Effect of Maitland Mobilization with Low Level Laser Therapy in Treatment of Patients with Knee Osteoarthritis

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ABSTRACT

Background: *Osteoarthritis is the most common joint disease affecting mostly the knee joint and characterized by progressive loss of articular cartilage, subchondral sclerosis, and joint space narrowing.*

Purpose: *To assess the effectiveness of low-level laser therapy (LLLT) with Maitland mobilization for patients suffering from chronic knee osteoarthritis.*

Subjects and methods : *Randomized controlled trial including 75 male and female individuals, with age ranging from 50 to 65 years distributed among three groups randomly. Group A was administered LLLT and the Maitland mobilization in addition to conventional physical therapy (CPT) , group B underwent LLLT and CPT and group C underwent Maitland mobilization and CPT. The intensity of pain was measured utilizing a visual analog scale (VAS), pressure pain threshold (PPT) estimated by pressure algometer, measurements of range of motion (ROM) performed using a digital goniometer, while functional abilities assessed by KOOS-PS, a short form for knee injuries and osteoarthritis outcome.*

Results: *The study revealed non statistically noteworthy variations in the mean values of pain among the three groups pre study ($p = 0.896$) and post study ($p = 0.189$), no significant variation in the average values of PPT (right and left) knees pre study ($p = 0.813$ and 0.836) and post study ($p = 0.122$ and 0.384) respectively also no significant variations in the mean values of KOOS-PS pre study ($p = 0.425$), and post study ($p = 0.101$).*

Conclusion: *Findings of the study indicate that LLLT along with Maitland mobilization had the same effect as using one of these modalities alone.*

Keywords: *Chronic knee osteoarthritis, Low-level laser therapy, Maitland mobilization.*

INTRODUCTION

Osteoarthritis (OA) is the most frequently seen deteriorating musculoskeletal condition affecting joints, primarily targeting the knees and hips as the primary joints that bear the body's weight [1]. Knee osteoarthritis is distinguished by changes not only in the primary articular cartilage but also in subchondral bone, synovia, ligaments, muscles and Hoffa's fat pad. This supports the perspective of viewing OA as a comprehensive joint disorder [2]. Based on data from the Global Burden of Disease and Injury Incidence and Prevalence Collaborators, about 85% of the global impact of OA is attributed to knee OA. The global prevalence of knee osteoarthritis has surged by 32.7% from 2005 to 2015, making OA plays a vital role in years lived through disability worldwide [3]. Advanced age, previous knee injuries, obesity, joint improper alignment, instability leading to additional mechanical stress, and repetitive actions like frequent kneeling and heavy lifting are all notable risk factors strongly related to the onset and progression of knee OA [4].

The primary goals of managing Knee OA include alleviating pain, preserving and enhancing mobility, and limiting physical impairments. Various guidelines currently exist for OA management, primarily derived from the evidence of interventions such as patient awareness, pharmacological and non-pharmacological therapies, and surgical options [5]. Knee osteoarthritis is correlated with pain and physical impairment, expensive treatment cost, absence from work and reduced productivity resulting in a significant and increasing societal burden [6]. Non-steroidal anti-inflammatory drugs (NSAIDs), the most frequently recommended drugs for knee OA, are known to have severe adverse effects. Elderly subjects with osteoarthritis often have coexisting health conditions that elevate the risk of drug interactions [7].

Numerous non-pharmacological interventions, including acupuncture, ultrasound, electrical nerve stimulation (TENS), exercise programs, laser therapy (LLLT), and various manual therapy techniques like Maitland mobilization, are categorized as non-invasive and safe treatments options for osteoarthritis [8].

The Maitland concept involves a systematic approach to evaluating, assessing, and treating musculoskeletal disorders through manipulative physiotherapy techniques. It employs a series of oscillatory mobilization techniques tailored to treat the pathological limit of the joints [9]. Mobilization generates numerous positive effects by stimulating peripheral mechanoreceptors, inhibiting nociceptors and enhancing synovial nutrition, all contributing to pain reduction. Local mechanical changes can also influence the chemical environment, potentially lowering concentrations of inflammatory mediators and further decreasing pain sensation [10]. Tsokanos et al. [11] carried out their systematic review to explore manual therapy effectiveness in subjects with knee OA, it was discovered that manual therapy techniques can have a favorable impact on knee OA management by diminishing pain levels and improving overall functionality.

