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Effectiveness of Low-Level Laser Therapy on Pain and Function in Individuals with Musculoskeletal-Related Disorders, A Pilot Study

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Abstract

Purpose: The primary purpose of this study is to investigate the effectiveness of Low-Level Laser Therapy (LLLT) on pain and function in individuals presenting with pain associated with musculoskeletal dysfunction. A secondary purpose is to examine the effects of age on observed outcomes associated with using LLLT. Methods: The study protocol included 12 sessions of LLLT using a class 3-B laser device. Treatment dosage for the LLLT was determined according to recommendations published by the World Association for Photobiomodulation Therapy (WALT). Physical therapists determined treatment locations for LLLT application during a pre-intervention evaluation. Following completion of the intervention protocol, participants were re-evaluated by physical therapists to collect post-intervention data. Pre- and post-intervention outcomes were compared via paired t-test or nonparametric equivalent. For the relationship between age and outcomes, Spearman's Rho correlations were used. Results: 31 individuals were included in the study with participant ages ranging from 29 to 77 years old, and average age of 55 years. Participant Current, Best, and Worst pain significantly improved with mean difference of 2, 2, 1 points respectively on Numeric Rating Scale (NRS) (p-values ranging from <0.001 to 0.00164). Patient-Specific Functional Scale (PSFS) measurements also demonstrated significant improvement (p-values ranging from <0.001 to 00248). Average grip strength significantly improved by 6.6 pounds (p= 0.047), while average joint range of motion increased significantly by 6.7 degrees (p= 0.024). No significant differences noted with lower extremity strength measured using manual muscle test (p= 0.204). No significant differences noted with trunk flexion range of motion measured using finger-tip to floor reach method (p= 0.942). A significant correlation was found between age and change in Worst pain (p= 0.024). Correlation between age and change in function on the PSFS was not significant (p= 0.147). Conclusions: LLLT was associated with significant improvements in pain ratings and measurements of function in individuals presenting with pain related to musculoskeletal dysfunction. A positive correlation was demonstrated between age and changes in worst-reported pain while no significant correlation could be found between age and change in function following treatment with LLLT.

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ABSTRACT

Purpose: The primary purpose of this study is to investigate the effectiveness of Low-Level Laser Therapy (LLLT) on pain and function in individuals presenting with pain associated with musculoskeletal dysfunction. A secondary purpose is to examine the effects of age on observed outcomes associated with using LLLT. **Methods:** The study protocol included 12 sessions of LLLT using a class 3-B laser device. Treatment dosage for the LLLT was determined according to recommendations published by the World Association for Photobiomodulation Therapy (WALT). Physical therapists determined treatment locations for LLLT application during a pre-intervention evaluation. Following completion of the intervention protocol, participants were re-evaluated by physical therapists to collect post-intervention data. Pre- and post-intervention outcomes were compared via paired t-test or nonparametric equivalent. For the relationship between age and outcomes, Spearman's Rho correlations were used. **Results:** 31 individuals were included in the study with participant ages ranging from 29 to 77 years old, and average age of 55 years. Participant Current, Best, and Worst pain significantly improved with mean difference of 2, 2, 1 points respectively on Numeric Rating Scale (NRS) (p-values ranging from <0.001 to 0.00164). Patient-Specific Functional Scale (PSFS) measurements also demonstrated significant improvement (p-values ranging from <0.001 to 00248). Average grip strength significantly improved by 6.6 pounds (p= 0.047), while average joint range of motion increased significantly by 6.7 degrees (p= 0.024). No significant differences noted with lower extremity strength measured using manual muscle test (p= 0.204). No significant differences noted with trunk flexion range of motion measured using finger-tip to floor reach method (p= 0.942). A significant correlation was found between age and change in Worst pain (p= 0.024). Correlation between age and change in function on the PSFS was not significant (p= 0.147). **Conclusions:** LLLT was associated with significant improvements in pain ratings and measurements of function in individuals presenting with pain related to musculoskeletal dysfunction. A positive correlation was demonstrated between age and changes in worst-reported pain while no significant correlation could be found between age and change in function following treatment with LLLT.

