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Effects of a combined low-level laser therapy and strengthening exercise program on pain perception and quality of life in office workers with chronic non-specific neck pain

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Abstract

Musculoskeletal disorders (MSDs) are commonly found among office workers, especially neck pain. This study evaluated the effectiveness of low-level laser therapy (LLLT) plus strengthening exercises on pain, neck flexibility, and quality of life in office workers with chronic non-specific neck pain. Thirty-six participants, aged between 25 and 40 years, were randomly divided into two groups: 18 received LLLT and strengthening exercises, while 18 received sham LLLT and the same exercises. The average body mass index (BMI) was 25.52 ± 5.08 in the LLLT group and 23.01 ± 3.34 in the sham group. Results revealed that the LLLT group experienced a significant reduction in pain compared to the sham group, as measured by a pain scale ($p < 0.05$). Both groups showed increased flexibility in all directions, but the LLLT group had significant improvements in flexion, right lateral flexion, and left rotation ($p < 0.05$). For quality of life, the LLLT group showed significant improvements in physical functioning, bodily pain, and general health on a standard quality-of-life questionnaire ($p < 0.05$). In conclusion, combining LLLT with strengthening exercises was more effective than sham LLLT and exercises in reducing pain perception, increasing neck flexibility, and improving quality of life in office workers with chronic non-specific neck pain.

Keywords: Low-Level Laser Therapy, Exercise, Pain, Quality of Life, Neck pain

1. Introduction

Musculoskeletal disorders (MSDs) are among the most common work-related problems, especially for office workers. There is ordinarily no single cause of MSDs. Instead, various risk factors often contribute to MSDs, including work accidents, repetitive trauma, muscle weakness, degeneration of joints, and poor postures. It has been suggested that overuse of certain muscle groups, repetitive movements, static positions, awkward postures, and manual handling of tasks are risk factors for developing musculoskeletal symptoms [1]. According to a prevalence study, the most common body parts affected were the neck and shoulders which varies from 42% to 63 % [2]. Therefore, neck pain is one of the most critical health issues worldwide because of office syndrome [3].

Office workers are frequently exposed to prolonged sitting, especially with poor workstation ergonomics, which may cause prolonged static contractions of muscles. This prolonged poor posture could put more pressure on the intervertebral discs and produce excessive tension on the surrounding tendons and muscles. Consequently, poor tissue flexibility, abnormal spinal curvatures, and weakened paravertebral muscles may develop. In more chronic cases, such changes may increase the risk of musculoskeletal damage in the spine [4, 5]. The symptoms can lead to disability and the need to give up work, adversely affecting job performance and quality of life.

While current guidelines for managing chronic neck pain provide vague recommendations regarding the preferred type of exercise [6], physical exercise has been suggested to treat musculoskeletal disorders. It was demonstrated that strengthening exercises could decrease pain [7-10]. A systematic review reported that strengthening exercises of the neck and shoulders, and general fitness training effectively reduced neck pain in office workers, with large effect sizes for strengthening exercises [2]. Another systematic review by Shereen Louw et al [11], found that participants in four out of five studies who received strengthening exercises showed significantly reduced neck pain and improved quality of life in office workers with neck pain.

Low-level laser therapy (LLLT) is considered part of light therapy as well as part of physiotherapy. It has been used to treat musculoskeletal disorders for decades. The wavelength of the light is within the range of 100 to 10000 nm in the electromagnetic spectrum [12]. This device has little to no thermal effect, has a stimulating effect on the target tissue, and is used to treat a variety of musculoskeletal disorders to relieve pain, reduce inflammation, promote wound healing, stimulate collagen metabolism, and aid in fracture healing [13]. A systematic review on the effects of LLLT on neck pain included 17 trials [13]. They found evidence that LLLT provided advantages for pain reduction, improved neck function, and quality of life in patients with neck pain. A meta-analysis and systematic review from randomized controlled trials on LLLT and neck pain reported that LLLT may cause a rapid decrease in pain for acute neck pain and up to 22 weeks after treatment in chronic neck pain patients [14]. Aligur et al [15], studied the effects of LLLT in managing chronic myofascial pain and found that it showed significant improvements in pain, depression score, some trigger points, functioning, and quality of life ($P<0.01$).

