Morning stiffness	Pre	6	5	5	2	0	6	6	3	2	2
	Med	11	3	3	1	0	12	5	2	0	0
	Post	9	8	1	0	0	14	2	3	0	0
2. Stiffness occurring later in the day	Pre	5	3	7	1	2	2	4	5	8	0
	Med	6	7	4	1	0	2	13	1	3	0
	post	5	9	4	0	0	8	1	6	3	1

NO: none/ S: slight/M: moderate/V: very/E: extremely.

Table 4.5.B: WOMAC descriptive analysis.

Womac categories		Experimental group (laser+excs) (N=18)					Control group (laser) (N=19)				
Physical function											
1. Descending stairs	Pre	1	2	8	5	2	2	3	6	5	3
	Med	5	5	6	1	1	7	7	4	1	0
	Post	6	4	6	1	1	5	5	5	2	0
2. Ascending stairs	Pre	1	1	9	4	3	1	2	9	4	3
	Med	4	6	6	2	0	4	8	5	2	0
	Post	5	7	2	3	1	2	6	6	4	1
3. Rising from sitting	Pre	8	4	3	3	0	7	7	4	0	1
	Med	9	4	4	1	0	10	6	3	0	0
	Post	11	3	1	2	1	13	3	3	0	0
4. Standing	Pre	2	1	8	4	3	4	4	5	4	2
	Med	3	4	9	2	0	4	9	4	2	0
	post	4	6	5	3	0	5	4	8	1	1
5. Bending to floor	Pre	2	1	6	7	2	1	7	2	3	6
	Med	5	6	4	3	0	8	5	2	3	1
	post	6	4	7	1	0	3	5	6	3	2
6. Walking on a flat surface	Pre	6	5	7	0	0	10	8	0	0	1
	Med	15	2	1	0	0	18	1	0	0	0
	Post	14	4	0	0	0	14	3	2	0	0
7. Getting in/out of car	Pre	5	2	5	5	1	6	5	5	2	1
	Med	11	4	1	2	0	11	4	3	1	0
	Post	8	7	2	1	0	11	3	2	3	0
8. Going shopping	Pre	3	3	4	8	0	3	1	6	6	3
	Med	4	6	6	2	0	3	7	3	6	0
	Post	5	7	6	0	0	8	3	3	3	2
9. Putting on socks	Pre	10	4	2	1	1	7	5	4	2	1
	Med	14	4	0	0	0	12	5	2	0	0
	post	15	3	0	0	0	14	2	2	1	0
10. Lying in bed	Pre	8	6	2	2	0	6	9	4	0	0
	med	13	4	0	1	0	11	6	2	0	0
	post	14	3	1	0	0	14	3	1	1	0
11. Taking off socks	Pre	8	6	2	1	1	9	4	3	2	1
	Med	13	5	0	0	0	13	2	3	1	0
	Post	14	4	0	0	0	14	2	2	1	0
12. Rising from bed	Pre	8	6	2	2	0	7	6	4	1	1
	Med	12	3	2	1	0	14	2	3	0	0
	Post	15	1	2	0	0	14	3	2	0	0
13. Getting in/out of bath	Pre	5	7	4	1	1	6	7	3	2	1
	Med	8	7	3	0	0	12	3	4	0	0
	post	13	1	4	0	0	12	4	1	1	1

NO: none/ S: slight/M: moderate/V: very/E: extremely.

Table 4.5.C: WOMAC descriptive analysis.

Womac categories		Experimental group (laser+excs) (N=18)					Control group (laser) (N=19)				
Physical function											
14. Sitting	Pre	8	5	3	1	1	14	1	2	2	0
	Med	11	5	1	1	0	15	2	1	1	0
	Post	14	2	2	0	0	13	2	3	0	1
15. Getting on/off toilet	pre	6	3	5	2	2	9	7	0	3	0
	Med	11	3	3	1	0	15	2	1	1	0
	post	14	3	1	0	0	13	4	2	0	0
16. Heavy domestic duties	Pre	0	2	4	8	4	2	1	5	6	5
	med	1	0	8	9	0	1	3	8	6	1
	post	1	3	7	7	0	2	3	4	9	1
17. Light domestic duties	Pre	4	7	6	1	0	6	5	5	3	0
	med	8	7	3	0	0	8	9	2	0	0
	post	8	8	2	0	0	7	6	6	0	0

NO: none/ S: slight/M: moderate/V: very/E: extremely.

4.4 Normality test for data

According to (Shapiro-Wilk\ Kolmogorov-Smirnov) testing, the normality test results revealed that both the VAS and the WOMAC score significantly deviated from a normal distribution ($p < 0.05$). Conversely, the 6-minute walk test and the 30-second chair stand test met the assumption of normality as illustrated in Table 4.6. These findings suggest that non-parametric statistical tests may be more appropriate for analyzing the VAS and WOMAC data, whereas parametric tests can be applied to the 6-minute walk and 30-second chair stand outcomes.

Table 4.6: Normality test for VAS, 6-minute walk, 30-second chair tests, and Womac scale.

Variables	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Visual analog scale 1	0.167	37	0.011	0.916	37	0.009
Visual analog scale 3	0.187	37	0.002	0.935	37	0.031
30-second chair stand test 1	0.142	37	0.058	0.962	37	0.238
30-second chair stand test 3	0.109	37	.200*	0.966	37	0.308
Six-minute walk test 1	0.086	37	.200*	0.965	37	0.291
Six-minute Walk Test 3	0.107	37	.200*	0.969	37	0.372
Womac1totalscore	0.082	37	.200*	0.968	37	0.358
Womac3totalscore	0.193	37	0.001	0.912	37	0.006

Sig: significance = p-value.

Appendix 1 Table 1 shows the normality assessment for the range of motion of the right and left knee in both flexion and extension revealed that all measured variables significantly deviated from a normal distribution ($p < 0.05$). This indicates that the data related to knee joint mobility in flexion and extension for both sides were not normally distributed, and therefore, non-parametric statistical methods are required for subsequent analysis.

The normality test for muscle peak strength of the bilateral quadriceps, gluteus Medius, and gluteus maximus indicated that all variables were normally distributed ($p > 0.05$), which is shown in Appendix 1 Table 2. These results confirm that the data for lower limb muscle strength met the assumption of normality, supporting the use of parametric statistical tests in subsequent analyses.

Appendix 1 Table 3 represented the normality test for average muscle strength of the bilateral quadriceps, gluteus Medius, and gluteus maximus, demonstrating that all variables were normally distributed ($p > 0.05$). This finding indicates that the data related to overall muscle strength fulfilled the assumption of normality, thereby allowing for the application of parametric statistical tests in subsequent analyses.

4.5 Inferential statistical analysis of the tested variables between the first experimental group (laser+ exercises) and the second control group (laser), and within-group.

4.5.1 Pain assessment (Visual Analogue Scale (VAS)

As shown in Table 4.7 and Figure 4.4, our results indicated that there was no significant difference between the two groups on the VAS medians' pre-tests (p=0.889) and med-test (p=0.975). However, a significant difference was recorded on the post-tests (p = 0.004), where the Experimental (laser + exercises) group showed a significant improvement with a large effect size (Cohen's d = 1.0).

Table 4.7: Visual analogue scale analysis.

Group		Mean ± SD	Median	P-value
VAS Pre-test	Experimental (laser+excs)	6.5± 1.38	7	0.889
	Control (laser)	6.42± 1.95	7	
VAS Med-test	Experimental (laser+excs)	3.61± 1.37	4	0.975
	Control (laser)	3.58± 1.50	4	
VAS Post-test	Experimental (laser+excs)	2± .84	2	0.004
	Control (laser)	3.26±1.63	3	

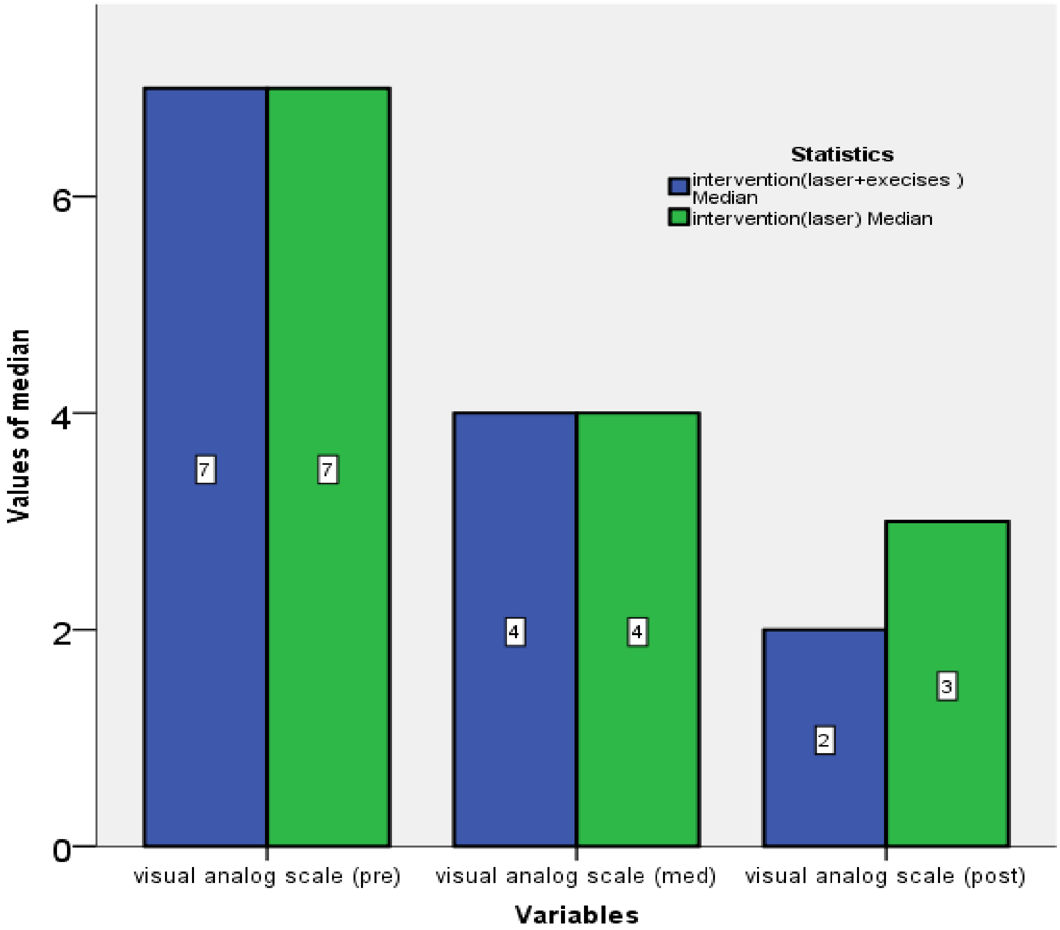

Figure 4.4: Visual analog scale median values.