The application of laser therapy is extensively employed for treating different musculoskeletal conditions. The key advantages of LLLT include alleviation of pain and enhancement of functionality. LLLT has been shown to influences the healing process at all its stages (inflammatory, remodeling, and proliferative phases). Furthermore, the analgesic effects of LLLT are facilitated by the inhibition of synaptic activity in second-order neurons, hence preventing activation of cerebral cortex pain processing region [13].

It's shown that LLLT can relieve pain related to inflammation by reducing the amount of inflammatory mediators particularly tumor necrosis factor-alpha (TNF-alpha), prostaglandin E2 (PGE2) and also interleukin-1 beta (IL-1 beta), which hinder collagen synthesis and cell proliferation, leading to pain and tissue damage [13,14]. Stausholm et al. [15] in their systematic review revealed that LLLT leads to pain reduction and improved functionality in knee osteoarthritis (OA) when administered at dosages of 4–8 Joules with wavelengths between 785–860 nanometers, and at 1–3 Joules with a wavelength of 904 nanometers for treatment point.

Earlier trials have checked the effectiveness of mobilization or manipulation techniques along with LLLT for pain management in different body regions such as the shoulder and lumbar spine [16,17]. However, a study examining the treatment effects of Maitland mobilization along with LLLT on patients suffering from chronic knee OA pain has not been conducted to date up to the researcher knowledge. Therefore, this trial was carried out to assess the combined treatment outcomes of Maitland mobilization along with LLLT on pain intensity, pressure pain threshold, ROM , and functional abilities in individuals with grade II and III chronic Knee OA.

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MATERIALS AND METHODS

Study design: This randomized controlled trial including both pre-tests and post-tests was conducted at Physical Therapy faculty, Cairo University outpatient clinic. The required sample size was determined according to previous studies excuted by Aftab Ahmad [18] and Ahmad Alghadir et al. [19], which reported mean Visual Analog Scale (VAS) scores post-treatment as 3±1.25 for low-level laser therapy and 1.6±1.4 for Maitland mobilization. To identify a significant difference in means among these groups with a 80% power, 0.8 effect size and 5% significance level, a total sample size of 78 patients was calculated. This translates to 26 patients in each group. The sample size estimation was conducted using G*Power software (version 3.1.9.2; Germany).

Participants: Out of 94 patients initially referred by their physicians for assessment, 14 individuals did not meet the inclusion criteria. After randomization, 5 patients withdrew from the trial ; among them, three failed to attend all of their scheduled treatment sessions without providing clear reasons. The remaining two patients dropped out due to the ongoing coronavirus situation. Consequently, seventy-five patients in total fulfilled the study successfully. The flow of selection of participants is shown in figure 1.

Subjects recruited for the study were diagnosed and referred by orthopedists with bilateral knee osteoarthritis grades II and III, aged between 50 and 65 years, based on the standards established by the American College of Rheumatology. These standards include knee pain as well as presence of a minimum of three of the following criteria: being ≥50 years old, experiencing ≤30 minutes of morning stiffness, exhibiting crepitus during active motion, having bony tenderness or enlargement, and no detectable warmth of synovia [20]. Only subjects diagnosed with osteoarthritis in X-ray stages II and III, as per the Kellgren & Lawrence classification system [21], were selected. Additionally, patients having a body mass index (BMI) equals 30 or lower, experiencing knee pain for a duration of not less than 6 months with a severity of not less than 3 on the Visual Analog Scale (VAS) while performing activities such as sitting, squatting and climbing stairs. Also individuals with normal mental conditions, and those who had not participated in physical therapy programs in the last three

months were included in the trial [22]. Subjects were excluded if they presented with medical history of autoimmune diseases, infection, tumor, previous trauma, gout or any other causes of knee pain or deformities [23], patients with neurologic and cognitive dysfunctions, a history of chronic diseases that could potentially impact the study outcomes, or patients who had underwent knee intra-articular injections during the last 6 months [22].