The main mechanisms by which LLLT produces analgesic effects that are believed to involve elevating pain thresholds, resulting in neural blockade of A and C nerve fibers and stimulating endogenous opioid release [14]. On the other hand, the mechanisms of strengthening exercise on pain reduction may be due to major changes. First is adaptation of the muscle fibers. The direct relationship between the increased cross-sectional area of the muscle and the generation of increased force during maximal muscle contraction has been shown [16]. Second is neural adaption in the degree to which the motor units can activate the muscle. Increases in the surface electromyography signals appeared well before the muscle had increased in size, and changes in coordination and learning of motor unit synchronization were found [17, 18]. These components can be critical to diminishing the burden of neck pain and improving the quality of life for office workers. Compared to ultrasound therapy, LLLT was found to be more effective in pain reduction in nonspecific low back pain patients [19]. Moreover, it is relatively safer and could be used as a home-use device for patients with musculoskeletal disorders. Combining LLLT and strengthening exercises may provide more therapeutic effects in decreasing neck pain in office workers. However, these effects have not been validated. Therefore, this study aims to investigate the benefit of LLLT and strengthening exercise on neck pain in office workers. The findings of this study may provide an alternative treatment for office workers to prevent and reduce musculoskeletal pain in the neck, thus improving the quality of their lives.

2. Materials and methods

2.1 Study design

A single-blinded randomized controlled trial (blinded the participants using a sham LLLT) was used to investigate the immediate and short-term effects of combined LLLT and strengthening exercises on pain, cervical range of motion, neck muscle strength, upper trapezius tissue hardness and tenderness, and the quality of life of office workers with non-specific neck pain.

2.2 Participants

Participants were office workers recruited from the Nakhon Ratchasima Rajabhat University. They were males and females, aged 25-40 years old, who had neck pain for more than three months (chronic stage) and a pain score on the VAS of not less than 3 out of 10. Participants with one of the following conditions were excluded: a history of accident or surgery on the head, neck, or arm, pain in more than three body regions, a history of fracture in the upper extremity, neurological pathologies, a history of cancer or tumors within the body, a history or joint disability and joint instability of the spine or neck, and being pregnant.

The sample size for this study was determined using the G*Power software program. As the main outcome of this study, the sample size was calculated using data from the Visual Analog Scale in the pilot study. The experimental group had a mean of 1.90 and a standard deviation of 1.10, with 10 participants, while the control group had a mean of 0.50 and a standard deviation of 1.35, also with 10 participants. The parameters for sample size estimation were set at 80% power of the test and 0.05 alpha level. Finally, thirty-six participants were included. Simple random assignment by manual drawing method, was used to allocate eighteen participants per group.