Keywords: photobiomodulation, low-level laser therapy, pain, function, musculoskeletal

INTRODUCTION

Low-level laser therapy (LLLT), also known as Photobiomodulation, is a therapeutic modality often used in rehabilitation settings for a variety of clinical applications most notably addressing musculoskeletal dysfunction and pain.[1] LLLT is a low-powered form of light amplification by stimulated emission of radiation, more commonly referred to as laser.[2] LLLT provides a photochemical effect. The power, or rate of energy flow, can be delivered in a wide range of milliwatts (mW) resulting in a variety of laser classifications.[1,2] There are four classes of lasers with power intensity ranging from less than 0.5mW to greater than 500mW and LLLT is categorized as a power of less than 500mW in the 3B class power range.[2] Lasers can be used to deliver a specified dose of energy (measured in joules by multiplying power and time) for therapeutic effects.[1] LLLT was approved for treatment of pain in 2001 by the United States Food and Drug Administration and involves the use of light in the red or infrared range of the electromagnetic spectrum.[3]

Studies conducted in the United States over the past 30 years have included the use of LLLT for pain reduction using the scientific premise of light waves reaching cellular tissue to create a physiological response to ultimately decrease a patient's pain.[1] The physiological effects of LLLT at the cellular and tissue level have been found dependent upon the intensity of light energy utilized during treatment.[1,4,5] LLLT has been shown to produce analgesic, anti-inflammatory, and biostimulating effects.[4] Lower doses of LLLT have been shown to stimulate mitochondrial activity, leading to enhanced healing of tissue including skin, tendons, cartilage, and bone; conversely, higher doses of LLLT have been shown to have an inhibitory effect on mitochondrial activity in neural fibers contributing to a neural blockade at various levels including the neuromuscular junctions which may aid in pain management.[5]

The use of LLLT has been studied alone and in conjunction with other treatment procedures as a modality for the management of musculoskeletal pain and dysfunction and has contributed to an overall improvement in function.[6-9] The use of LLLT alone was reported to demonstrate reduced pain by Li et al. in a study examining the use of LLLT for treatment of knee osteoarthritis.[8] A randomized control trial conducted by Cinar et al revealed LLLT was associated with a significant reduction in pain for treatment of plantar fasciitis when used in conjunction with exercise and orthotics.[6] Seo et al indicated LLLT combined with neural mobilization exercises has been found to produce greater differences in improving pain and function in subjects with chronic low back pain compared to exercise alone.[9] Regarding treatment dosages for LLLT, Jovicic et al reported three different dosage levels were "equally effective in alleviating lumbar and leg pain."[7(p656)] Despite decades of research and advancement of laser technology the effectiveness of LLLT for pain mediation remains a widely debated topic with a variety of parameters for practitioners to examine for optimal results for multiple regions of the body.

Musculoskeletal pain can broadly be categorized as inflammatory and neurogenic. The importance of these categorizations is the effective correlation, perhaps the moderating effect, that LLLT has on both inflammatory and neurogenic pain. LLLT demonstrates promising results as an effective modality to reduce inflammatory pain.[10,11] Further, a systematic review highlighted LLLT as effective in the control of neurogenic pain. However, de Andrade et al.[12] determined LLLT parameters for neurogenic pain do not follow a specific standard.[12] LLLT may address neurogenic pain at lower doses by improving mitochondrial membrane permeability. Improved membrane permeability of mitochondria results in increased adenosine triphosphate production that reduces reactive oxygen species.[13] The improved oxygen metabolism helps mitigate neurogenic pain and reduce inflammation.[14,15] The stages of healing, acute, sub-acute, and chronic, that align with musculoskeletal inflammatory and neurogenic pain seem to equally benefit from LLLT when dosing is adequate.

The effects of LLLT upon muscle performance have also been studied with mixed results. Tsuk et al examined the effects of LLLT application upon quadriceps muscle performance and recovery.[16] No significant changes were observed in muscle peak torque or total work measurements, and no significant changes in blood lactate levels were noted with the use of LLLT before or after a session of exercise.[16] In a study conducted by Orssatto et al, photobiomodulation applied prior to exercise demonstrated no effect upon muscle fatigue and damage following performance of lower limb exercise in judo athletes.[17] However, a systematic review conducted by Borsa et al reported improvements to skeletal muscle performance and protection when photobiomodulation was used prior to resistance exercise.[18] Additionally, another systematic review conducted by Ferlito et al also indicated that photobiomodulation produced beneficial results upon muscle recovery following high-intensity exercise.[19] Leal Junior et al. reported increased muscle endurance along with decreased levels of biochemical markers post-exercise when LLLT was applied to the biceps muscle prior to a session of exercise.[20] Jankaew et al also reported increased muscle strength following the application of LLLT to the knee in individuals with knee osteoarthritis.[21]