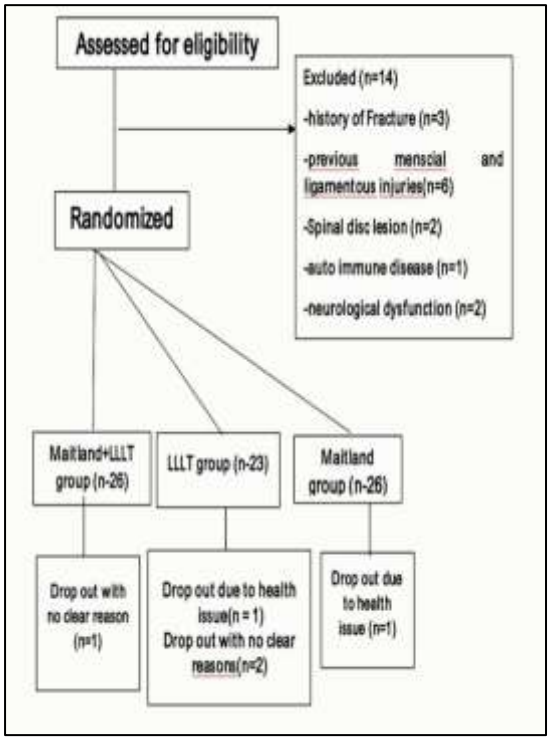

Figure 1: schematic presentation of sample allocation.

The Research Ethical Committee of the Faculty of Physical Therapy, Cairo University, granted ethical approval for all procedures in this study. The approval number is P.T.REC/012/003616. Furthermore, the study has been officially registered on ClinicalTrials.gov with the identification NCT06233955

Randomization was accomplished by asking the patients randomly select closed envelopes from a bowl containing an equal number of papers labeled with either letter A, B, or C, corresponding to one of the treatment groups [24]. The participants remained blinded to their group assignment throughout the study duration. They were informed that they would receive treatment for knee osteoarthritis without specific details regarding the treatment type.

Participants were allocated into three groups using random assignment:

1- Group A: Twenty six subjects underwent Maitland mobilization along with LLLT and conventional physical therapy treatment.

2- Group B: Twenty three subjects underwent LLLT along with conventional physical therapy treatment.

3- Group C: Twenty six subjects received Maitland mobilization along with conventional physical therapy treatment.

Measurements procedures:

The outcome measures assessed in the trial were pain intensity assessed utilizing the Visual Analog Scale, pressure pain threshold calculated using pressure algometer, range of motion (ROM) evaluated using a digital goniometer and patients' self-reported knee joint function level evaluated utilizing the Knee Injury and Osteoarthritis Outcome Score (KOOS-PS). All participants underwent assessments at baseline and after completing the final treatment session.

For pain intensity assessment the participant was asked to make a mark on the horizontal line representing how much pain was being experienced. The consolidated question for all participants was as follows: identify how your pain is felt during the past period by marking a mark (x symbol) on the horizontal line [25].

Pressure threshold was assessed at most tender spot on the medial knee joint line identified by palpation [20] approximately 3 cm medial to the midpoint on the medial edge of the patella

[26]. The algometer was placed and the pressure increased at approximately 1 kg/s until the participant indicated the pressure had turned to pain [27,28].

The algometric measurements were performed while the patient was in the side-lying position [29] with the knee flexed at 90 [30].

Figure 2 : Pressure pain threshold measurment procedure.

To measure the ROM, each participant was asked to lie in the supine lying position with the knee joint clear of clothes. Then, the fulcrum of goniometer was placed on the lateral epicondyle of the patient's femur, and the stationary arm of the goniometer was aligned with the midline of the femur, using the greater trochanter as a reference. After that, the participant was asked to bend her/his knee as much as they could without pain; while the moving arm of the goniometer was aligned parallel to midline of fibula pointed to the lateral malleolus of the participant. Three measurements were taken each time, and the mean of the three measurements was recorded [25].