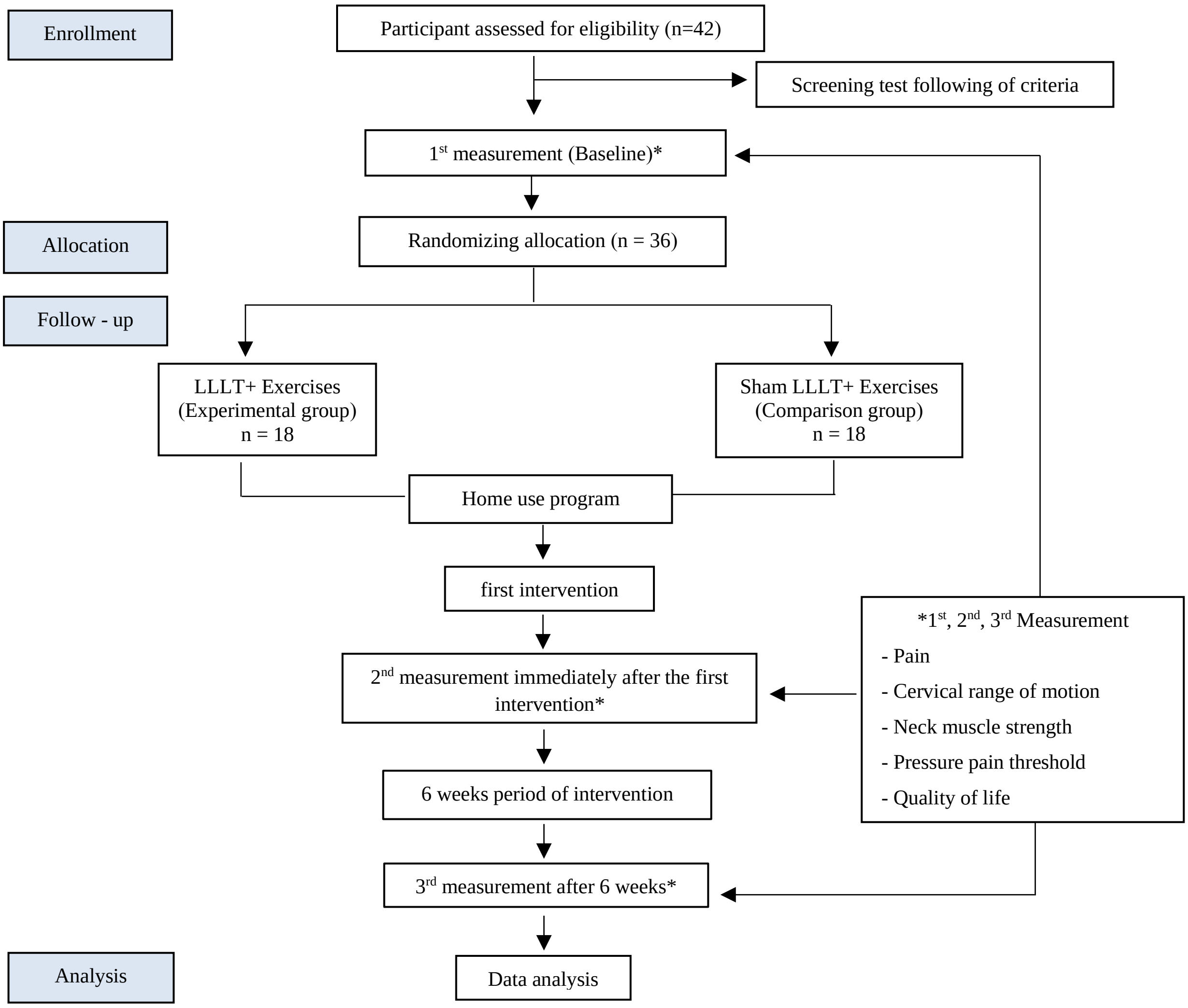

Figure 1 Consort flow diagram.

2.3 Intervention

All participants in this study participated in a comprehensive intervention program designed to address neck pain in office workers. The program consisted of four components: (1) low-level laser therapy (30 minutes), (2) strengthening exercises (15 minutes), (3) neck stretching exercises (15 minutes), and (4) a health education program. One group received active LLLT (the experimental group), while the other received sham LLLT (the comparison group). Each of the participants was advised and provided one LLLT pad (48 LED diodes, wavelength 660 nm; PRIMA Laser therapy, Thailand) with a strap to use at home for 6 weeks. Participants were blinded by using sham LLLT. This design allowed us to evaluate the effectiveness of the entire intervention protocol, with LLLT serving as the specific intervention of interest.

Figure 2 LLLT pad (48 LED diodes, wavelength 660 nm; PRIMA Laser therapy, Thailand) and its application to the trapezius muscle.

2.4 Outcome measures

2.4.1 Pain

To assess participants' pain intensity, this study employed the Visual Analogue Scale (VAS), a widely used tool in musculoskeletal disorder (MSD) research and across diverse adult populations. We chose the simplest version of the VAS, featuring a horizontal line spanning 0 to 10 cm (the most common VAS range). On this scale, "0" on the left indicates no pain, while "10" on the right side represents severe pain. Higher scores signify greater pain intensity. Following established protocols, each participant marked a point on the scale corresponding to their current average pain level. This simple yet reliable measure allowed us to capture subjective pain experiences throughout the study (e.g., Xiao Li et al.,) [20].

2.4.2 Neck range of motion

The cervical range of motion measurement device (CROM) is one of the clinically available instruments for measuring cervical ROM. CROM was used to measure six positions, including flexion, extension, lateral flexion (right and left), and rotation (right and left). One practice trial was performed in each direction before measurement to familiarize the subjects with the procedure and the motions being measured. Participants were instructed to perform maximum ROM in each direction without pain, and the highest recorded value was used for analysis.