4.5.2 Six-minute Walk test result

As presented in Table 4.8 and Figure 4.5, no significant differences were observed between the two groups at baseline (pre-test, p = 0.820) or at the mid-test assessment (p = 0.559) in the six-minute walk test. However, a statistically significant difference emerged at the post-test stage (p = 0.004), toward the experimental group (laser + exercises), which demonstrated a marked improvement with a large effect size (Cohen's d = 0.72).

Table 4.8: Six-Minute Walk test analysis.

Inclinometer categories	Group(N=32)	Mean ± S	P-value	Mean difference	95% Confidence Interval of the Difference	
					Lower	Upper
Six-minute Walk Pre-test	experimental group (laser exercise)	323.5± 63	0.82	4.40	-34.65	43.44
	Experimental group (laser)	319± 53				
Six-minute Walk Med - test	Experimental group (laser exercise)	366.61±58.68	0.559	11.35	-27.69	50.4
	Control group (laser)	355.26±58.26				
Six-minute Walk Post-test	Experimental group (laser exercise)	431.11±58.94	0.004	62.85	21.59	104.1
	Control group (laser)	368.26±64.65				

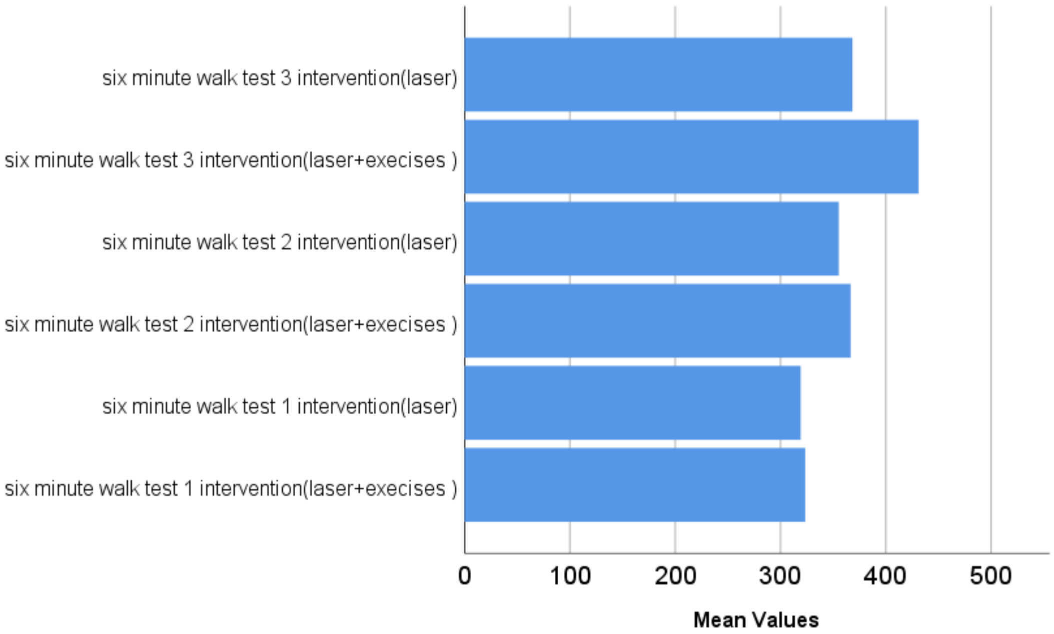

Figure 4.5: Six-minute Walk test means values. Test 3=post/test2=med/test1=pre.

4.5.3 30-second chair stand test results

As it's clear in Table 4.9, no significant differences were observed between the two groups in the 30-second chair stand test at baseline (pre-test, p = 0.877) or at the mid-test assessment (p = 0.794). However, a statistically significant difference was at the post-test stage (p = 0.002), favoring the experimental group (laser + exercises), which demonstrated a marked improvement with a large effect size (Cohen's d = 0.72).

Table 4.9: 30-second chair stand test analysis.

Inclinometer categories	Group(N=32)	Mean ± S	P-value	Mean difference	95% Confidence Interval of the Difference	
					Lower	Upper
30 Second chair stand test Pre-test	Experimental group(laser+exercise)	9.89±1.97	0.877	0.10	-1.19	1.39
	Control group (laser)	9.79±1.90				
30 Second chair stand test Med -test	Experimental group(laser+exercise)	10.67±1.7	0.794	-0.18	-1.52	1.17
	Control group(laser)	10.8±2.29				
30 Second chair stand test Post-test	Experimental group(laser+exercise)	13.2±1.98	0.002	2.43	0.95	3.91
	Control group (laser)	11.2±2.7				

4.5.4 Womac scale analysis results

Table 4.10Analysis of WOMAC scores indicated that both the experimental group (laser + exercise) and the control group (laser only) demonstrated reductions from baseline to post-test, reflecting overall improvement in functional status. However, comparisons between groups revealed no statistically significant differences at pre-test, mid-test, or post-test (all p > .05). The observed effect size (Cohen's d = 0.32) corresponded to a small-to-moderate magnitude; the effect was not sufficient to reach statistical significance within the present sample.

Table 4.10: WOMAC scores analysis.

Group		Mean ± SD	Medin	P-value
WOMAC Pre-test	Experimental (laser+excs)	38.2±17.24	39.5	0.543
	Control (laser)	35.68±19.3	33	
WOMAC Med-test	Experimental (laser+excs)	22.44±11.65	20	0.574
	Control (laser)	20.47±12.29	18	
WOMAC Post-test	Experimental (laser+excs)	20.39±14.01	18	0.648
	Control (laser)	23.05±16.71	18	

Table 4.11 presents the extent of improvement in the first group experimental (laser + exercises) and the second control group (laser) only for each group separately, between the pre- and post-assessments for the visual analog scales, six-minute walk test,30-second chair stand test, and WOMAC. The results for the experimental group are VAS with a p-value of 0.00, and for the six-minute walk, the p-value was 0.000. As for the 30-second chair stand test, the p-value is 0.00. Additionally, the WOMAC total score had a p-value of 0.00. Similarly, with the control group, results are VAS p-value=0.00, six-minute walk test p-value= .00, 30-second chair test p-value=.046, and finally WOMAC p-value=.004. This means that all results are significant, as their p-value is all less than 0.05 for each group.

Table 4.11: VAS, 30-second chair stand, six-minute walk test, WOMAC statistical analysis for each group separately.

Group	**categories**		**Mean ±SD**	**P-value**
Experimental (laser+exerci)	Pair 1	visual analog scale (pre)	6.50 ± 1.38	0.000
		visual analog scale (post)	2.00 ± .84	
	Pair 2	Six-minute Walk test (pre)	323.50 ± 63.03	0.000
		Six-minute Walk test (post)	431.11 ± 58.94	
	Pair 3	30-second chair stand test (pre)	9.89 ± 1.96	0.000
		30-second chair stand test (post)	13.17 ± 1.97	
	Pair 4	Womac total score (pre)	38.28 ± 17.23	0.000
		Womac total score (post)	20.39 ± 14.01	
Control (laser)	Pair 1	visual analog scale (pre)	6.42 ± 1.95	0.000
		visual analog scale (post)	3.26 ± 1.62	
	Pair 2	Six-minute Walk test (pre)	319.11 ± 52.99	0.000
		Six-minute Walk test (post)	368.26± 64.65	
	Pair 3	30-second chair stand test (pre)	9.79 ± 1.90	0.046
		30-second chair stand test (post)	10.74 ± 2.44	
	Pair 4	Womac total score (pre)	35.68 ± 19.29	0.004
		Womac total score (post)	23.05 ± 16.71	

4.5.5 Flexion knee results

As shown in Table 4.12, analysis of right knee joint flexion revealed no statistically significant differences between the groups at any time point (pre-test p = .419; mid-test p = .591; post-test p = .249). Nevertheless, the effect size (Cohen’s d = 0.40) suggests a small-to-moderate practical difference for the experimental group.

Table 4.12: RT knee flexion analysis.

Group		Mean ± SD	Median	P-value
Flexion RT Knee Pre-test	Experimental (laser+excs)	105.17±11.74	105.5	0.419
	Control (laser)	106.79±15.22	110	
Flexion RT knee Med-test	Experimental (laser+excs)	116.11±7.35	117	0.591
	Control (laser)	115±7.65	115	
Flexion RT knee Post-test	Experimental (laser+excs)	120.44±6.81	120	0.249
	Control (laser)	117.95±6.29	120	

RT: right

As indicated in Table 4.13, analysis of left knee joint flexion revealed no significant differences in groups at any time point (pre-test p = .843; mid-test p = 1.00; post-test p = .130). Nonetheless, the effect size (Cohen's d = 0.51) points to a moderate practical benefit of the experimental group compared to the control group.

Table 4.13: LT knee flexion analysis.

