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LOW LEVEL LASER THERAPY (LLLT) IMPROVES HEALTH STATUS AND QUADRICEPS MUSCLE ACTIVATION IN ELDERLY WITH KNEE OSTEOARTHRITIS

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SUMMARY

The quadriceps weakness associated with knee osteoarthritis (OA) has been partially attributed to the inability of the central nervous system of activating all quadriceps motor units, also known as muscle inhibition (MI). The analgesic effect of low-level laser therapy (LLLT) may reduce the afferent input from pain receptors increasing efferent output from quadriceps α motor neurons, restoring the ability to fully activating the muscle. This study aimed at determining the effects of LLLT on MI and health status in elderly with knee OA. Ten elderly women (mean age 64.5±6.2 yr) with knee OA performed an 8-week period of LLLT treatment (wavelength 830nm, continuous wave, output power 200W, 4J per point) using a single probe in contact with the skin at 6 different points at the knee joint. MI was assessed using the twitch-interpolation technique. Superimposed electrical shock (maximal voltage = 240 V) was applied to the femoral nerve during maximal isometric voluntary contractions at 90° of knee flexion (0° = full extension). MI was estimated by the amount of extra torque evoked by the superimposed twitch in relation to the voluntary maximal torque. The health status was assessed with the WOMAC questionnaire. Results revealed that LLLT reduced MI by 50% (effect size = 0.64, $p<0.05$). Pain, stiffness and functional limitation decreased by 40%, 44% and 33%, respectively (effect size = from 0.9 to 1.3, $p<0.001$). In conclusion, LLLT treatment appears to have a relevant potential to minimize MI as well as to improve the health status of OA patients.

INTRODUCTION

Quadriceps weakness is common in patients with knee osteoarthritis (OA) and may contribute to the substantial functional deficits that occur with disease progression [1,2]. The gradual decline in quadriceps strength associated with knee OA has been frequently associated with an inability of the central nervous system to fully activate all quadriceps motor units, also called muscle inhibition (MI) [2,3]. It has been suggested that MI occurs due the altered afferent input originating from mechanoceptores within the diseased joint reflexively reducing efferent output from quadriceps α motor neurons, thereby causing incomplete activation [3]. Thus, implementation of a treatment aimed at minimizing MI might be an appropriate strategy to overcome muscle weakness and to improve health status in these patients.

Considering the poor adherence of knee OA patients to regular quadriceps strengthening exercise due pain, the use of other therapeutic approaches should be considered in the management of knee OA. Traditionally, low-level laser therapy (LLLT) has been useful in the treatment of musculoskeletal disorders through its analgesic [4], anti-inflammatory action [5] and biostimulation effects [4,5]. It has been suggested that LLLT may reduce tonic peripheral nociceptive afferent input to the dorsal horn and facilitate reorganization of synaptic connections in the central nervous system producing pain modulation [6,7]. Despite the possible effects of LLLT in reducing the afferent input originating from pain receptors within the diseased joint and thereby causing more complete activation, to our knowledge, no prior studies have investigated the effects of LLLT on MI. The aim of this study was determine the effects of LLLT in MI of elderly with knee OA. Our hypothesis was that a LLLT should minimize MI and improve the health status of these patients.

METHODS

Ten elderly women (mean age 64.5±6.2 yr) with radiographic evidence of mild and moderate knee OA performed LLLT treatment 2 days per week for 8 weeks. LLLT was applied using the THOR DD2 Control Unit (THOR®–London, UK), with an Infra-Red Laser Single Probe of the same manufacturer, consisting of one 830 nm diode, with 0.029 cm^2 area and 200 mW output power. LLLT was applied with the probe held stationary in skin contact, with slight pressure for 20s, in 6 different points of the knee joint, which was maintained flexed at 90° angle. A total of 24J of LLLT was applied to knee joint. Every participant was assessed before and after the treatment by the following tests: (1) MI assessment and (2) administration of the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC). MI was assessed using the twitch-interpolation technique [2]. Thus, maximal isometric knee extensor torques were obtained on an isokinetic dynamometer (Biodex System 3; Biodex Medical Systems). Participants were positioned on the dynamometer according to the manufacturer's recommendations. After a warm-up and a familiarization session, each subject executed three maximal voluntary contractions (MVC) with the knee fixed at a flexion angle of

90° (0° = full extension). Each contraction lasted for 5 s and a 2-min interval was observed between consecutive contractions. During the 3rd and 4th second of MVC, a superimposed electrical twitch (square-wave, 800μs, and 240-V pulses) was applied to the femoral nerve. Stimulation was applied using a Grass S88 Muscle Stimulator in combination with an isolation unit (Quincy, MA, USA). Carbon-impregnant rubber electrodes (4.5 X 10 cm) were thinly coated with a conductive gel and secured to the thigh with adhesive tape. Using a custom-made script written in Matlab software (Version 5.3, Math Works Inc., Natick, MA, USA) MI was estimated by the amount of extra torque evoked by the superimposed twitch. Health status was obtained by WOMAC pain, stiffness and functional capacity scores. Paired t-test was used to determine the effects of LLLT on the investigated variables. Significance was set at $\alpha = 0.05$. The effect size (ES) (difference between the pretest and posttest scores divided by SD of the pretest) was interpreted using the scale proposed by Rhea [8]: trivial (0.50), small (0.50 – 1.24), moderate (1.25–1.99), and large (>2.0).