The impact of LLLT application upon joint range of motion (ROM) has been examined in multiple studies. Nakamura et al reported no significant differences in knee range of motion following application of LLLT to the knee over a period of 4 weeks.[22] Another study completed by Ordahan et al demonstrated no significant improvement in goniometric measurements following treatment of the shoulder with a combined regimen of LLLT and stretching exercise in patients with adhesive capsulitis.[23] However, knee flexion

ROM was significantly improved in patients post total knee arthroplasty following a program of therapy that included LLLT application to the knee and exercise when compared with a control group of exercise alone.[24] Baltzer et al reported increased hand ROM with the use of LLLT in patients diagnosed with osteoarthritis.[25]

With regard to the effects of LLLT upon overall function, the use of LLLT has been associated with improved outcomes. While the study conducted by Ordahan et al demonstrated no improvement in shoulder ROM, the authors did report significant improvement in scores for both the Visual Analog Scale and the Shoulder Pain and Disability Index tools following treatment with LLLT.[23] Moreover, Jankaew et al[21] demonstrated that LLLT application to the knee was associated with significant improvements in multiple measures of functional performance including walking speed, stair climbing ability, sit-to-stand ability, and the Timed Up and Go Test.[21] Alghamdi et al also reported significant improvement in scores for the Western Ontario and McMaster Universities Osteoarthritis index in individuals who received a program of LLLT and exercise for the knee.[24]

LLLT use has been studied in patients of various ages, including children and adults. LLLT utilized in a group of children aged 5-18 years and diagnosed with spastic diplegia has demonstrated reduced pain and improved muscle performance.[26] Another study reported enhanced bone remodeling following the application of LLLT in children ranging from 9-16 years.[27] In the study conducted by Alghamdi et al, the average age of participants receiving LLLT following total knee arthroplasty was 61.6 years.[24] The average age of participants receiving LLLT for treatment of low back pain in the study by Seo et al was 41.1 years.[9] In addition to being used with various populations, LLLT has been the subject of many studies regarding the variability in parameters and protocols utilized by examiners. For example, Yeh et al described multiple dosages and wavelengths of light being utilized for the treatment of fibromyalgia in past studies.[16] Due to the variety of parameters involved in the application of LLLT and a wide spectrum of treatment specifications reported in the literature, a standardized framework for recommendations has emerged from The World Association for Photobiomodulation Therapy (WALT).[1] The WALT recommendations provide a guideline for treatment doses for LLLT based on a diagnosis of tendinopathy or arthritis at numerous areas of the body.[28] The WALT recommendations were updated in 2010 and give providers specific parameters for the application of LLLT for class 3B lasers at the 904 and 760-820 nanometer wavelengths.[1] Jankaew et al described the delivery of LLLT at a wavelength of 808 nm for the treatment of knee osteoarthritis based on the dosages recommended by WALT.[21]

The purpose of this study was to assess the effectiveness of LLLT alone upon pain and function in individuals presenting with reports of persistent or acute musculoskeletal-related pain while utilizing the WALT guidelines. A secondary purpose was to examine any effects age had on outcomes.

METHODS

Study Design

Participants were recruited through paper flyers, email advertisements, newsletters, radio announcements, and word of mouth. Participants were informed about the procedures of the study and informed consent forms were obtained. This study was approved by the Institutional Review Board of Arkansas Colleges of Health Education and the procedures were conducted in accordance with the Helsinki Declaration. Participants received the LLLT intervention three times a week for four weeks, with a total of 12 visits. Assessments of pain were performed at every visit. Assessments of range of motion, strength, and function were assessed at first visit, and upon last visit.