Group		Mean ± SD	Median	P-value
Flexion LT knee Pre-test	Experimental (laser+excs)	103.94±13.88	103	0.843
	Control (laser)	103.74±16.66	110	
Flexion LT knee Med-test	Experimental (laser+excs)	114.22±9.35	115	1.00
	Control (laser)	114.05±8.71	115	
Flexion LT knee Post-test	Experimental (laser+excs)	120.65±6.41	120	0.130
	Control (laser)	111.53±24.45	115	

LT: left

4.5.6 Knee Extension Results

As reported in Table 4.14, RT knee extension values did not differ significantly between the groups at baseline (p = 0.853) or mid-test (p = 0.730). By contrast, the post-test revealed a statistically significant difference (p = 0.020), with the experimental group (laser + exercises) achieving superior outcomes, supported by a large effect size (Cohen's d = 0.7576).

Table 4.14: RT knee extension analysis±.

Group		Mean ± SD	Median	P-value
Extension RT knee Pre-test	Experimental (laser+excs)	-4.78±2.533	-4.5	0.853
	Control (laser)	-4.74±2.16	-5	
Extension RT knee Med-test	Experimental (laser+excs)	-2.94±1.66	-2	0.73
	Control (laser)	-2.53±1.22	-2	
Extension RT knee Post-test	Experimental (laser+excs)	-1.67±1.37	-1	0.02
	Control (laser)	-2.68±1.29	-3	

As indicated in Table 4.15, analysis of left knee joint extension revealed no significant between-group differences at any time point (pre-test p = .064; mid-test p = .060; post-test p = .086). Nonetheless, the effect size (Cohen's d = 0.5) points to a moderate practical benefit of the experimental group compared to the control group.

Table 4.15: LT knee extension analysis

Group		Mean ± SD	Median	P-value
Extension LT knee Pre-test	Experimental (laser+excs)	-5.5±2.75	-5	0.064
	Control (laser)	-4.16±1.89	-4	
Extension LT knee Med-test	Experimental (laser+excs)	-3.56±2.35	-3.5	0.060
	Control (laser)	-2.26±.81	-2	
Extension LT knee Post-test	Experimental (laser+excs)	-1.67±1.78	-1	0.086
	Control (laser)	-2.53±1.81	-2	

Table 4.16 presents the results demonstrating the improvement in the range of motion of the knee joint bilaterally, in both flexion and extension movements, in pre and posttests. The findings indicate a significant difference in all measurements, with p-values =.00, less than the p-value of 0.05 for both groups separately. Except for LT knee flexion in the control group, which shows no significant difference (p=.272).

Table 4.16: Bilateral knee joint ROM statical analysis for each group separately.

Group			Mean ±SD	P-value
Experimental (laser +exerc)	Pair 1	range of motion, right knee flexion (pre)	105.17± 11.74	0.000
		range of motion, right knee flexion (post)	120.44± 6.82	
	Pair 2	range of motion left knee flexion (pre)	103.94±13.88	0.000
		range of motion left knee flexion (post)	120.56±6.42	
	Pair 3	range of motion right knee extension (pre)	-4.78-± 2.53	0.000
		range of motion, right knee extension (post)	-1.67-± 1.37	
	Pair 4	range of motion left knee extension(pre)	-5.50-± 2.75	0.000
		range of motion left knee extension(post)	-1.67-± 1.78	
Control (laser)	Pair 1	range of motion, right knee flexion (pre)	106.79± 15.22	0.006
		range of motion, right knee flexion (post)	117.95± 6.29	
	Pair 2	range of motion left knee flexion (pre)	103.74± 16.66	0.272
		range of motion left knee flexion (post)	111.53± 24.45	
	Pair 3	range of motion right knee extension (pre)	-4.74-± 2.16	0.001
		range of motion, right knee extension (post)	-2.68-± 1.29	
	Pair 4	range of motion left knee extension(pre)	-4.16-± 1.89	0.001
		range of motion left knee extension(post)	-2.53-± 1.80	

4.5.7 Muscles' peak and average strength results

As reported in Table 4.17, right quadriceps muscle strength did not differ significantly between the groups at baseline (peak: $p = 0.977$; average: $p = 0.661$) or at mid-test (peak: $p = 0.368$; average: $p = 0.412$). In contrast, post-test assessments revealed statistically significant improvements in the experimental group (laser + exercises), both for peak strength ($p = 0.017$; Cohen's $d = 0.74$) and average strength ($p = 0.018$; Cohen's $d = 0.815$), with both outcomes supported by large effect sizes.

Table 4.17: RT quadriceps muscle peak and average analysis.

Categories	Group	Mean ± SD	P-value	Mean diff.	95% Confidence Interval of the Difference	
					Lower	Upper
Peak RT quadriceps MP						
Peak RT quadriceps MP Pre-test	Experimental group (laser+exercise)	16.9±3.56	0.977	0.041	-2.80	2.88
	Control group(laser)	16.88±4.8				
Peak RT quadriceps MP Med -test	Experimental group (laser+exercise)	22±6.106	0.368	1.83	-2.25	5.91
	Control group(laser)	20.16±6.1				
Peak RT quadriceps MP Post-test	Experimental group (laser+exercise)	26.39±5.5	0.017	4.60	0.86	8.24
	Control group(laser)	21.84±5.5				
Average RT quadriceps MP						
Average RT quadriceps MP Pre-test	Experimental group (laser+exercise)	13.46±3.5	0.661	-0.66	-3.67	2.34
	Control group(laser)	14.12±5.3				
Average RT quadriceps MP Med-test	Experimental group (laser+exercise)	20.25±5.6	0.412	1.55	-2.24	5.34
	Control group(laser)	18.7±7.7				
Average RT quadriceps MP Post-test	Experimental group (laser+exercise)	24.65±5.4	0.018	4.29	0.78	7.79
	Control group(laser)	20.36±5.1				

MP: muscle power

As shown in Table 4.18, analysis of left quadriceps peak and average strength revealed no statistically significant differences between groups at any time point (peak strength: pre-test p = .780, mid-test p = .555, post-test p = .109, average strength: pre-test p = .643, mid-test p = .0699, post-test p = .102). Nonetheless, the effect sizes for both peak (Cohen's d = 0.541) and average strength (Cohen's d = 0.553) indicate a moderate practical benefit of the experimental compared to the control group.

Table 4.18: LT quadriceps muscle peak and average analysis.

Categories	Group	Mean ± SD	P-value	Mean diff.	95% Confidence Interval of the Difference	
					Lower	Upper
Peak RT quadriceps MP						
Peak RT quadriceps MP Pre-test	Experimental group (laser+exercise)	16.12±4.1	0.78	-0.43	-3.57	2.71
	Control group(laser)	16.55±5.2				
Peak RT quadriceps MP Med -test	Experimental group (laser+exercise)	21.33±5.8	0.555	1.08	-2.58	4.73
	Control group(laser)	20.25±5.5				
Peak RT quadriceps MP Post-test	Experimental group (laser+exercise)	25.77±5.1	0.109	2.85	-0.67	6.38
	Control group(laser)	22.9±5.46				
Average RT quadriceps MP						
Average RT quadriceps MP Pre-test	Experimental group (laser+exercise)	14.08±3.7	0.64	-0.70	-3.72	2.33
	Control group(laser)	14.77±5.2				
Average RT quadriceps MP Med-test	Experimental group (laser+exercise)	19.54±5.6	0.699	0.68	-2.88	4.25
	Control group(laser)	18.86±5.1				
Average RT quadriceps MP Post-test	Experimental group (laser+exercise)	24.1±4.57	0.102	2.63	-0.55	5.79
	Control group(laser)	21.45±4.9				

As it's clear in Table 4.19, analysis of right gluteus maximus peak and average strength revealed no statistically significant differences between groups at any time point (peak strength: pre-test p = .505, mid-test p = .330, post-test p = .095; average strength: pre-test p = .886, mid-test p = .205, post-test p = .068). However, the effect sizes for both peak (Cohen’s d = 0.564) and average strength (Cohen’s d = 0.622) indicate a moderate benefit of the experimental compared to the control group.

Table 4.19: RT gluteus maximus muscle peak and average analysis.

Categories	Group	Mean ± SD	P-value	Mean diff.	95% Confidence Interval of the Difference	
					Lower	Upper
Peak RT gluteus max MP						
Peak RT gluteus max MP Pre-test	Experimental group (laser+exercise)	11.78±4.43	0.505	-1	-4.01	2.01
	Control group(laser)	12.78±4.59				
Peak RT gluteus max MP Med - test	Experimental group (laser+exercise)	15.98±4.26	0.33	1.63	-1.72	4.99
	Control group(laser)	14.35±5.70				
Peak RT gluteus max MP Post-test	Experimental group (laser+exercise)	19.47±4.13	0.095	2.93	-0.54	6.41
	Control group(laser)	16.53±6.10				
Average RT gluteus max MP						
Average RT gluteus max MP Pre-test	Experimental group (laser+exercise)	10.11±4.25	0.885	-0.23	-3.39	2.92
	Control group(laser)	10.34±5.16				
Average RT gluteus max MP Med-test	Experimental group (laser+exercise)	15.09±4.44	0.205	2.05	-1.17	5.27
	Control group(laser)	13.04±5.15				
Average RT gluteus max MP Post-test	Experimental group (laser+exercise)	18.17±4.34	0.068	3.22	-0.25	6.69
	Control group(laser)	14.95±5.89				

Max: Maximus

As reported in Table 4.20, left gluteus maximus muscle strength values did not differ significantly between the groups at baseline (peak: p = 0.711; average: p = 0.778) or at mid-test (peak: p = 0.069; average: p = 0.115). In contrast, post-test assessments revealed statistically significant improvements in the experimental group (laser + exercises), both for peak strength (p = 0.025; Cohen’s d = 0.767) and average strength (p = 0.023; Cohen’s d = 0.786), with both outcomes supported by large effect sizes.

Table 4.20: LT gluteus maximus muscle peak and average analysis.