For knee functional level assessment the patient was asked to answer the questions of the 7 items concerning level of function on performing usual daily level activities and level of difficulty they have experienced in the past week. Item responses are coded from 0 to 4, none to extreme respectively. The questionnaire is scored by summing the raw response (range 0-28) and then using the nomogram so the raw score is converted to a true interval score (0-100) where zero means no difficulty and 100 means extreme difficulty.

Treatment Procedures:

The gallium-arsenide (Ga-As) laser device used had specifications of 850 nm wavelength, 100 mW power output, and a 1.0 mm spot size (Model IDEA, Class I type B, S.N 00003165). The transcutaneous electrical stimulation (TENS) device employed was the Chattanooga device (MDD: Class IIa IP class: IP Applied part: Type BF). Both devices underwent inspection by a maintenance specialist before each initial treatment session. Subsequently, the participants were allocated at random to one of three groups following baseline data collection and assessments. All patients received 15 min of heat from electrical hot back wrapped in a soft towel put around the knee before beginning the main treatment. Conventional physical therapy comprising of TENS and prescribed strengthening and stretching exercises [31].

In Group A, patients underwent LLLT on six acupuncture points, followed by 20 minutes of TENS application, Maitland mobilization, and a structured exercise program involving stretching and strengthening exercises. During LLLT sessions, patients were positioned supine with the treated knee slightly held in flexion by a rolled towel. The laser targeted six acupuncture points commonly utilized in knee osteoarthritis treatment: SP 9, SP 10, GB 34, ST 34, ST 35 and EX-LE4 [32], using a 50 mW, 850 nm laser for 60 s per point, delivering 6 J/point and a total energy delivered per session was 36 J/cm2 for 6 minutes [19].

TENS treatment was delivered by placing two electrodes on the medial and

lateral joint lines, using a frequency of 100 Hz frequency, 50-100 us pulse width, and intensity set to the individual's tingling threshold for 20 minutes [22].

Maitland mobilization techniques in the form of Grade II & III glides were applied in the patello-femoral and tibio-femoral joints, ranging from two to three oscillations per second for one to two minutes and adjusted in accordance with the patient comfort and response [33,34].

Figure 3: Tibiofemoral anterior glide from prone position.

The exercise program included both strengthening and stretching exercises. The strengthening exercise program consisted of isometric quadriceps, hamstrings, and Vastus Medialis Obliques (VMO) exercises with a hold for 10 seconds rest 6 seconds, 3 sets of 10 repetitions with 2 minutes of rest between every set, meanwhile the stretching exercise program included quadriceps and hamstring stretches with hold of 30 sec repeated 3 times [35,36].

Subjects in group B was given LLLT followed by TENS and finally the previously explained exercises, while Group C was given TENS, Maitland mobilization, and the exact same exercises.

Data analysis:

Demographic data and collected variables was analyzed using descriptive statistics such as mean, frequency and standard deviation. MANOVA was employed to compare means between and within groups. All statistical tests have a significance level set at $p > 0.05$. Statistical analyses were carried out using SPSS Version 25 for Windows, provided by IBM SPSS, located in Chicago, IL, USA

Results

Demographic characteristics

No statistically significant variations were seen among the three groups concerning age, height, weight and BMI ($p>0.05$). Additionally, there were no noticable variations observed among the groups by means of gender distribution and the grades of right and left knee osteoarthritis.

Table 1. General characteristics of subjects of three groups.

Subject characteristic	Group A	Group B	Group C	f-value	p-value
Age (years)	**56.2 ± 7**	60.2 ± 5.7	57.8 ± 8.5	2.062	0.135
Weight (kg)	**81.8 ± 10.8**	82.5 ± 12.5	80.2 ± 8.3	0.293	0.747
Height (cm)	**166.3 ± 7.2**	165.4 ± 8.2	163.7 ± 8.2	0.701	0.500
BMI (kg/m^2)	**29.6 ± 3.6**	30.1 ± 3.9	30 ± 3.3	0.143	0.867
Sex N (%) Male Females	 3 (12%) 22 (88%)	 4 (16%) 21 (84%)	 5 (20%) 20 (80%)	χ^2 =0.595	0.743