Participants

An *a priori* power analysis was performed with alpha set at 0.05, an estimated effect size of 0.25 and power set at 0.8. The minimal sample size needed to detect a difference in reported pain was 27 participants. To account for attrition, 31 individuals with musculoskeletal pain were recruited. The participants met the following inclusion criteria: 18 years of age or older, having a persistent or acute discomfort/pain in a muscle or joint of their body, ability to speak English or provide own translator, provide own transportation, ability to complete the pre-test/post-test and attend treatment sessions three times per week. Participants were excluded if pregnant, currently undergoing immunosuppressive therapy, and history of cancer near current site of pain. With this being a pilot study, the inclusion criteria were developed to accommodate variability in participant age, pain location, and impairment during the recruitment process.

Interventions

Initial Evaluation

Subjects were evaluated by one of two physical therapists for their primary complaint, in which only one body part was addressed. Participants completed an 11-point Numeric Rating Scale (NRS) to describe the intensity of their pain.[29] For the NRS used in the current study, 0 represents “no pain” and 10 represents “the worst pain imaginable.”[30] Subjects completed the pain rating scale for current pain, as well as best and worst pain in the past 24 hours in order to capture pain behavior. The Patient-Specific Functional

Scale (PSFS) is a self-reported functional activity score that is reliable and valid for patients with spine, upper and lower extremity problems.[31,32] This scale was utilized to measure the change in function over time in the study. Strength was captured via manual muscle testing of the affected body part and relevant range of motion measures were also obtained. A physical therapy diagnosis was established to inform treatment areas for low-level laser therapy treatment.

Laser Therapy Treatment

Participants were treated with the Richmar TheraTouch LX2 cluster head including four 650 nm (10mW) LED diodes and five gallium-aluminum-arsenide 850 nm (200 mW) laser diodes. Total output for the LLLT device was 1040 mW. Parameters for dosage and location were established for each participant based on area of pain. Protocols for dosage of joules were established using the WALT recommendations while protocols for the location of LLLT application were set forth by Enwemeka[33] and clinician expertise if a protocol for the participant's condition was unavailable. Due to the variance in body region affected, dosage and number of treatment sites were variable from subject to subject, however, the dosage and number of treatment sites were standardized per condition across the study. The LLLT was administered using the documented protocol for treatment as designated in each participant's chart. The documented protocol included the number of sites, number of joules, amount of time, written description of location for treatment, hand-drawn depiction of location, and an indication of treatment location on professional images of the muscle groups and joints. This documentation of the LLLT allowed for the same treatment intervention even with different professionals applying the treatment. Participants were seen for 12 sessions over a four-week period, and completed a numeric pain rating scale, as previously described, during each visit.

Final Evaluation

At the final visit, subjects were treated with LLLT per their specific protocol that was established following the initial evaluation. Following treatment, they were re-evaluated by one of the two physical therapists who performed the initial evaluation utilizing NRS, PSFS, and strength and range of motion measures of the affected joint.

Data Analysis

Patient-reported pain (current, best, worst) and function (PSFS) were compared at pre- and post-treatment using the Wilcoxon signed-rank test (1-sided). Spearman's Rho Correlations were utilized to compare age with pre- and post-treatment findings related to pain and function. The Wilcoxon signed-rank test (2-sided) was also used to compare pre- and post-treatment lower extremity manual muscle testing data. Range of motion and grip testing data pre- and post-treatment were compared using a paired t-test. In the event of missing data (e.g. a participant did not attend the follow-up assessment), the last observation carried forward approach was used. An alpha value of ≤ 0.05 was used for statistical significance. Statistical analysis was completed using SPSS software.

RESULTS

Thirty-one participants were screened for eligibility, and all applicants met eligibility requirements. Of the thirty-one participants enrolled, nineteen completed the initial session followed by the treatment protocol of twelve sessions. Twelve participants did not complete the entire protocol of twelve treatment sessions for various reasons including failure to return for follow-up, missed visits, or withdrawal from the study. Two subjects were withdrawn from the study due to reports of increased pain. See Table 1: Participant Completion Rate.

Twenty-two enrolled participants identified as being female, mean age was 56.7 years with age range of 38-77 years. Nine enrolled participants identified as being male, mean age was 52.3 years, and age range was 29-67 years. 26 of 31 total participants (84%) self-identified as white. See Table 2: Participant Characteristics.