Categories	Group	Mean ± SD	P-value	Mean diff.	95% Confidence Interval of the Difference	
					Lower	Upper
Peak LT gluteus max MP						
Peak LT gluteus max MP Pre-test	Experimental group (laser+exercise)	13.33±4.32	0.711	0.56	-2.49	3.61
	Control group(laser)	12.76±4.79				
Peak LT gluteus max MP Med - test	Experimental group (laser+exercise)	19.42±5.88	0.069	3.69	-0.30	7.68
	Control group(laser)	15.73±6.05				
Peak LT gluteus max MP Post-test	Experimental group (laser+exercise)	23.11±5.33	0.026	4.35	0.56	8.14
	Control group(laser)	18.75±5.99				
Average LT gluteus max MP						
Average LT gluteus max MP Pre-test	Experimental group (laser+exercise)	11.60±4.31	0.778	0.44	-2.70	3.58
	Control group(laser)	11.16±5.04				
Average LT gluteus max MP Med-test	Experimental group (laser+exercise)	17.96±5.77	0.115	3.14	-0.81	7.09
	Control group(laser)	14.815±6.04				
Average LT gluteus max MP Post-test	Experimental group (laser+exercise)	21.43±4.90	0.023	4.25	0.63	7.85
	Control group(laser)	17.19±5.86				

As presented in Table 4.21, the analysis of right gluteus medius peak and average strength demonstrated no statistically significant differences between groups at any time point (peak strength: pre-test p = .524, mid-test p = .714, post-test p = .237; average strength: pre-test p = .515, mid-test p = .868, post-test p = .117). However, the effect sizes for both peak strength (Cohen’s d = 0.361) and average strength (Cohen’s d = 0.527) suggest a weak to moderate practical benefit of the experimental group relative to the control group.

Table 4.21: RT gluteus Medius muscle peak and average analysis.

Categories	Group	Mean ± SD	P-value	Mean diff.	95% Confidence Interval of the Difference	
					Lower	Upper
Peak RT gluteus med MP						
Peak RT gluteus med MP Pre-test	Experimental group (laser+exercise)	7.30±2.09	0.524	-0.54	-2.22	1.15
	Control group(laser)	7.84±2.88				
Peak RT gluteus med MP Med -test	Experimental group (laser+exercise)	9.99±1.88	0.71	-0.30	-1.92	1.33
	Control group(laser)	10.29±2.85				
Peak RT gluteus med MP Post-test	Experimental group (laser+exercise)	12.12±2.42	237	0.85	-0.58	2.28
	Control group(laser)	11.27±2.42				
Average RT gluteus med MP						
Average RT gluteus med MP Pre-test	Experimental group (laser+exercise)	5.83±2.12	0.515	-0.53	-2.15	1.10
	Control group(laser)	6.35±2.69				
Average RT gluteus med MP Med-test	Experimental group (laser+exercise)	9.32±1.82	0.868	-0.12	-1.65	1.40
	Control group(laser)	9.44±2.6				
Average RT gluteus med MP Post-test	Experimental group (laser+exercise)	11.19±1.9	0.117	1.07	-0.28	2.43
	Control group(laser)	10.11±2.13				

Med: medius

Table 4.22indicates no significant differences between groups for left gluteus Medius peak or average strength across time points (peak: pre-test p = .89, mid-test p = .69, post-test p = .45; average: pre-test p = .78, mid-test p = .51, post-test p = .23). Despite this, effect sizes (Cohen’s d = 0.300 for peak, 0.40 for average) suggest weak to moderate practical benefits of the experimental group.

Table 4.22: LT gluteus Medius muscle peak and average analysis.

Categories	Group	Mean ± SD	P-value	Mean diff.	95% Confidence Interval of the Difference	
					Lower	Upper
Peak LT gluteus med MP						
Peak LT gluteus med MP Pre-test	Experimental group (laser+exercise)	7.81±2.29	0.89	0.11	-1.60	1.83
	Control group(laser)	7.69±2.80				
Peak LT gluteus med MP Med - test	Experimental group (laser+exercise)	10.708±1.94	0.69	0.37	-1.51	2.25
	Control group(laser)	10.34±3.45				
Peak LT gluteus med MP Post-test	Experimental group (laser+exercise)	12.98±2.07	0.45	0.61	-0.99	2.21
	Control group(laser)	12.38±2.66				
Average LT gluteus med MP						
Average LT gluteus med MP Pre-test	Experimental group (laser+exercise)	6.41±2.40	0.78	-0.24	-1.94	1.46
	Control group(laser)	6.65±2.68				
Average LT gluteus med MP Med-test	Experimental group (laser+exercise)	10.09±2	0.514	0.62	-1.30	2.54
	Control group(laser)	9.47±3.5				
Average LT gluteus med MP Post-test	Experimental group (laser+exercise)	12.12±2.24	0.30	0.99	-0.65	2.65
	Control group(laser)	11.13±2.63				

The following Table 4.23 summarizes the results of the bilateral improvement in muscle strength averages for the quadriceps, gluteus maximus, and Medius following the treatment trial of the experimental (laser + exercises) group and the control group. Statistical analysis revealed a significant difference in all strength averages for all muscles, which are less than 0.05for each group as a separate form.

Table 4.23: Bilateral muscle strength average statistical analysis for quadriceps, gluteus max, and Medius. For both intervention groups separately (paired t-test).

Group		**Variables**	**Mean ±SD**	**P-value**
Experimental (laser+ exercises)	Pair 1	average right quadriceps muscle power (pre)	13.46 ± 3.54	0.000
		average right quadriceps muscle power (post)	24.64± 5.37	
	Pair 2	average left quadriceps muscle power (pre)	14.07± 3.68	0.000
		average left quadriceps muscle power (post)	24.07± 4.57	
	Pair 3	average right gluteus maximus muscle power (pre)	10.11± 4.25	0.000
		average right gluteus maximus muscle power (post)	18.16± 4.34	
	Pair 4	average left gluteus maximus muscle power (pre)	11.59± 4.34	0.000
		average left gluteus maximus muscle power (post)	21.43± 4.90	
	Pair 5	Average right gluteus Medius muscle power (pre)	5.82± 2.11	0.000
		Average right gluteus Medius muscle power (post)	11.18± 1.92	
	Pair 6	Average left gluteus Medius muscle power (pre)	6.40± 2.39	0.000
		Average left gluteus Medius muscle power (post)	12.11± 2.24	
Control (laser)	Pair 1	average right quadriceps muscle power (pre)	14.12± 5.26	0.000
		average right quadriceps muscle power (post)	20.36± 5.14	
	Pair 2	average left quadriceps muscle power (pre)	14.77± 5.20	0.000
		average left quadriceps muscle power (post)	21.45± 4.90	
	Pair 3	average right gluteus maximus muscle power (pre)	10.33± 5.15	0.000
		average right gluteus maximus muscle power (post)	14.94± 5.89	
	Pair 4	average left gluteus maximus muscle power (pre)	11.16± 5.04	0.000
		average left gluteus maximus muscle power (post)	17.18± 5.86	
	Pair 5	average right gluteus Medius muscle power (pre0	6.35± 2.69	0.000
		Average right gluteus Medius muscle power (post)	10.11 ± 2.12	
	Pair 6	Average left gluteus Medius muscle power (pre)	6.64± 2.68	0.000
		Average left gluteus Medius muscle power (post)	11.12± 2.65	

4.6 Inferential Analysis Based on Age Group (<55 vs. ≥55 Years)

Table 4.24 presents statistical analysis of participants categorized into two groups (<55 and ≥55 years) for the variables VAS, 30-second stand chair, in addition to the six-minute walk, and WOMAC.

An inferential analysis was conducted to compare treatment outcomes between participants below and above 55 years of age. Pain intensity measured by the VAS showed a p-value of 0.316 with a small effect size (Cohen's d = 0.33). Performance on the 30-second chair stand test improved with a p-value of 0.10 and a large (Cohen's d = 0.99). The six-minute walk test demonstrated a statistically significant improvement (p = 0.012) accompanied by a large effect size (Cohen's d = 0.97). Similarly, the WOMAC scale revealed a p-value of 0.056 with a moderate (Cohen's d = 0.67) effect.

Table 4.24: Statistical analysis of VAS,30-second stand chair, six-minute walk, and WOMAC into two groups (<55 and ≥55 years).

Variables	age	N	Mean± SD	Mean diff.	P-value
visual analog scale (pre)	>= 55	14	6.64 ±1.21	0.30	0.571
	< 55	23	6.35 ± 1.92		
visual analog scale (post)	>= 55	14	2.93 ± 1.07	0.45	0.316
	< 55	23	2.48 ± 1.62		
30-second chair stand test (pre)	>= 55	14	9.07 ± 1.90	-1.23	0.061
	< 55	23	10.30 ± 1.79		
30-second chair stand test (post)	>= 55	14	10.50 ± 2.59	-2.28	0.01
	< 55	23	12.78 ± 2.09		
Six-minute Walk test (pre)	>= 55	14	287.64±44.24	-54.05	0.003
	< 55	23	341.7±55.35		
Six-minute Walk test (post)	>= 55	14	359.64±75.4	-63.05	0.012
	< 55	23	422.7±53.23		
Womac total score (pre)	>= 55	14	39.14± 21.66	3.534	0.602
	< 55	23	35.61± 15.97		
Womac total score (post)	>= 55	14	27.86± 14.20	9.814	0.056
	< 55	23	18.04± 15.04		
Variables	**age**	**N**	**Mean± SD**	**Mean diff.**	**P-value**

4.7 Statistical analysis for osteoarthritis grade (ANOVA)

Tables 4.25 illustrate statistical analysis comparing the results of improvement in post-treatment trial in visual analog scale, 30-second chair stand test, and six-minute walk test across grades of osteoarthritis for the participants in both groups.

