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Electromyography in muscle activation lumbar region in a comparison between manual therapy and photobiomodulation associated with kinesiotherapy in individuals with low back pain

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ABSTRACT

Introduction: About 10 million people have low back pain (LBP) disability in Brazil. Several therapies are used to treat this condition, such as kinesiotherapy, manual therapy (MT), and photobiomodulation (PBM). Although the use of these methods in LBP has been investigated, studies evaluating the efficacy of the association between these techniques are still needed. **Objective:** To evaluate the activation of the lumbar region muscles by PBM or MT associated with kinesiotherapy for the treatment of LBP. **Methods:** Twenty individuals with chronic LBP were randomly divided into two groups. The first group (MT) received vertebral mobilization associated with a kinesiotherapy exercise program. The second group (830nm-PBM) received PBM associated with the exercise program, twice a week for 8 weeks. Evaluation of pain perceived was performed by the visual analogic scale (VAS), lumbar disability by the Oswestry questionnaire, muscle strength by strain gauge, and activation through surface electromyography (EMG). Data were collected before and after the treatment. EMG data was analyzed by MatLab®. The ANOVA two-way test was used (degree of significance $p \leq 0.05$), and the size of the effect by the Hedge test. **Results:** Considering pain, the two groups presented a significant result ($p<0.05$). In muscle activation, only the multifidus was different during the side bridge ($p<0.05$) when compared intragroup. None of the variables were different when evaluating intergroup. **Conclusion:** Both MT and PBM associated with kinesiotherapy for 8 weeks are effective in reducing pain, and improving motor control and stability of the lumbar spine in patients with chronic LBP.

Keywords: low back pain; musculoskeletal manipulations; lasers; exercise therapy.

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INTRODUCTION

Non-specific low-back pain (LBP) is defined as pain or discomfort between the margins of the lower ribs and the gluteal folds, associated or not with neurological symptoms in the inferior members[1,2]. This pain is one of the main causes of absence from work, affecting life quality and leading to functional incapacity and disability to perform daily-life activities, resulting in higher economic costs for social security systems and health services[3,4]. Around 10 million people present some deficiency associated with lumbar pain in Brazil, and data suggest that at least 70% of the population will have a painful episode throughout life[5]. The etiology of LBP is considered multifactorial, highlighting occupational factors (heavy physical work, rotation movements, inclination, and vibrations) and others such as for overweight, muscle weakness, postural changes, shortening, and imbalance of the muscle chain[2,6,7]. Thus, musculoskeletal injuries have an important role in the LBP symptoms by leading to changes in the control of the deep musculature, failure of the activation of the trunk muscles, and consequently spinal instability[8]. The instability is the result of a tissue injury that makes the segment less resistant and with weak muscle control, is thus suggested as the cause of functional disorders, such as tensions and pain[8].

Studies describe that kinesiotherapy presents positive effects on the treatment of the LBP symptoms, improving spine and lumbar stability, incapacity, strength, flexibility, and range of motion (ROM), besides reducing pain[9,10]. In the systematic review study carried out by Chou et al.[11], they recommend the use of exercises for the rehabilitation of patients with chronic low back pain.

Other treatments encompass non-thermic or photochemical reactions to modify the condition of damaged tissues, such as photobiomodulation, or manual therapy, acting as possible treatments for chronic low back pain[3,12]. A metanalysis pointed out that photobiomodulation when used alone or in combination with other modalities, presents an important role in the reduction of lumbar pain[13]. The articular mobilization proposed by Maitland is based on the evaluation and treatment through passive accessory intervertebral movements, and analgesia is produced by stimulating mechanical periarticular receptors, inhibiting nociceptors, and generating a positive response of the descendent pain inhibition systems[3,14,15]. The study of Ali et al.[15] demonstrated that manual therapy leads to a significant improvement in pain time, movement amplitude, back extensor muscular activity, and chronic LBP disability.

Kreiner et al.[16] organized a study to answer eighty-two clinical questions seeking to answer them as a summary of the clinical guidelines for the treatment of low back pain. In this research, the authors presented strong recommendations for physical exercise. However, for manual therapy and PBM, the recommendations were poor. In the guideline written by Meroni et al.[17], the authors describe physical exercises with a strong recommendation for patients with chronic low back pain whereas the other modalities used in the present study, there is a need to be studied as the weak recommendations for the isolated use of manual therapy and the evidence do not support the use of photobiomodulation[17] for this patient profile so we justify the present study by associating physical exercises with manual therapy and PBM with the objective was to evaluate the activation of the muscles lumbar region with the influence of photobiomodulation and Manual Therapy associated with kinesiotherapy in the treatment of non-specific Chronic Low Back Pain.

METHODS

Design

The project and execution followed the orientation of the consort checklist. This study had a prospective character, presenting a randomized clinic essay with two parallel groups: MT, or manual therapy with ten exercises; and PBM, or 830 nm photobiomodulation with ten exercises. The Randomized Clinical Trial was performed for eight weeks, with a two-time weekly frequency, totalizing 16 visits.