Table 1. Participant Completion Rate

Level of Completion	n
Completed all 12 sessions of treatment protocol	19
Incomplete due to missed visits or no follow-up attendance	10
Incomplete, withdrawal due to reports of increased pain	2
Total	12

Table 2. Participant Characteristics

Characteristic		Females	Males
Age	Range	38-77 years	29-67 years
	Median	56.7 years	52.3 years
Race/Ethnicity	American Indian or Alaska Native	n= 1	n= 1
	Asian	n= 1	n= 0
	Native Hawaiian or Other Pacific Islander	n= 0	n= 0
	Black or African American	n= 1	n= 0
	White	n= 18	n= 8
	More than one race	n= 0	n= 0
	Unknown or Not Reported	n= 1	n= 0
Total		n= 22	n= 9

Following initial screening and assessment, participants were assigned to one of seven categories according to the location of primary baseline pain complaints. The category representing those with hip and/or thigh region pain complaints was the largest category and included seven (23%) participants. Both the foot pain and shoulder pain categories were the smallest categories and included 2 (7%) participants for each. See Table 3: Location of Pain.

Table 3. Location of Pain

Location	n
Wrist & Hand	6
Cervical	4
Hip & Thigh	7
Low Back	5
Knee	5
Foot	2
Shoulder	2

Nineteen participants had full data at pre- and post-treatment. Twelve observations (i.e. pain ratings and PSFS) were inputted via last observation carried forward (1 for pre-treatment, 11 for post-treatment). Thus, data from 31 participants were analyzed. Pain ratings for Current, Best, and Worst pain demonstrated significant improvements post-treatment with p-values <0.001, 0.00164, and <0.001 respectively. PSFS measurements demonstrated significant improvements as well with p-values ranging from <0.001 to 0.00248. Table 4: Pain and Function Results displays pre- and post-treatment values for participant NRS and PSFS.

Table 4. Pain and Function Results

	n	Pre	Post	Median of Differences	P Value	Z-Value
Current Pain	31	3 (2)	1 (3)	2	<0.001	-3.4452
Best Pain	31	2 (3)	0 (2)	1	0.00164	-2.937
Worst Pain	31	7 (4)	3 (4)	2	<0.001	-4.1786
PSFS-Item 1	31	4 (2)	6 (5)	1	<0.001	-3.6214
PSFS- Item 2	31	4 (2)	5 (5)	1	0.00205	-2.8746
PSFS-Item 3	27	4 (2)	5 (3)	0	0.00248	-2.8114

Note: Values reported as median (IQR).

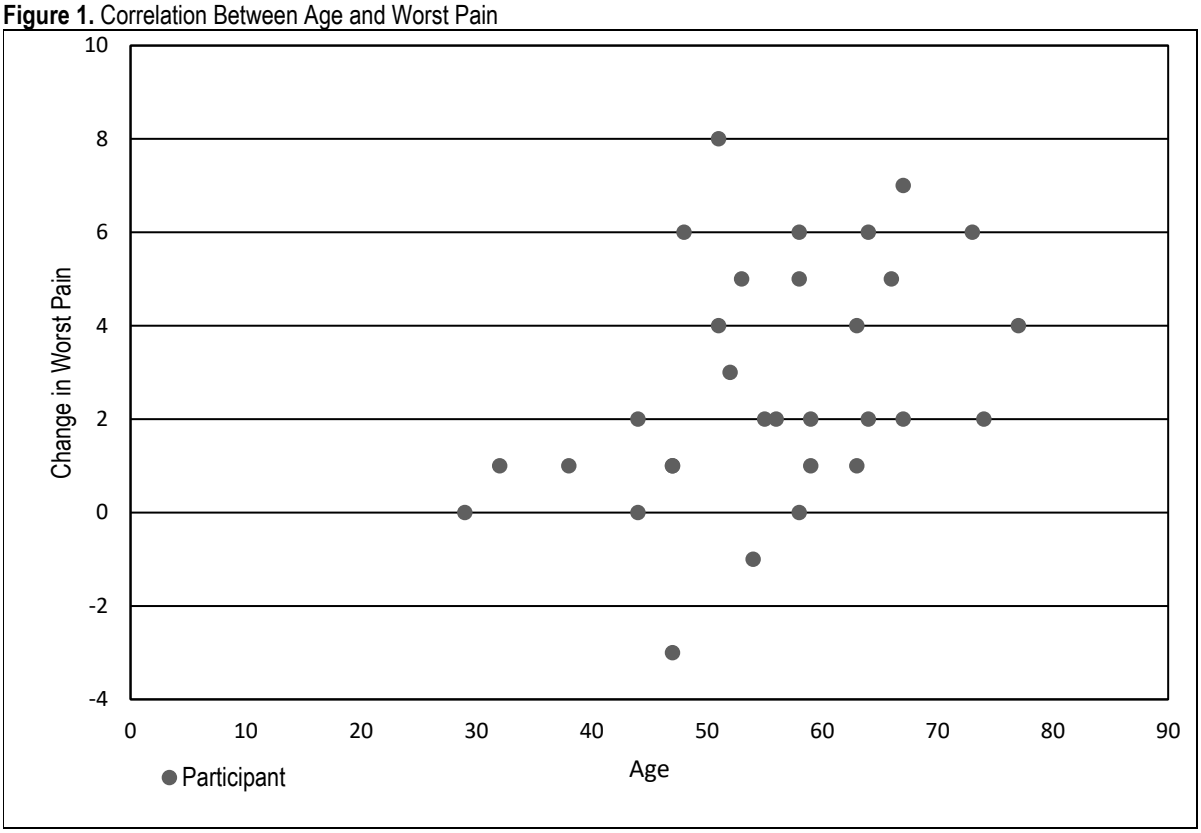
Age was statistically significant and positively correlated with change in Current and Worst reported pain and with the most important activity listed on the PSFS. There were no other significant correlations between age and outcomes. To note, as participants' age increased, the magnitude of change in pain became greater. For Worst reported pain, age explains 13.4% of the variability in change in pain (p=0.024). However, age only explained 3.9% of the variability in change in function on the PSFS, which was not statistically significant (p=0.147). See Table 5: Spearman's Rho Correlations between age and pre-post interventions change in pain and function. The distribution of participant ages in relation to change in Worst reported pain is shown by Figure 1: Correlation Between Age and Worst Pain.