An inferential analysis was conducted to compare treatment outcomes between participants with mild (I), moderate (II), and severe (III) osteoarthritis grades. In experimental group (laser+exercises), pain intensity measured by the VAS showed a p-value of 0.109. Performance on the 30-second chair stand test p-value =0.873. The result of the six-minute walk test is p-value =.265, demonstrating a statistically nonsignificant difference. Similarly, the control group (laser) VAS revealed a p-value of 0.542, 30-second chair stand p-value =215, and for the six-minute walk test, the p-value =306.

Table 4.25: Statistical analysis of OA grades (ANOVA).

Group	Variables	OA grade	Mean± SD	P-value
Experimental (laser+exercises)	visual analog scale (post)	mild	1.25 ± 1.26	0.109
		moderate	2.27± .65	
		severe	2.00 ±.00	
		Total	2.00 ± .84	
	30-second chair stand test (post)	mild	13.50 ± 1.73	0.873
		moderate	13.18 ± 2.14	
		severe	12.67 ± 1.31	
		Total	13.17 ± 1.98	
	Six-minute Walk test (post)	mild	452.00 ± 20.31	0.265
		moderate	437.09 ± 60.25	
		severe	381.33 ± 77.26	
		Total	431.11 ± 58.94	
Control (laser)	visual analog scale (post)	mild	3.00 ± 2.12	0.542
		moderate	3.17 ± 1.40	
		severe	4.50 ± 2.12	
		Total	3.26 ± 1.63	
	30-second chair stand test (post)	mild	12.40 ± 2.30	0.215
		moderate	10.17 ± 2.33	
		severe	10.00 ± 2.83	
		Total	10.74 ± 2.45	
	Six-minute Walk test (post)	mild	407.00 ± 39.66	0.306
		moderate	353.00 ± 69.11	
		severe	363.00 ±77.79	
		Total	368.26 ± 64.65	

4.8 Discussion of results

This randomized controlled trial was designed to explore how strengthening exercises for the quadriceps, gluteus maximus, and gluteus Medias, together with low-intensity laser therapy, or laser only, influence key functional outcomes in women aged 45–65 years with grade I–III knee osteoarthritis. Moreover, the study compared the degree of improvement in pain, physical function, range of motion, muscle performance, endurance, and gait between younger (45–55 years) and older (56–65 years) female participants.

The results were analyzed from four main perspectives. First, the improvements in outcome measures were compared between the experimental group (low-intensity laser therapy combined with exercises) and the control group (laser therapy only) in pre-med and post-tests along the intervention period. Second, the effectiveness of each intervention was examined independently by assessing pre- and post-treatment changes within each group to distinguish the specific impact of each therapeutic modality. Third, the data were analyzed according to age, comparing participants aged below and above 55 years to identify potential age-related differences in treatment response. Finally, the effectiveness of the interventions was evaluated across different grades of osteoarthritis severity.

The study found no significant pain difference between groups during the initial therapeutic intervention. However, a clear significant reduction in pain was observed in the later treatment phase for the experimental group, attributed to strengthening exercises that alleviated pressure on the knee joint. This aligns with previous studies indicating that quadriceps and hamstring strengthening enhances joint stability and range of motion, leading to decreased pain. Additionally, the combination of quadriceps strengthening and Baduanjin qigong training resulted in greater pain reduction and improved long-term compliance among patients with knee osteoarthritis. (Jiang et al., 2024),(F. Wang et al., 2021).

Furthermore, it is consistent with the pain item in the first research hypothesis in the study, which assumes that pain will decrease significantly in the experimental group than the control group.

On the other hand, the results of pain in each group separately show that just as pain has decreased significantly in the first group, it has also decreased significantly in the second group between pre- and post the therapeutic intervention. This is consistent with the effect of laser on the healing process in KOA, one of the effects of which is reducing pain, as studies have proven in previous studies which indicate that laser low intensity has analgesic effects besides bio modulatory effect on microcirculatory inconclusion that will increase pain -relieving(Hegedűs et al., 2009), and it is consistent with the second research hypothesis that assumes the clear effect of low-intensity laser on pain. Unlike a systematic and meta-analysis study, which investigated that there was no significant difference in VAS after therapy between LLLT and control (Huang et al., 2015).

The 6-minute walk test indicated significant improvement in gait endurance and walking efficiency during the second treatment phase, particularly in the experimental group compared to the control. This aligns with a hypothesis that muscle-strengthening exercises positively affect these outcomes over time. The results correspond with similar studies that found significant enhancements in spatiotemporal gait parameters in patients with mild to moderate knee osteoarthritis, following an 8-week resistance training protocol (Rosada et al., 2024). Another study demonstrated that incorporating both strengthening and balance exercises led to significant improvements in the 6-minute walk test among patients with primary knee osteoarthritis with different grades (Abdel-Fattah et al., 2023).

Likewise, results of the 30-second chair stand test showed a significant improvement after the therapeutic intervention for the first experimental group compared to the second group control group. This may be attributed to the fact that this improvement in this test indicates that More repetitions suggest better muscle strength, especially in the quadriceps and glutes, endurance, and the ability to perform daily activities like standing up from a chair or climbing stairs (Jones et al., 1999),(Ho-Henriksson et al., 2025).

On the other hand, the results show a significant improvement for the control group, the laser alone, in the six-minute walk test, in addition to the 30-second chair stand test. This is also accompanied by a decrease in pain, and this is considered a logical progression because the effect of Low-level laser therapy (LLLT) has been employed in physical therapy to treat a variety of medical conditions. Its therapeutic effects include enhancing tissue oxygenation, stimulating the release of neurotransmitters involved in pain modulation, and promoting the secretion of anti-inflammatory mediators. LLLT is primarily utilized to alleviate pain, reduce inflammation, and support the regeneration of damaged tissues. Current evidence suggests that LLLT offers moderate efficacy in pain relief. This reduces knee joint stiffness and eases movement, which increases walking speed and the joint's ability to tolerate more functional load. (de Matos Brunelli Braghin et al., 2019),(Hegedűs et al., 2009)

The WOMAC assessment revealed improvements across pain, stiffness, and physical function domains in both study groups, with more substantial gains observed in the experimental group receiving combined laser therapy and exercise. Post-intervention data indicated that a greater proportion of participants in the combined treatment group reported minimal or no symptoms, suggesting that the integration of exercise with laser therapy may enhance functional and symptomatic outcomes more effectively than laser therapy alone.

Nonetheless, statistical analysis did not demonstrate a significant difference in overall improvement between the two groups. Both groups exhibited significant progress independently, indicating that participants experienced measurable benefits across all three dimensions—pain, stiffness, and physical function. Therefore, it is important to consider that the WOMAC scale is an inherently subjective scale, relying on individual self-reporting. Consequently, each participant’s responses may reflect personal perceptions of symptom relief and functional improvement, which are influenced by their unique activity levels, lifestyle, and pain tolerance. These results are not entirely consistent with the research hypothesis of finding a significant difference between the two groups in function, stiffness, and pain; however, the results confirm that there is a significant difference in the therapeutic intervention for the two groups separately.

In comparable studies involving groups getting exercise alone, low-level laser treatment (LLLT) alone, a combination of both, and a placebo, this study determined significant enhancements in WOMAC scores were noted solely in the exercise-only group. Similarly, another randomized controlled trial examined the impact of various exercise modalities—high-resistance, low-resistance, and stretching—on distinct groups, revealing that functionality, as shown by WOMAC scores, enhanced across all groups. A thorough review indicated no substantial functional disparity between laser therapy combined with exercise and exercise alone. In other words, it negates the efficacy of the laser in enhancing function.

Unlike comparable studies that included groups receiving exercise alone, low-level laser therapy (LLLT) alone, a combination of both, and a placebo, this study found that improvements in WOMAC scores were observed exclusively in the exercise-only group. (de Matos Brunelli Braghin et al., 2019).

Likewise, in another RCT study that investigated the effect of several types of exercises on different groups, namely high-resistance exercises, low-resistance exercises, and stretching exercises, it was found that function, which was expressed by the WOMAC results, improved in all groups. (Dilawar et al., 2022)

A systematic review revealed no significant functional difference between laser combined with exercise and paired with exercise only. In other words, it cancels out the effect of the laser in improving the function (Malik et al., 2023) .

The results also indicate that the difference in range of motion improvement between the two groups is not statistically significant. In contrast, when each group is analyzed independently, both demonstrate a general significant enhancement in range of motion. This discrepancy may be attributed to the inverse relationship between movement limitation and factors such as pain and inflammation, as merely decreasing these symptoms alone appears sufficient to increase range of motion, yielding comparable outcomes across both groups. (Al-Rashoud, 2014).

However, in similar studies, the increase in ROM is attributed solely to exercise, independent of the effect of low-intensity laser therapy, where it was shown that the exercise regimen combined with laser therapy achieved results that did not differ from the results of the Exercise set with placebo LLLT(Malik et al., 2023)

Muscle strength analysis between groups of the quadriceps, gluteus maximus, and gluteus Medius muscles assessed by using a handheld dynamometer revealed a gradation in strength differences across the muscle groups. The quadriceps demonstrated statistically significant differences with a moderate effect size (Cohen's d), closely mirrored by the gluteus maximus. In contrast, the gluteus Medius exhibited only minimal strength variation, indicated by a small Cohen's d, suggesting the difference was not clinically noticeable**.** Although the effect of strengthening exercises was evident in the results of the 30-second chair stand test and the six-minute walk, this might be due that training the gluteus Medius muscle may require higher concentration in terms of training angle, intensity, and possibly duration to show a difference compared to the control group. Furthermore, dysfunction or weakness of the gluteus medius correlates with numerous lower extremity ailments and gait irregularities in walking and running, such as iliotibial band syndrome, patellofemoral pain syndrome, and anterior cruciate ligament injuries. This may elucidate why strengthening activities aimed at this muscle do not produce as significant enhancements as those for the larger quadriceps and gluteus maximus muscles. The variation in muscle size likely accounts for the differences in strength improvements reported among different muscle groups (Daniel et al., 2017).