RESULTS AND DISCUSSION

It has been suggested that MI can result from progressive joint degeneration that results in abnormal articular afferent information being sent to the α-motoneurons, thereby reducing their activation [1,2]. It was hypothesized that LLLT could reduce the afferent input originating from nociceptores within the diseased joint and thereby causing more complete activation [6,7]. Confirming our hypothesis, the primary results of this study shows that LLLT treatment in elderly women with mild and moderate knee OA decreases MI (Figure 1) and improves WOMAC scores (Table 1).

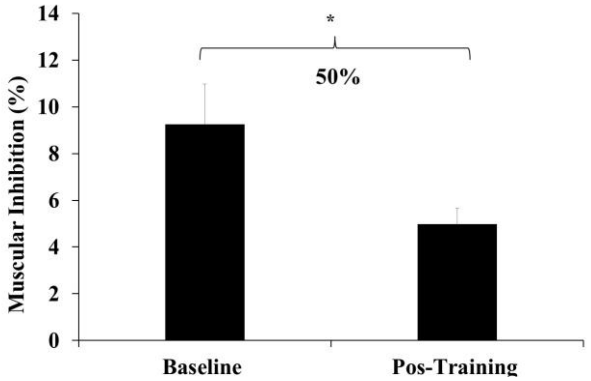

Figure 1: IM from OA patients during the LLLT treatment (mean ± SD). ***** = p<0.05.

Although our patients demonstrated MI levels smaller than those reported by previous studies [1], similar MI levels was also found for studies that used a sample comprised by patients with mild and moderate knee OA [9,10]. In addition, it is thought that a 9% MI can indicate the presence of a problem that could get worse with progression of OA. Future studies could investigate the natural progression of MI in OA patients and its association with the degree of severity of the disease.

Given the extensive findings of persistent muscle weakness associated with MI [1-3], and the high likelihood of early-onset of OA, the development and implementation of therapies to treat the underlying cause of muscle weakness is the primary concern of clinicians. In this study, LLLT was able to minimize MI by 50% (a small ES = 0.64) and decrease pain, stiffness and functional limitation by 40%, 44% and 33%, respectively (a moderate ES = from 0.9 to 1.3). Since individuals without MI would have greater success during quadriceps strengthening programs [2, 10], these results have important clinical implications for the rehabilitation of OA patients. The development of clinical trials with larger number of participants might reduce data variability increasing ES.

WOMAC Domain	Baseline	Post-Training
Joint pain*	8.29±4.2	4.87±3.0
Joint stiffness*	3.55±1.9	1.86±1.5
Functional limitation*	28.48±15.4	15.87±8.48

Table 1: WOMAC Scores from OA patients before and after LLLT Treatment (Mean ± SD). ***** = p<0.05.

CONCLUSIONS

LLLT treatment appears to have a potential to minimize MI as well as to improve the health status of OA patients.

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REFERENCES

1. Hart JM, et al. Quadriceps activation following knee injuries: a systematic review. *J Athletic Training*, **45**:87-97, 2010.
2. Suter E and Herzog WJ. Extent of Muscle Inhibition as a function of knee angle. *Eletromyogr Kinesiol*, **7**:123-130, 1997.
3. Hurley MV, Jones DW. Newham DJ. Arthrogenic quadriceps inhibition and rehabilitation of patients with extensive traumatic extensive injuries. *Clin Sci* (London), **86**: 305-310, 1994.
4. Chow RT, et al. Efficacy of low-level laser therapy in the management of neck pain: a systematic review and meta-analysis of randomized placebo or active - treatment controlled trials. *Lancet*, **374:**1897-1908, 2009.
5. Yamaura M, et al. Low level light effects on inflammatory cytokine production by rheumatoid arthritis synoviocytes. *Lasers Surg Med*, **41**:282–290, 2009.
6. Coderre TJ, et al. Contribution of central neuroplasticity to pathological pain: review of clinical and experimental evidence. *Pain*, **52**: 259–285, 1993.
7. Mense S. Nociception from skeletal muscle in relation to clinical muscle pain. *Pain*, **54**: 241–289, 1993.
8. Rhea MR. Determining the magnitude of the treatment effects in the strength training research through the use of the effect size. *J Strength Condition Res*, **18**:918–920, 2004.
9. Kean CO, et al. Minimal detectable change in quadriceps strength and voluntary activation in patients with knee osteoarthritis. *Arch Phys Med Rehabil*, **91**:1447-51, 2010.
10. Lewek MD, et al. Quadriceps femoris muscle weakness and activation failure in patients with symptomatic knee osteoarthritis. *J Orthopaed Res*, **22**: 110-115, 2004.