Table 5. Spearman's Rho Correlations Between Age and Pre-post Interventions Change in Pain and Function

		Age	MedCurrent	MedBest	MedWorst	MedFun1	MedFun2	MedFun3
Age	Correlation Coefficient	1.000	0.454*	0.224	0.447*	0.362*	0.322	0.137
	Sig. (2-tailed)		0.010	0.225	0.012	0.045	0.078	0.495
	n	31	31	31	31	31	31	27
Median Current Pain (MedCurrent)	Correlation Coefficient	0.454*	1.000	0.548**	0.676**	0.283	0.060	0.227
	Sig. (2-tailed)	0.010		0.001	< 0.001	0.123	0.747	0.255
	n	31	31	31	31	31	31	27
Median Best Pain (MedBest)	Correlation Coefficient	0.224	0.548**	1.000	0.409*	0.221	0.004	0.176
	Sig. (2-tailed)	0.225	0.001		0.023	0.232	0.983	0.379
	n	31	31	31	31	31	31	27
Median Worst Pain (MedWorst)	Correlation Coefficient	0.447*	0.676**	0.409*	1.000	0.267	0.049	0.167
	Sig. (2-tailed)	0.012	< 0.001	0.023		0.146	0.792	0.406
	n	31	31	31	31	31	31	27
Median Function 1 (MedFun1)	Correlation Coefficient	0.362*	0.283	0.221	0.267	1.000	0.659**	0.605**
	Sig. (2-tailed)	0.045	0.123	0.232	0.146		< 0.001	< 0.001
	n	31	31	31	31	31	31	27
Median Function 2 (MedFun2)	Correlation Coefficient	0.322	0.060	0.004	0.049	0.659**	1.000	0.289
	Sig. (2-tailed)	0.078	0.747	0.983	0.792	< 0.001		0.143
	n	31	31	31	31	31	31	27
Median Function 3 (MedFun3)	Correlation Coefficient	0.137	0.227	0.176	0.167	0.605**	0.289	1.000
	Sig. (2-tailed)	0.495	0.255	0.379	0.406	< 0.001	0.143	
	n	27	27	27	27	27	27	27

*Correlation is significant at the 0.05 level (2-tailed)
**Correlation is significant at the 0.01 level (2-tailed)

Figure 1. Correlation Between Age and Worst Pain



Range of motion (ROM) data was collected for motion related to the participants' primary complaint using a goniometer and a measuring tape for trunk flexion. The data was analyzed in SPSS using a paired t-test with a significant difference found for joint ROM as measured in degrees (p= 0.024), but not for trunk flexion motion as measured in cm (p= 0.942). Grip strength was gathered using a hand dynamometer and analysis using a paired t-test showed a significant increase in strength post-intervention (p= 0.047). Lower extremity strength was assessed with manual muscle testing (MMT) for participants with lower extremity complaints and data was analyzed using a Wilcoxon signed-rank test with no significant improvement shown post-intervention (p= 0.204). See Table 6: Range of Motion and Strength Results.