Conversely, the findings indicated that enhancing the specific muscles within each group individually resulted in notable improvements for each group independently. The substantial reduction in pain and the enhancement of functional activity may be attributed to the challenges patients face when exerting maximum force during acute pain, as this method is employed to assess maximum strength and is repeated to calculate the average strength. Furthermore, the significant enhancement in functionality within each set will also manifest in muscle strength. The results of a 12-week trial aimed at strengthening the quadriceps muscle, conducted three times per week, indicated a considerable increase in muscle strength, accompanied by a reduction in pain and improvement in function. Interestingly, the strengthening exercises did not alter the quadriceps force during knee loading while walking in patients with KOA. (Aaboe et al., 2014).

The comparative results between the two age groups below and above 55years showed no significant difference in pain or function, as indicated by the VAS scale and WOMAC score. However, there was a significant difference in the 30-second chair stand, which represents muscle strength and endurance. Notably, the difference was also significant before and after treatment between the two groups in the 6-minute walk test. Although these results differ more from the third hypothesis, which suggested there would be a significant difference between the two age groups in the research measures, they are still promising results that offer greater hope for treatment across a wide age range**.** These results could also be because the older age group is not overwhelmingly older, despite a significant age difference between the two groups.

Numerous studies have identified age as a significant risk factor contributing to both the severity of KOA and the challenges associated with its management. The study found a strong link between age and the severity of knee osteoarthritis. Individuals aged 65 and older were significantly more likely to develop moderate to severe OA, with the risk increasing every five years. This is due to age-related joint changes such as cartilage degeneration, osteophyte formation, muscle loss, and chronic low-grade inflammation. Aging also leads to chondrocyte senescence and increased production of inflammatory molecules that accelerate cartilage breakdown. Although both obesity and age were associated with OA severity, age was identified as the only independent, non-modifiable risk factor (Mustari et al., 2023),(Wallace et al., 2018),(Abdel-Fattah et al., 2023)

The analytical results categorized by the severity of KOA (grade I mild, grade II moderate, and grade III severe) demonstrated no statistically significant differences in pain, as measured by VAS, muscle strength, and walking endurance (evaluated through the 30-second chair stand test and the 6-minute walk test), in either the experimental group (laser and exercise) or the control group (laser only), as determined by ANOVA in the post-test.

A comparable study indicated that a strengthening exercise regimen could enhance pain, physical function, and dynamic balance irrespective of the severity of knee osteoarthritis (KOA), whereas ongoing exercise in mild instances may yield superior improvements relative to severe cases. (Abdel-Fattah et al., 2023).

4.9 Study Limitations

- The sample size posed challenges in both acquiring participants and ensuring adherence to the inclusion criteria. Furthermore, convincing the orthopedic doctor to consent to refer eligible patients demanded considerable time and effort, further complicating the sample collection process.
- Due to the limited sample size, it was not feasible to divide participants into three distinct groups—laser-only, strength training-only, and a combined laser and strength training group- to conduct a broader study.
- The withdrawal of several participants midway through the research process was troubling and affected the sample size.
- The participants' commitment to the three-month research-based therapeutic intervention required considerable effort due to financial and political reasons.

Chapter Five

5 Conclusion and Recommendations

5.1 Conclusion

- Significant differences ($p<0.05$) were observed between groups, where the experimental group showed a better improvement and within-group at posttest in pain measured by VAS, gait endurance measured by the 6-minute walk test, and strength and physical function measured by the 30-second chair test.

- Analysis of the WOMAC scores did not reveal statistically significant differences ($P>0.05$) between groups (experimental and control groups); however, significant improvements were observed within each group following the intervention. A similar pattern was noted in the ROM measurements for bilateral knee flexion and extension, where intra-group changes reached statistical significance, while inter-group comparisons did not.

- The experimental group, which received laser therapy combined with strengthening exercises, demonstrated greater improvements in muscle strength compared to the control group that received laser therapy alone. Post-test analysis revealed statistically significant gains in quadriceps and gluteus maximus strength, both showing moderate effect sizes. In contrast, the gluteus Medius exhibited non-significant changes, with a small effect size, indicating limited responsiveness to the intervention under the applied training conditions.

- There is no significant difference between participants above and below 55 years in WOMAC score and VAS, whereas there is a significant difference in the 30-second chair stand in the post-test.

- There are no significant differences in analytical results between KOA grades in pain measured by VAS, gait endurance measured by a 6-minute walk test, and strength and physical function measured by the 30-second chair test.

5.2 Recommendations

❖ For Researchers

- Promoting a collaborative research team approach in clinical studies facilitates the implementation of double-blind randomized controlled trials, supports the recruitment of larger sample sizes, and enables the extension of treatment durations.

- Conducting the research experiment on male participants with KOA to compare the results between the sexes.

- Initiating new scientific research to determine the prevalence of KOA in Palestine, to inform public health strategies and resource allocation.

- Organizing long-term scientific research or follow-up studies to determine the long-term therapeutic effect.

❖ For Physiotherapists

- Imploring my colleagues in physiotherapy to be informed about the most recent treatment regimens for KOA to attain superior outcomes and guarantee that these outcomes are sustainable rather than ephemeral.

- Implement an “Exercise-First” Model of Care
Mandate completion of a structured 6–12-week non-surgical management program.

❖ For Policymakers

- **Prioritize Prevention through Public Education**
Develop national education campaigns to counter the misconception that osteoarthritis is an inevitable consequence of aging, emphasizing that it is a manageable condition responsive to lifestyle and therapeutic interventions.

- **Promote Equity and Community-Based Care Delivery**
Shift osteoarthritis management away from hospital-centric models toward community settings such as local gyms, community centers, and home-based programs to reduce costs and improve accessibility

- **Regulate Access to Diagnostic Imaging**
Restrict routine use of MRI and CT scans for initial KOA diagnosis and prioritize clinical assessment based on symptoms and functional impairment. Excessive reliance on imaging contributes to unnecessary surgical interventions and increases patient anxiety and catastrophe symptoms.

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Appendices

Appendix 1: Normal Distribution Tables

Appendix 1 Table 1: Normality test for range of motion.

Categories	Kolmogorov-Smirnova			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
range of motion, right knee flexion 1	0.146	37	0.045	0.90	37	0.004
range of motion, right knee flexion 3	0.199	37	0.001	0.95	37	0.085
range of motion left knee flexion 1	0.13	37	0.118	0.91	37	0.008
range of motion left knee flexion 3	0.24	37	0	0.52	37	0
range of motion, right knee extension 1	0.188	37	0.002	0.91	37	0.005
range of motion, right knee extension 3	0.179	37	0.004	0.92	37	0.01
range of motion left knee extension 1	0.28	37	0	0.89	37	0.001
range of motion left knee extension 3	0.20	37	0.001	0.89	37	0.002

Appendix 1 Table 2: Normality test for muscle peak strength.

Categories	Kolmogorov-Smirnova			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
peak right quadriceps muscle power 1	0.18	37	0.003	0.88	37	0.001
peak right quadriceps muscle power 3	0.09	37	.200*	0.98	37	0.717
peak left quadriceps muscle power 1	0.11	37	.200*	0.89	37	0.002
peak left quadriceps muscle power 3	0.12	37	0.159	0.97	37	0.338
peak right gluteus maximus power 1	0.14	37	0.059	0.95	37	0.08
peak right gluteus maximus muscle power 3	0.08	37	.200*	0.98	37	0.748
peak left gluteus maximus muscle power 1	0.11	37	.200*	0.97	37	0.43
peak left gluteus maximus muscle power 3	0.18	37	0.004	0.93	37	0.026
peak right gluteus Medius muscle power 1	0.15	37	0.034	0.92	37	0.014
peak right gluteus Medius muscle power 3	0.11	37	.200*	0.97	37	0.44
peak left gluteus Medius muscle power 1	0.10	37	.200*	0.97	37	0.36
peak left gluteus Medius muscle power 3	0.07	37	.200*	0.98	37	0.714

Appendix 1 Table 3: Normality test for average muscle strength.

Categories	Kolmogorov-Smirnova			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Average right quadriceps muscle power 1	0.1	37	.200*	0.88	37	0.001
Average right quadriceps muscle power 3	0.074	37	.200*	0.98	37	0.723
Average left quadriceps muscle power 1	0.091	37	.200*	0.9	37	0.003
The average left quadriceps muscle power is 3	0.13	37	0.127	0.97	37	0.315
Average right gluteus maximus muscle power 1	0.12	37	.200*	0.94	37	0.033
Average right gluteus maximus muscle power 3	0.09	37	.200*	0.98	37	0.661
Average left gluteus maximus muscle power 1	0.09	37	.200*	0.98	37	0.655
Average left gluteus maximus muscle power 3	0.14	37	0.055	0.95	37	0.065
Average right gluteus Medius muscle power 1	0.21	37	0	0.91	37	0.004
Average right gluteus Medius muscle power 3	0.11	37	.200*	0.98	37	0.64
Average left gluteus Medius muscle power 1	0.11	37	.200*	0.96	37	0.18
Average left gluteus Medius muscle power 3	0.07	37	.200*	0.99	37	0.90

Appendix 2: exercise schedule and exercise images

Testing using the Handheld Dynamometer

A

B

C

Appendix 2 Figure 1: muscle testing A: Quadriceps muscle strength testing. B: Gluteus medius muscle strength testing. C: Gluteus maximus muscle strength testing