2.4.3 Neck muscle strength

This study utilized isometric neck extension to assess the strength of the neck extensor muscles. We employed a digital scale (Model: NUN4048GL) with a maximum weight capacity of 150 kg and a one-decimal place display for accurate measurement. Participants were assessed in a supine position on the floor, maintaining a 45-degree flexion of both hips and knees and a neutral cervical spine with their bodies aligned straight. Each participant performed the task twice; the highest recorded value was used for analysis.

2.4.4 Pain pressure threshold

Building upon digital algometers' widely recognized validity and reliability, we employed a WE algometer to quantify pain pressure thresholds. Prior to measurement, we marked the midpoint of the line connecting the acromion process of the scapula and the C7 spinous process on the upper trapezius, following the protocol established by Kim & Lee [21]. Each of the participants was seated comfortably on a chair while the researcher gradually applied pressure from the algometer on the marked point. Upon experiencing discomfort or mild pain, the participant simply pressed a designated switch button. This triggered the sensor to automatically register the applied pressure, accompanied by an audible confirmation. Each measurement was repeated three times per set, and the average value was recorded as the outcome.

2.4.5 Quality of life

Short Form-36 (SF-36) Thai version was used because it is a widely used questionnaire among Thai people that assesses participants' health status and well-being across two main dimensions: physical and mental. Each participant received a paper version of the questionnaire and a pen to mark their answers. We allocated 5-10 min for participants to complete the questionnaire at their own pace, ensuring they had sufficient time to review and confirm their responses.

2.5 Statistical analyses

Means and standard deviations were employed for each variable to characterize the distribution of data. To evaluate the effects of the intervention on outcomes including pain, cervical range of motion, neck muscle strength, pressure pain threshold of the upper trapezius muscle, and quality of life, repeated measures ANOVA was utilized. This enabled us to discern any significant differences before and after the intervention. For comparisons between the intervention group and the comparison group, independent t-tests were conducted.

All statistical analyses were performed using SPSS software (version 26; IBM Corporation, Armonk, NY). Statistical significance was established at a p-value of less than 0.05.

3. Results

A total of 36 office workers meeting the inclusion criteria participated in the study. The average age was 32.83 ± 4.57 years in the experimental group and 33.22 ± 4.80 years in the comparison group. In the experimental group, there were two males and 16 females (11.1% male and 88.9% female). The comparison group had 7 males and 11 females (38.9% male and 61.1% female), Similarly, the average body mass index (BMI) was 25.52 ± 5.08 in the experimental group and 23.01 ± 3.34 in the comparison group. (Table 1).

Table 1 Baseline Characteristics for Experimental and Comparison Group.

Variables	Experimental Group LLLT (X̄ ± SD) (n = 18)	Comparison Group Sham LLLT (X̄ ± SD) (n = 18)	*p*-value
Age (year)	32.83 ± 4.57	33.22 ± 4.80	0.222
Gender (Male: Female) %	2: 16 (11.1/88.9 %)	7: 11 (38.9/61.1 %)	0.058
Body mass index (kg/m2)	25.52 ± 5.08	23.01 ± 3.34	0.091

Table 2 highlights the significant improvements in the experimental group compared to the comparison group after intervention. The experimental group experienced a marked reduction in pain ($p < 0.001$), while the comparison group did not show significant change. For neck flexibility, the experimental group demonstrated increased ROM in all directions from Day 0 to 6 weeks ($p < 0.001$), whereas the comparison group only exhibited slight improvement in left flexion and right rotation (p=0.024, 0.017, respectively). The experimental group showed significant gains in muscle strength ($p < 0.001$), while the comparison group did not display notable changes. In addition, the experimental group exhibited significantly increased pressure pain threshold ($p < 0.001$), compared to the comparison group with no significant change.

Table 2 Within the group comparison on VAS, Neck ROM, Neck muscle strength, PPT.