Grade of right OA Grade 2 Grade 3	 11 (44%) 14 (56%)	 9 (36%) 16 (64%)	 9 (36%) 16 (64%)	χ^2 =0.450	0.799
Grade of left OA Grade 2 Grade 3	 9 (36%) 16 (64%)	 7 (28%) 18 (72%)	 13 (54%) 12 (46%)	χ^2 =3.14	0.207

VAS scores

The VAS scores indicated a significant improvement in pain for all three groups when comparing pre and post interventions. The mean values ± SD of pain scores pre-study for group A were 6.15 ± 1 and post-study were 3.38 ± 0.9 (p = 0.001), for group B pre-study were 6 ± 1 and post-study were 3.8± 0.8 (p = 0.001), and for group C pre-study were 6.06 ± 1.13 and post-study were 3.7 ± 0.9 (p = 0.001). There were no notable variations in the mean pain values among the three groups both pre-study (p = 0.896) and post-study (p = 0.189).

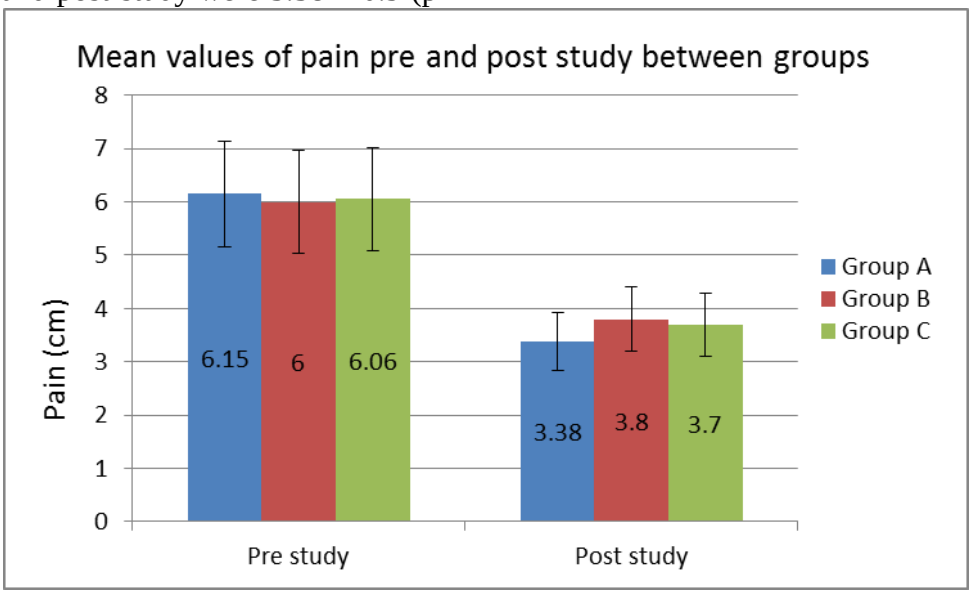

Figure 4 : Mean values of pain pre and post-study between groups

Pressure pain threshold scores

The mean values ± SD of PPT for both right and left knees pre-study in group A were (4.5 ± 1 and 4.6 ± 1) kg, and post-study were (6 ± 0.9 and 6 ± 0.9) kg, respectively (p = 0.001). For group B, pre-study values were (4.4 ± 1.1 and 4.7 ± 0.9) kg, and post-study were (5.6 ± 0.6 and 5.8 ± 1) kg, respectively (p = 0.001). Group C had pre-study values of (4.6 ± 1.1 and 4.5 ± 0.86) kg, and post-study were (5.5 ± 0.88 and 5.6 ± 0.8) kg, respectively (p = 0.001). There were no noteworthy changes noticed in the mean PPT values for both right and left knees between the three groups pre-study (p = 0.813 and 0.836) and post-study (p = 0.122 and 0.384) respectively.