Warming up exercises

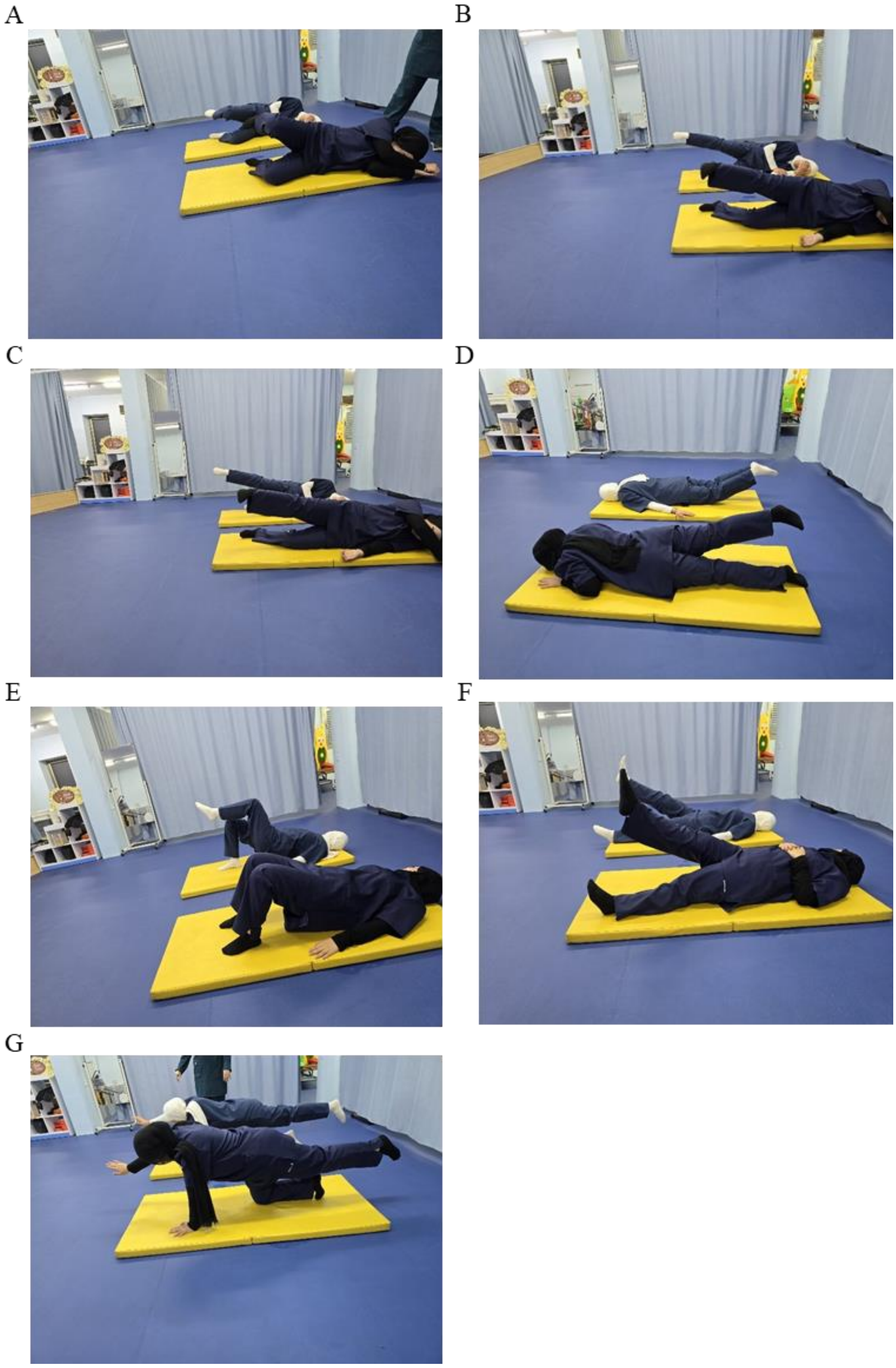
A

B

C

Appendix 2 Figure 2: warming up exercise. A: walking backward. B: walking forward. C: cycling on a static bike

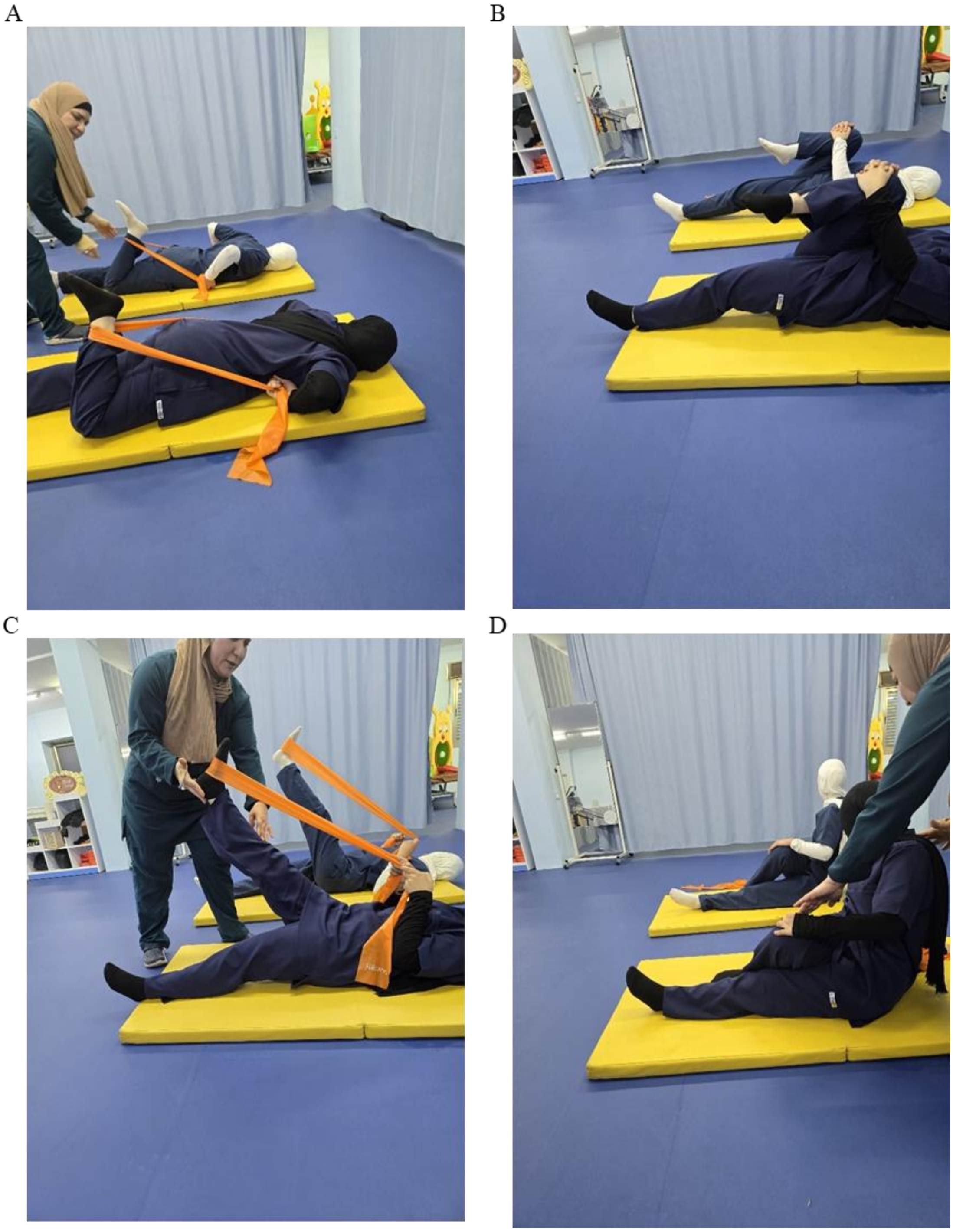
Strengthening exercises



Appendix 2 Figure 3: Strengthening exercises. A: clamshell exercise. B, C: lateral straight leg raises. D: reverse flutter exercise. E: bridging and half bridging exercise. F: straight leg raise exercise. G: bird dog exercise.

Appendix 2 Figure 4: Strengthening exercises. A: squatting exercise. B: standing single leg exercise. C: squatting exercise (lateral view). D: lateral step-up exercise, E: anterior set-up exercise.

Stretching exercises



Appendix 2 Figure 5: Stretching exercises. A: band-assisted quadriceps stretch. B: knee chest exercise, lying hamstring stretch with band. D: seated twist exercise.

Appendix 3: Research Data Sheet

Date:
Patient name:
Serial number (SN):
Past medical history:
Group:
Age
Occupation:
Status:
Living floor:
Family members:
VAS:0 1 2 3 4 5 6 7 8 9 10
Life style: sedentary, average, active, very active
Osteoarthritis grade: Side
Height: weight
Body mass index (BMI):
Data tools (outcome measurement):

- Goniometer:(to measure range of motion)

1-Range of motion right knee flexion (ROMRTNF)
2-Range of motion left knee flexion (ROMLTNF)
3-Range of motion right knee extension (ROMRTNE)
4-Range of motion left knee extension (ROMLTNE)

- Hand held dynamometer:(to evaluate isometric muscle strength):

1-Muscle power for right quadriceps (MPRTQ)
2-Muscle power for left quadriceps (MPLTQ)
3-Muscle power for right gluteus maximus (MPRTG)
4-Muscle power for left gluteus maximus (MPLTG)
5-Muscle power for right gluteus Medius (MPRTGM)
6-Muscle power for left gluteus Medius (MPLTGM)

- **Six-Minute Walk Test (6MWT): a measure of physical endurance;** the total distance walked during the test will be recorded.
- **30-second chair stand test (CTS):** (to assess mobility, functional lower extremity strength, and endurance in individuals)

Appendix 4: Self-Management Booklet

تعديل نمط الحياة

ممارسة النشاط البدني المنتظم

مثل المشي أو السباحة، وتجنب الأنشطة التي تضع ضغطا زائدا على الركبة.

اختيار الأحذية المناسبة

استخدام أحذية مبطنة تقلل من الضغط على الركبة.

تجنب الجلوس أو الوقوف لوقت طويل

يساعد ذلك في تقليل تصلب المفصل.

تجنب حمل الأوزان الثقيلة

يمكن أن يؤدي ذلك إلى تفاقم الألم وزيادة الضغط على المفصل.