Variables	Experimental Group LLLT (n = 18)				Comparison Group Sham LLLT (n = 18)			
	Day 0 (X̄ ± SD)	Day 1 (X̄ ± SD)	6 weeks (X̄ ± SD)	*p*-value	Day 0 (X̄ ± SD)	Day 1 (X̄ ± SD)	6 weeks (X̄ ± SD)	*p*-value
VAS (cm)	5.58 ± 1.37	5.06 ± 1.34	2.53 ± 1.42	<0.001	4.83 ± 1.25	4.66 ± 1.54	4.28 ± 1.27	0.079
Neck ROM (degree)								
Flexion	54.33 ± 10.43	54.83 ± 7.15	62.50 ± 7.52	<0.001	57.22 ± 9.27	56.39 ± 6.82	57.78 ± 7.52	0.642
Extension	56.39 ± 7.54	59.89 ± 7.60	64.22 ± 8.48	<0.001	58.72 ± 9.29	62.89 ± 8.45	61.33 ± 9.87	0.124
Rt. Lateral Flexion	36.83 ± 5.59	38.83 ± 5.24	44.39 ± 6.02	<0.001	39.72 ± 4.36	39.77 ± 4.89	40.83 ± 4.93	0.583
Lt. Lateral Flexion	37.89 ± 6.06	39.44 ± 6.84	45.11 ± 6.05	<0.001	38.06 ± 5.72	37.72 ± 6.37	41.22 ± 7.77	0.024
Rt. Rotation	56.39 ± 10.68	63.28 ± 8.29	69.06 ± 5.49	<0.001	54.55 ± 9.76	59.44 ± 7.05	61.94 ± 8.25	0.017
Lt. Rotation	61.11 ± 6.98	65.55 ± 6.39	71.05 ± 4.01	<0.001	62.77 ± 7.37	64.39 ± 7.37	64.44 ± 9.98	0.618
Neck Muscle Strength (kg)	10.56 ± 3.35	12.33 ± 3.51	13.17 ± 3.59	<0.001	12.77 ± 4.29	13.68 ± 4.86	14.07 ± 4.87	0.065
PPT (kg)	3.77 ± 1.05	3.87 ± 0.80	4.38 ± 0.96	<0.001	3.96 ± 1.36	3.95 ± 1.37	4.33 ± 1.21	0.269

Table 3 delves into the quality-of-life changes within each group. The experimental group exhibited significant improvements across various domains, including physical functioning, bodily pain, general health, and mental health (all $p < 0.001$). Vitality score also showed moderate improvement ($p = 0.048$), and Role-Emotional functioning displayed a minor, yet statistically significant, uptick ($p = 0.030$). In contrast, the comparison group only demonstrated a notable change in vitality score ($p = 0.015$) at different time points, with minimal to no significant differences in other quality-of-life domains.

Table 3 Within-group comparison on quality of life.

Variables	Experimental Group LLLT (n = 18)				Comparison Group Sham LLLT (n = 18)			
	Day 0 (X̄ ± SD)	Day 1 (X̄ ± SD)	6 weeks (X̄ ± SD)	*p*-value	Day 0 (X̄ ± SD)	Day 1 (X̄ ± SD)	6 weeks (X̄ ± SD)	*p*-value
PF	65.6 ± 20.4	75.0 ± 23.3	88.6 ± 13.0	<0.001	66.9 ±19.0	63.6 ± 22.7	70.8 ±18.1	0.297
RP	73.3 ± 19.9	75.4 ± 17.9	82.3 ± 16.4	0.179	78.5 ± 14.4	75.4 ± 17.2	79.2 ± 14.5	0.516
BP	52.6 ± 18.7	65.1 ± 15.6	82.9 ±15.1	<0.001	64.0 ± 14.3	62.4 ± 16.0	69.6 ± 15.0	0.243
GH	56.1 ± 15.8	62.5 ± 20.8	78.1 ± 15.8	<0.001	49.2 ± 17.9	50.6 ± 19.1	55.3 ± 15.0	0.136
VT	61.8 ± 22.1	61.8 ± 16.5	84.4 ± 42.0	0.048	56.6 ± 17.6	56.3 ± 19.1	66.0 ± 14.5	0.015
SF	74.3 ± 20.8	77.1 ± 17.8	85.4 ± 13.0	0.056	73.6 ± 17.1	75.7 ± 17.4	79.2 ± 16.0	0.329
RE	87.2 ± 16.9	78.7 ± 18.6	91.7 ± 14.6	0.030	76.4 ± 18.8	73.6 ± 18.8	81.0 ± 17.1	0.384
MH	72.2 ± 16.2	70.3 ± 14.6	85.8 ± 10.5	<0.001	68.6 ± 16.1	69.4 ± 14.1	74.2 ± 29.3	0.486

Abbreviation, PF = Physical Functioning, RP = Role-Physical, BP = Bodily Pain, GH = General Health, VT = Vitality, SF = Social Functioning, RE = Role-Emotional, MH = Mental Health, HT = Reported Health Transition.