Table 6. Range of Motion and Strength Results

	n	Pre	Post	Difference	P-value
ROM (degrees)	17	67.3	74.0	6.7	0.024
Trunk Flexion (cm)	7	21.8	21.6	-0.2	0.942
Grip Strength (lbs)	7	56.6	63.2	6.6	0.047
Lower Extremity MMT	15	10.4	10.6	0.2	0.204

Note: Values reported as mean. P-values reported as two-sided.

DISCUSSION

The current study demonstrated that the use of LLLT had a positive effect on multiple measures of pain and function for individuals with pain associated with musculoskeletal-related dysfunction. Significant improvements in pain ratings observed with the use of LLLT are consistent with the findings of decreased pain ratings reported by Baltzer et al and Ordahan et al.[23,25] The increased grip strength found in the current study is consistent with other studies that have demonstrated improved muscle performance following the application of LLLT.[20,21] Additionally, the increase in ROM and overall function observed in the current study is consistent with

the findings reported by other examiners who reported increased joint mobility with treatment protocols that included the use of LLLT.[24,25]

Change in function did not differ based on the participant's age. The variability in pain score changes due to age was significant when examining Worst pain but was not significant for Current pain. In other words, the older participants tended to report greater positive changes in Worst pain. Whether the laser treatment was the sole cause of the reduction in pain for older participants is unclear. The role of laser treatment in the reduction of pain can be questioned considering the lack of an effect on the younger population. The subjective nature of pain and the associated expectations with advanced technology could reinforce a placebo effect in older participants. Further, a plausible consideration for the older participants is the by-product of the added socialization—talking to other participants in the waiting room, visiting with the researchers during treatment, and physical touch during the treatment—were contributing factors in the reduction of Worst pain for this age dynamic since it did not significantly improve all their functional scale scores. Additionally, the ages of the participants were not evenly distributed, which may have had an effect on age-related correlations.

There were several limitations in this study. The small sample size and high attrition decreased the strength of the study. Another limitation of the study was the lack of diversity in participant demographics which may limit the generalizability of the research results. The focus of the research was on pain without full consideration of either a primary mechanical diagnosis or a stage of recovery. The results of the study may not reflect a comprehensive application of specific laser interventions consistent with inflammatory or neurogenic pathologies within certain stages of recovery. Additional limitations included different interventionists applying the intervention and a lack of a control group. Without a control group, it is unknown if participants would have improved without the use of LLLT. Despite the lack of a control group, the utilization of LLLT as the sole intervention was the quintessence of the study. It is also possible the participants were receiving treatments from other healthcare providers during the time of intervention which could have skewed the results. Further research could investigate the use of LLLT in conjunction with other treatments from various providers. The strengths of the study included a single laser being used for the intervention and the same interventionists performing the pre/post-tests with participants to minimize variability. Furthermore, to minimize inconsistencies, all interventionists received the same training on the calibrated laser used for the study and a body chart was utilized to ensure consistent placement of the laser head.

CONCLUSION

The use of LLLT alone was associated with reports of decreased pain and improved function overall for the treatment of musculoskeletal pain when applied using the parameters within the current study. LLLT was the only intervention applied to participants, and parameters for the delivery of LLLT were based upon the WALT guidelines. While LLLT was not associated with improved strength as measured with MMT, this study did demonstrate a significant improvement in strength when measured using a hand dynamometer. Additionally, a positive correlation was demonstrated between age and changes in Worst-reported pain while no significant correlation could be found between age and change in function following treatment with LLLT. The results of this study support the rationale for inclusion of LLLT as an adjunct for management of acute and persistent musculoskeletal-related pain in adults. Additional research is encouraged to assess the duration of benefits reported and observed for specific musculoskeletal-related conditions in order to further refine application protocols.

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