التعلم عن تآكل مفصل الركبة

فهم الحالة

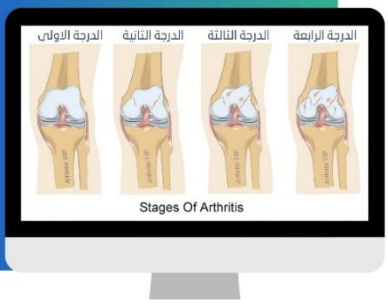
التعرف على أسبابها، مراحلها، والعلاجات المتاحة يساعد في اتخاذ قرارات صحية أفضل.

استشارة الأطباء والمختصين

للحصول على أحدث العلاجات والنصائح الشخصية.

متابعة الفحوصات الدورية

لمراقبة تطور الحالة وتعديل العلاج حسب الحاجة.



الإرشاد السلوكي المعرفي للنساء للتصرف الإيجابي

تقبل الواقع مع التفاؤل

هي اول خطوة في التفكير السليم الذي يساعد على التأقلم والتكيف والحد من تفاقم الألم والضغط على المفصل

ممارسة تقنيات الاسترخاء

مثل التأمل، التنفس العميق، واليوغا لتخفيف التوتر وتحسين الصحة العامة.

البحث عن الدعم الاجتماعي

الانشغال بنشاطات ممتعة يعزز الشعور بالرضا والتوازن النفسي.

وضع أهداف صغيرة قابلة للتحقيق

مثل المشي لمسافة قصيرة يوميًا أو ممارسة تمارين خفيفة.

ممارسة الهوايات

التحدث مع الأصدقاء، العائلة، أو مجموعات الدعم يساعد في تخفيف القلق.

اتباع هذه النصائح

يمكن أن يساعد في تحسين جودة الحياة للأشخاص الذين يعانون من تآكل الركبة. من المهم الالتزام بالعلاجات، تبني نمط حياة صحي، والمحافظة على التفكير الإيجابي لمواجهة التحديات اليومية.

Appendix 5: Self-Management Weekly Calendar Checklist

Patient name:

Date *Categories*	*1 W*	*2 W*	*3 W*	*4 W*	*5 W*	*6 W*	*7 W*	*8 W*	*9 W*	*10 W*	*11 W*	*12 W*
Pain management												
Healthy nutrition												
Lifestyle modification												
positive guidance behavior												
Behavior to avoid												

W=week

Always committed=3 / Often committed =2 / Sometimes committed =1/ Never committed =0

Total score =15 / 100%

Appendix 6: Ethical Approval

Al-Quds University
Jerusalem
Deanship of Scientific Research

بسم الله الرحمن الرحيم

جامعة القدس
القدس
عمادة البحث العلمي

Research Ethics Committee
Committee's Decision Letter

Date: February 11, 2025
Ref No: 497/REC/2025

Dears Dr. Hadeel Halaweh, Ms. Wafa Natsheh,

Thank you for submitting your application seeking approval for research ethics. After a thorough review of your submission titled "Efficacy of Quadriceps and Gluteal Strengthening, Self-Management Education, Low Intensity Laser Therapy Versus Education and Laser Therapy Alone on Knee Osteoarthritis Progression", the Research Ethics Committee (REC) at Al-Quds University is pleased to confirm that your application aligns with our research ethics guidelines. Please be aware that while this approval authorizes your research, it does not replace any departmental or other necessary approvals. These may include permissions for sample shipment, data sharing, or administrative approval to distribute questionnaires.

Additionally, we kindly request that you provide us with a copy of your final research report or publication once it is available.

Thank you once again for your commitment to conducting ethical research. We extend our best wishes for a productive research endeavor that benefits your research subjects.

Please note that this ethical approval letter is valid for two years from the date of issuance.
If your research extends beyond this timeframe, a renewal request will be necessary. This approval remains valid as long as there are no changes to the data collection procedures or any aspect of the research protocol.

Sincerely,

Suheir Ereqat, PhD
Associate Professor of Molecular Biology
Suheir Ereqat
Research Ethics Committee Chair

Cc. Prof. Imad Abu Kishek - President
Cc. Members of the committee
Cc. file

Abu-Dies, Jerusalem P.O.Box 20002
Tel-Fax: #970-02-2791293
research@admin.alquds.edu
أبوديس، القدس ص.ب. 20002
تلفاكس: 970-02-2791293#

Appendix 7: research participation consent form

<u>نموذج موافقة على المشاركة في بحث علمي</u>

عنوان الدراسة: فعالية تقوية العضلة رباعية الرؤوس وعضلات الالوية وتعلم الإدارة الذاتية والعلاج بالليزر منخفض الكثافة مقابل التعلم والعلاج بالليزر فقط في علاج تقدم التهاب وخشونة مفصل الركبة

الباحثة: وفاء صلاح النتشة

أوافق على المشاركة في هذا البحث العلمي بطوعية مع احتفاظي بالحق في الانسحاب من البحث في أي وقت ودون أي سبب مع العلم أنى قد بلغت بأهداف البحث والبيانات التي سيتم جمعها وكيفية التعامل مع هذه البيانات بعد الانتهاء من البحث.

واني على علم ان جميع المعلومات التي أدلى بها او يتم جمعها ستعامل بسرية تامة ولن تعلن باي شكل قد تؤدي الى التعريف بهويتي، كما أوافق على انه يمكن نشر بيانات البحث وان هذه الدراسة خاضعة للبحث العلمي فقط.

قد تم شرح حقوقي المتضمنة:

- سرية المعلومات وعدم اطلاع أي شخص عليها وتخزينها في مكان امن لا يصل اليه سوى الباحث
- استخدام المعلومات للأغراض العلمية البحثية فقط
- حقي في الاطلاع على نتائج البحث النهائية
-

اسم المشاركة: ....

توقيع المشاركة: ....

التاريخ: ....

شاكرين لكم حسن تعاونكم.

فعالية تقوية العضلة الرباعية الرؤوس والألوية، والتثقيف حول الإدارة الذاتية للحالة، والعلاج بالليزر منخفض الكثافة مقابل التثقيف والعلاج بالليزر وحده في علاج تطور خشونة مفصل الركبة

اعداد: وفاء صلاح النتشة

اشراف: د. هديل حلاوة

الملخص

الخلفية: خشونة مفصل الركبة هو اضطراب تنكسي تدريجي يُقلل من حركة المفصل ووظيفته. على الرغم من وجود مناهج علاجية متنوعة، إلا أن التأثير المشترك لتقوية عضلات الفخذ الرباعية، والعضلة الألوية الكبرى، والعضلة المتوسطة لدى النساء المصابات بفصال الركبة العظمي لم يُثبت بشكل قاطع.

الأهداف: دراسة تأثير تقوية هذه المجموعات العضلية على الألم والقوة والقدرة على التحمل ومدى الحركة والوظيفة العامة لدى النساء المصابات بمتلازمة خشونة الركبة من الدرجة الأولى إلى الثالثة. وكان الهدف الثانوي تحديد ما إذا كان العلاج بالليزر منخفض الكثافة يُحسّن هذه النتائج.

الطريقة: قُسِّمت 37 امرأة تتراوح أعمارهن بين 45 و65 عامًا مصابات بمتلازمة خشونة الركبة إلى مجموعتين: مجموعة التدخل (عددهن 18) ومجموعة الضبط (عددهن 19) لدراسة استمرت ثلاثة أشهر . تلقَّت مجموعة التدخل برنامجًا مُنظَّمًا لتقوية العضلات، بالإضافة إلى الليزر منخفض الكثافة وكتيب للإدارة الذاتية، بينما تلقَّت مجموعة الضبط ليزر منخفض الكثافة وكتيب للإدارة الذاتية. قُيِّست النتائج باستخدام مقياس التناظر البصري لقياس الألم، وقياس الديناميكية اليدوي، واختبار المشي لمدة 6 دقائق، واختبار الجلوس والوقوف لمدة 30 ثانية وقياس المدى الحركي في الركبة واخيرا ستماره ووماك لاختبار النشاط الوظيفي والالم وتيبس مفصل الركبة.

النتائج: بلغ متوسط أعمار المشاركين 52 ± 10 سنوات. أظهر اختبار مجموعة التدخل تحسنا ذا دلالة إحصائية مقارنةً باختبار مجموعة الضبط في الألم(الدلالة الإحصائية=004,) واختبار 6 دقائق مشي(الدلالة الإحصائية =004,) واختبار عدد مرات الوقوف في 30 ثانية(الدلالة الإحصائية له =002,) كما لوحظت أحجام تأثير كبيرة أو متوسطة في قوة العضلات، بما في ذلك قوة العضلة الرباعية اليمنى(الدلالة الإحصائية 017,) وعضلة الألوية الكبرى اليمنى(حجم التأثير=6,) وعضلة الألوية الكبرى اليسرى (الدلالة الإحصائية =025,) .كشف التصنيف العمري (55≤ و55≥) عن اختلافات كبيرة، وتحديدًا في اختبار 6 دقائق من المشي (الدلالة الإحصائية=012,) وعدد مرات الوقوف خلال 30 ثانية (الدلالة الإحصائية=010,) ومع ذلك، لم يظهر التقسيم الطبقي حسب شدة الإصابة بخشونة الركبة (الدرجات الأولى إلى الثالثة) أي اختلافات كبيرة (الدلالة الإحصائية اكبر من05,) في الألم بعد التدخل، أو الحركة الوظيفية، أو قوة العضلات.

الاستنتاج: إن تقوية عضلات الفخذ الرباعية وعضلات الورك الباسطة/المبعدة تؤدي إلى تحسينات فائقة في الألم والقوة والقدرة على التحمل مقارنة بعلاج الليزر منخفض الكثافة وحده، على الرغم من أن علاج الليزر منخفض الكثافة لا يزال يساهم في تقليل الألم والقدرة الوظيفية.

الكلمات المفتاحية: التهاب مفاصل الركبة، الليزر منخفض الكثافة، تمارين التقوية، برنامج الإدارة الذاتية