Table 4 sheds light on the comparative effects of LLLT and sham LLLT, scrutinizing both immediate and short-term outcomes. The investigated variables encompassed pain intensity measured by the VAS, neck range of motion (ROM), muscle strength, and pain pressure threshold. Notably, immediate effects did not reveal any significant differences across all examined parameters. However, a distinct divergence emerged in short-term outcomes, with LLLT demonstrating a significantly greater reduction in pain compared to sham LLLT ($p < 0.001$). Further analysis of neck ROM revealed significant differences in favor of LLLT for flexion ($p = 0.001$), right flexion ($p = 0.003$), and left rotation ($p = 0.008$).

Table 4 Comparison of mean changes between LLLT and sham LLLT in immediate and short-term effects.

Variables	Immediate effect ($\bar{X}$ ± SD)		*p*-value	95% CI	Short Term effect ($\bar{X}$ ± SD)		*p*-value	95% CI
	Experimental Group LLLT (n = 18)	Comparison Group Sham LLLT (n = 18)			Experimental Group LLLT (n = 18)	Comparison Group Sham LLLT (n = 18)		
VAS (cm)	0.53 ± 0.70	0.17 ± 0.52	0.086	-0.05, 0.78	3.06 ± 1.15	0.56 ± 1.10	< 0.001	1.73, 3.26
Neck ROM (degree)								
Flexion	1.50 ± 7.43	-0.83 ± 6.47	0.322	-2.38, 7.05	9.16 ± 7.33	0.56 ± 7.25	0.001	3.67, 13.55
Extension	3.50 ± 4.58	4.17 ±7.28	0.744	-4.78, 3.45	7.83 ± 8.61	2.61 ± 10.42	0.110	-1.25, 11.70
Rt. Lateral Flexion	2.00 ± 3.55	0.06 ± 4.49	0.159	-0.80, 4.69	7.56 ± 7.10	1.11 ± 5.02	0.003	2.28, 10.61
Lt. Lateral Flexion	1.56 ± 4.06	-0.33 ± 5.46	0.247	-1.37, 5.15	7.22 ± 6.59	3.16 ± 6.18	0.065	-0.27, 8.38
Rt. Rotation	6.89 ± 8.52	4.89 ± 9.12	0.501	-3.98, 7.98	12.67 ± 10.70	7.39 ± 11.99	0.173	-2.42, 12.98
Lt. Rotation	4.44 ± 5.11	1.61 ± 6.39	0.151	-1.09, 6.75	9.94 ± 6.24	1.67 ± 10.85	0.008	2.28, 14.27
Neck Muscle Strength (kg)	1.77 ± 2.28	0.91 ± 1.90	0.229	-0.57, 2.28	2.61 ± 2.18	1.30 ± 2.50	0.103	-0.28, 2.90
PPT (kg)	0.10 ±0.76	-0.02 ± 0.87	0.676	-0.44, 0.67	0.60 ± 0.65	0.37 ± 1.25	0.490	-0.44, 0.91

Table 5 delves into the comparative effects of LLLT and **s**ham LLLT on quality of life, specifically focusing on both immediate and short-term outcomes. While no significant differences were observed in the immediate effects across any measured domains, short-term impacts painted a different picture. The experimental group (LLLT) exhibited significant improvements in several key areas compared to the comparison group (**s**ham LLLT). These included physical functioning ($p = 0.003$), bodily pain ($p < 0.001$), and general health ($p = 0.005$). Notably, all other quality-of-life domains remained unchanged in both groups during the immediate phase.

Table 5 Comparison of mean changes of quality of life between LLLT and Sham LLLT in immediate and short-term effects.