Range of motion scores

The mean values ± SD of knee flexion (right and left) pre-study in group A were (121.3 ± 4.5 and 121.1 ± 2.8) degrees, and post-study were (125.3 ± 4.2 and 124.6 ± 2.9) degrees, respectively (p = 0.001). For group B, pre-study values were (121.6 ± 2.2 and 121.6 ± 2.4) degrees, and post-study were (123.8 ± 2.1 and 123.6 ± 2.3) degrees, respectively (p = 0.001). Group C had pre-study values of (122.1 ± 2.3 and 121.7 ± 1.7) degrees, and post-study were (125.8 ± 2.4 and 125.1 ± 2) degrees, respectively (p = 0.001). No significant

variations in the mean knee flexion values were detected among the three groups pre-study (p = 0.623 and 0.635) and post-study (p = 0.070 and 0.102), respectively.

The mean values ± SD of knee extension (right and left) pre-study in group A were (174.6 ± 1.7 and 174.8 ± 1.8) degrees, and post-study were (177.5 ± 1.3 and 177.8 ± 1.2) degrees, respectively (p = 0.001). For group B, pre-study values were (175 ± 1.6 and 174.8 ± 1.9) degrees, and post-study were (176.5 ± 1.5 and 176.9 ± 1.7) degrees, respectively (p = 0.001). Group C had pre-study values of (175.1 ± 1.9 and 175.6 ± 1.5) degrees, and post-study were (177.1 ± 1.9 and 177.5 ± 1.1) degrees, respectively (p = 0.001). No significant variations in the mean knee extension values were determined among the three groups pre-study (p = 0.523 and 0.200) and post-study (p = 0.085 and 0.089), respectively.

The Knee Injury and Osteoarthritis Outcome Scores

The mean values ± SD of KOOS-PS pre-study in group A were 43.8 ± 5.6 and post-study were 35.4 ± 4.9 (p = 0.001). For group B, pre-study values were 41.9 ± 4.7 and post-study were 37.4 ± 4.4 (p = 0.001). Group C had pre-study values of 42.3 ± 5.6 and post-study were 38 ± 3.8 (p = 0.001). There were no noticable changes noticed in the mean KOOS-PS values among the three groups pre-study (p = 0.425) and post-study (p = 0.101).

DISCUSSION

Knee osteoarthritis represents a significant global contributor of pain and disability. Our study is the first of its kind to explore how combining LLLT and Maitland mobilization affects chronic knee osteoarthritis. Despite osteoarthritis affecting females and males aged 55–65 at a ratio of 1.7:1, our study participants were exclusively women. This could be due to differences in pain tolerance influenced by sociocultural factors [37]. Research indicates that women generally experience more chronic or experimental pain and have lower pain thresholds. Other factors such as personal experiences, positive family dynamics, and various sociodemographic or cultural factors may also contribute to why women make up the majority of those reporting knee pain [38].

According to our study findings, all three groups demonstrated a noteworthy difference in pain reduction and improved knee joint range of motion (ROM) and function, as indicated by VAS and KOOS-PS scores, before and after interventions. However, a combination of LLLT and Maitland mobilization did not yield superior results compared to either therapy alone. Our findings aligned with a comparative study on the results of photobiomodulation and manual therapy either individually or in combination for individuals with tempo mandibular disease (TMD). The study revealed that the combined use of photobiomodulation and manual therapy did not enhance their individual effectiveness [39].

The primary outcome of the current trial was the change in VAS scores for pain experienced while performing movement. Lee et al. [40] reported a decrease of 3 cm in the Visual Analog Scale (VAS) mean measurement scores is considered clinically significant in terms of pain severity. Our study's within-group analysis revealed that OA symptoms had substantially improved across all three groups as determined by a decreased VAS score for knee pain. Notably, this improvements achieved a statistically and clinically significant level in group A by 45% where patients received LLLT and Maitland mobilization. This improvement surpassed the minimal clinical important improvement (MCII) for pain intensity in knee OA, which is stated to be 40.8% on a visual analog scale (VAS) according to Tubach et al. [41], specifically regarding pain during movement. However, there were no significant variations in pain

reduction throughout the three groups post-study.