Variables	Immediate effect ($\bar{X}$ ± SD)		*p*-value	95% CI	Short Term effect ($\bar{X}$ ± SD)		*p*-value	95% CI
	Experimental Group LLLT (n = 18)	Comparison Group Sham LLLT (n = 18)			Experimental Group LLLT (n = 18)	Comparison Group Sham LLLT (n = 18)		
PF	9.4 ± 19.9	-3.3 ± 18.0	0.051	-0.1, 25.6	23.1 ± 17.3	3.9 ± 18.8	0.003	7.0, 31.4
RP	2.1 ± 23.6	-3.1 ± 15.4	0.438	-8.3, 18.7	9.0 ± 23.9	0.7 ± 14.0	0.211	-4.9, 21.6
BP	12.5 ± 17.8	-1.7 ± 14.6	0.013	3.1, 25.2	30.3 ± 17.2	5.6 ± 22.4	<0.001	11.2, 38.3
GH	6.4 ± 12.8	1.4 ± 11.9	0.233	-3.4, 13.4	22.0 ±17.4	6.1 ±14.3	0.005	5.0, 26.6
VT	0.0 ± 12.7	-0.4 ± 15.8	0.943	-9.4, 10.1	22.6 ± 45.0	9.4 ± 16.4	0.248	-9.7, 36.1
SF	2.8 ± 23.3	2.1 ±16.2	0.918	-12.9, 14.3	11.1 ± 16.5	5.6 ± 15.0	0.298	-5.1, 16.3
RE	-8.5 ± 23.8	-2.8 ± 23.1	0.467	-21.6, 10.1	4.4 ± 20.4	4.6 ± 25.6	0.981	-15.9, 15.5
MH	-1.9 ± 10.3	0.8 ± 14.7	0.516	-11.4, 5.8	13.6 ± 12.9	5.6 ± 27.2	0.267	-6.4, 22.5

Abbreviations, PF = Physical Functioning, RP = Role-Physical, BP = Bodily Pain, GH = General Health, VT = Vitality, SF = Social Functioning, RE = Role-Emotional, MH = Mental Health, HT = Reported Health Transition.

Overall, the combined LLLT and strengthening exercise program in the experimental group was found to be superior to the sham LLLT and strengthening exercise program in the comparison group in reducing pain severity, increasing range of motion, and improving quality of life in office workers with non-specific neck pain.

4. Discussion

This randomized controlled trial delves into the potential benefits of combining LLLT with strengthening exercises for office workers suffering from non-specific neck pain. We recruited 36 office workers experiencing neck discomfort and randomly assigned them to two groups: one receiving both LLLT and strengthening exercises, and the other receiving sham LLLT alongside the exercises. Our primary objective was to assess the effectiveness of this combined treatment approach compared to the control group. Specifically, we aimed to evaluate the immediate and short-term effects of the intervention on several parameters: pain intensity, cervical range of motion, neck muscle strength, tissue hardness, tenderness, and quality of life.

The findings revealed that the combined LLLT and exercise group demonstrated statistically and clinically significant greater improvements in pain intensity, neck range of motion, and quality of life compared to the comparison group in the short term. While both groups showed some improvement in neck muscle strength and pain pressure threshold, these changes were not statistically significant.

While the immediate effects of LLLT on pain intensity in Table 4 were inconclusive, the short-term results revealed a significantly greater reduction in pain for the LLLT group compared to sham LLLT (p<0.001). In the context of Minimal Clinically Important Difference (MCID), a commonly cited MCID for pain scales is approximately

1 cm [22]. The experimental group exhibited a statistically meaningful reduction in the VAS score of 3.06 cm at six weeks, when compared to the sham group at six weeks, which had a VAS score of only 0.56 ± 1.10. These changes in the experimental group were clinically significant. This pain-reducing effect of LLLT in office workers with neck pain may be attributed to its ability to stimulate endogenous opioid release [14], modify the release of noxious mediators like bradykinin and histamine [23, 24], and ultimately reduce inflammation and pain [25].

As a form of light therapy and physiotherapy, LLLT boasts a range of benefits for musculoskeletal disorders. Its analgesic and anti-inflammatory properties include wound healing, inflammation reduction, collagen metabolism stimulation, and even fracture healing. Numerous studies have documented the positive impact of LLLT on both acute and chronic musculoskeletal pain, with applications in knee injuries [26], Achilles tendonitis [27], osteoarthritis [28], neck pain, and other chronic musculoskeletal conditions [29, 30]. A systematic review further reinforces the evidence, concluding that LLLT effectively reduces pain, improves neck function, and enhances the quality of life in neck pain patients [13].

Further solidifying the benefits of LLLT and strengthening exercises, Table 2 highlights significant improvements in ROM for the experimental group compared to the comparison group. The experimental group experienced enhanced flexibility in all directions, including flexion, extension, lateral flexion, and rotation, while the comparison group only displayed noticeable improvements in left lateral flexion and right rotation. The experimental group also exhibited a significantly increased pressure pain threshold ($p<0.001$), suggesting improved pain sensitivity, compared to the comparison group with no significant change. These advancements in the experimental group were statistically significant ($p<0.001$), showcasing the potential of this combined approach.

While Table 4 revealed slightly different nuances, with the experimental group generally demonstrating higher mean changes in ROM across all measured directions, statistical significance was only achieved for flexion ($p=0.001$), right lateral flexion ($p = 0.003$), and left rotation ($p = 0.008$) in the short term. The findings suggest that the beneficial changes observed in the experimental group exceed the typical thresholds recognized for significant clinical improvement in these outcomes. When MCID was considered for individuals with neck pain, it ranged from 3 to 10 degrees [31]. This indicates that while the combined therapy consistently improves ROM to a clinically significant extent, the magnitude of these improvements may vary across specific movements.

Importantly, the combined effects of LLLT and strengthening exercises extend beyond pain relief. They offer a potent, two-pronged approach to address neck-related limitations. LLLT can stimulate muscle function and blood circulation, while strengthening exercises promote muscular adaptation and improved coordination, which contribute to enhanced ROM [16]. This synergistic effect is further supported by studies such as that of Panida Chaiming et al. [32], which demonstrated significant increases in cervical ROM in computer users with non-specific neck pain after receiving strengthening exercises. Therefore, the evidence presented strongly suggests that the combined therapy of LLLT and strengthening exercises can significantly contribute to improved range of motion in individuals suffering from non-specific neck pain induced by musculoskeletal disorders.

Table 3 paints a compelling picture of the combined LLLT and strengthening exercise program's impact on quality of life. After six weeks of intervention, the experimental group demonstrated significant improvements across various domains, including physical functioning, bodily pain, general health, vitality, role-emotional functioning, and mental health. In contrast, the comparison group only exhibited a significant change in vitality. This well-focused difference highlights the comprehensive and multifaceted benefits of the combined therapy.

Table 5 further reinforces this observation, revealing that the experimental group maintained significant improvements across all measured quality of life domains; however, statistical significance was only achieved for physical functioning (0.003), bodily pain (<0.001), and general health (0.005), while the comparison group remained largely unchanged, except for vitality. However, quality of life improvement was unequivocal in terms of MCID, which is suggested to be an improvement of 15.5 points of bodily pain, 5.1 points of physical functioning, and general health [33]. These findings offer compelling evidence that this targeted intervention can significantly enhance well-being and promote a healthier lifestyle.

Understanding how each component contributes to this overall improvement is key. LLLT plays a crucial role by modulating pain perception, promoting tissue repair, and reducing inflammation, ultimately leading to improved mobility and comfort [34, 35]. Similarly, regular physical activity, including the implemented strengthening exercises, is well-documented for its positive impact on mood and stress reduction, ultimately enhancing mental health and overall quality of life [36].

A limitation of the study was that it focused on the short-term effects of combining LLLT and strengthening exercises lasting for six weeks. A longer follow-up period could provide insights into the sustainability of the improvements in pain perception, neck flexibility, and quality of life. The authors did not assess the reliability of outcome measurements. It would have strengthened the study if the reliability of these outcome measurements had been evaluated. Future research could explore these aspects to gain a more comprehensive understanding of the benefits of this combined approach in managing musculoskeletal disorders in office workers with neck pain.

5. Conclusion

Overall, this study's findings paint a promising picture of the potential of combining LLLT and strengthening exercises in managing musculoskeletal disorders, particularly for office workers. The experimental group receiving this combined intervention consistently outperformed the comparison group. Notably, the experimental group experienced significant reductions in pain severity, increased range of motion, and improved quality of life. These findings suggest that this intervention could offer a valuable alternative treatment option for office workers with non-specific neck pain, potentially leading to prevention and reduction of musculoskeletal symptoms and, ultimately, an improved quality of life.

6. Ethical approval

This study's protocol received ethical approval from the Khon Kaen University Research Ethics Committee (HE652034). Before participating, all individuals provided informed consent, signifying their understanding of the study's purpose, procedures, potential benefits, and foreseeable risks.

7. Acknowledgements

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8. Conflicts of interest

The authors declare no conflict of interest.

9. References

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