Group C, where patients received Maitland mobilization, exhibited a slightly higher improvement in VAS scores by 39% ($p = 0.001$) compared to Group B, where patients underwent LLLT, with a 37% improvement ($p = 0.001$). The pain-reducing impact of Maitland mobilization was described by Kumar & Ganesh [42], who explained that these techniques are beneficial for painful joints because the oscillations may inhibit pain perception by provoking mechanoreceptors, thus effectively blocks the propagation of pain signals through the spinal cord and brain stem. Mobilization aids in fluid exchange, enhancing venous drainage and dispersing chemical irritants. This process reverses the cycle of ischemia, inflammation, and edema leading to reduced joint effusion and easing of pain experience by alleviating pressure on nerve endings [9].

The second outcome of this study focused on changes in Pressure Pain Threshold (PPT). Lacourt et al.[43], in their investigation of PPT reliability and convergence, recommended aggregating PPT values across different body points into a single mean PPT, particularly averaging bilateral body points. In our study, as we measured the same points on both sides (right and left), the mean PPT values post-intervention were as follows: Group A (Maitland + laser) had a mean value of 6 kg, Group B (laser) had a mean value of 5.7 kg, and Group C (Maitland) had a mean value of 5.55 kg. There was no statistically noticable variations in PPT values among the three groups post-intervention, although Group A exhibited a slightly higher mean value compared to the other groups.

The laser therapy group exhibited a marginally greater mean PPT when compared to the Maitland mobilization group. The variation could be ascribed to the LLLT anti-inflammatory role of which may reduce joint line tenderness. Studies like Nambi [44] have highlighted that LLLT can effectively reduce inflammation markers like IL-1β, TNF-α, and MMP-13, modulate inflammatory cell proliferation, and promote the release of anti-inflammatory markers such as prostaglandin E2 (PGE2) and osteocalcin. Additionally Giuliani et al. [45] observed that LLLT' was beneficial in minimizing edema and pain experienced in inflammatory conditions when applied at specific acupuncture points.

According to the study findings regarding knee range of motion (ROM), all three groups clinically improved in flexion ROM, with the most significant improvements seen in group A (Maitland and LLLT group) and group C (Maitland group). The improved ROM is most likely the result of the mechanical force applied during mobilization, which breaks up adhesions, realigns collagen fibers, and maintains joint mobility through assisting synovial fluid exchange and joint lubrication [46].

The observed improvements in ROM could also be attributed to the exercise programs, including stretching and strengthening exercises provided to all groups. Regular exercise is known relieve pain, increase joint stability, and enhance functionality in subjects with knee OA [47].

Finally for the knee joint functional level, The three groups considered clinically improved with the most functional improvements was in group A where patients underwent Maitland and LLLT. The joint mobilization techniques along with therapeutic exercises in this study contributed to pain reduction, increased extensibility of tissues, enhanced joint lubrication, improved proprioception, and overall functional improvement in knee osteoarthritis patients [48]. Furthermore, patient education play a crucial role in managing symptoms and enhancing

overall quality of life for individuals suffering from knee osteoarthritis [49].

Limitations of the study:

Firstly there were no measures taken to assess or manage the daily activities's duration and frequency such as standing, walking, and stair climbing, which could have influenced the outcomes. Also the avoidance of analgesics by participants is a factor that cannot be fully controlled by the therapist and may have affected the pain scores reported during the study. A further limitation is the absence of an extended follow-up period beyond three months, which could have provided insights into the sustainability of the treatment effects over time.

CONCLUSION

According to the findings of the present data, it can be stated that the combined application of LLLT and Maitland mobilization techniques yielded similar outcomes to using either of these modalities alone with regard to the pain intensity reduction and improving functional abilities in subjects with chronic knee OA.

Recommendations:

Future studies could be undertaken to evaluate additional variables related to the functional abilities of the knee joint. Additional research focusing on the long-term effects of combining LLLT and Maitland mobilization technique is also required. Similar investigations could be extended to other conditions such as mechanical neck pain to broaden our understanding of the efficacy of these combined therapies across different musculoskeletal issues.

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