Participants

The sample occurred by convenience. The participants were recruited in the period between November 2014 and July 2016, in Universidade Paulista, through social media and flyers distributed in the city of Ribeirão Preto, Brazil. We recruited twenty men and women between 18 and 60 years old with chronic non-specific LBP. The individuals were included when presented with chronic LBP with or without irradiation to lower members, with more than three months of symptoms. The participants were excluded if they presented low back pain due to injuries in the central or peripheral nervous system, spine fracture, specific LBP (such as scoliosis, spondylolisthesis, and disc protrusion), or association to red flag (e.g., tumors, cauda equina syndrome, infections, and abdominal aortic aneurysm[2,18]. The flowchart of the participants screened and included in this research is shown in Figure 1.

Randomization

The randomization was performed through a brown envelope with 23 papers containing the numbers 1 (PBM group) and 2 (MT group). On the first day of attendance, the individual took a paper from the envelope, which indicated the group to which he would be forwarded. The numbers one to eleven were designated for the MT group and 12 to 23 for the PBM group. Only three patients did not perform the procedures until the end and were excluded from the study.

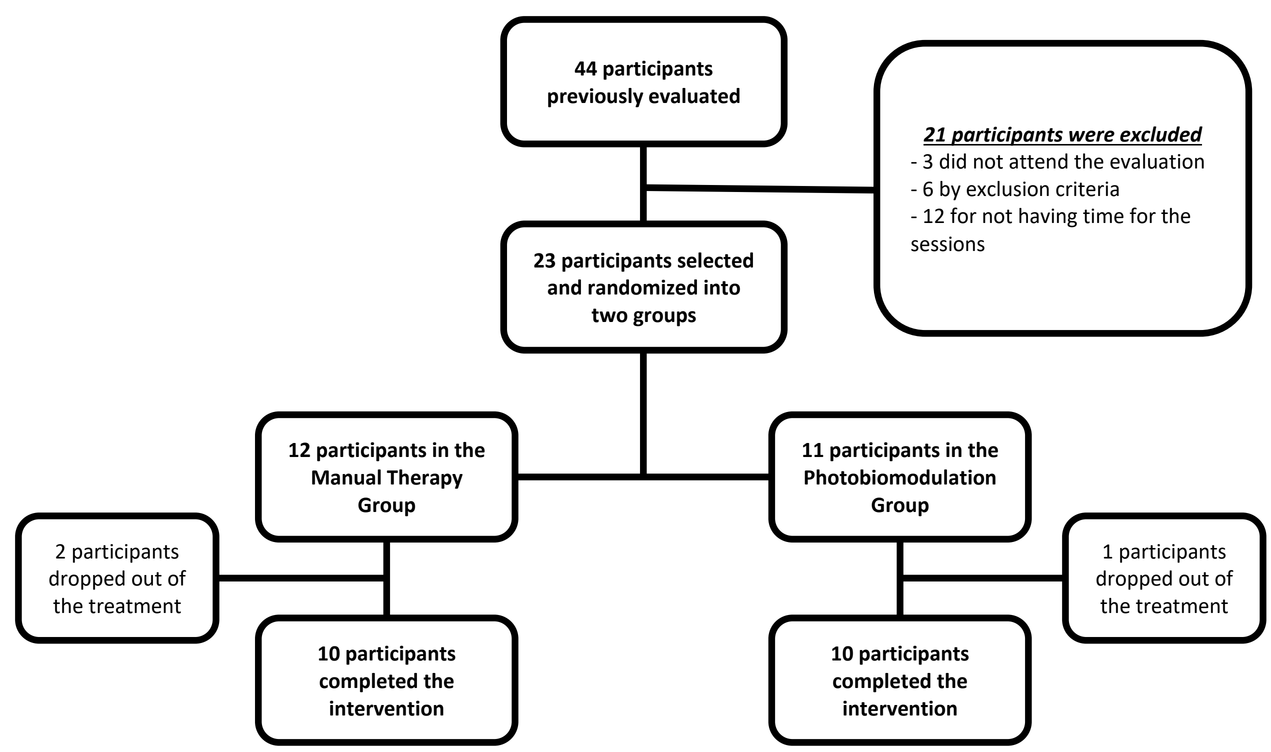

Figure 1: Flowchart showing the division of the participants

Intervention

To better describe the interventions, we used the TiDier checklist. Costa et al.[19] demonstrated that the motor control exercise leads to a decrease in persistent lower back pain. The two groups in the present study received the kinesiotherapeutic protocol consisting of 12 exercises. Only eight exercises were performed during each attendance, and some were changed along with the attendances, thus embracing all the exercises. The protocol was composed of ground exercises, where the individual could remain in sedation, supine, lateral, and ventral positions, being able to move to positions on four supports. The voluntaries performed eight repetitions of eight exercises, with a progression along the weeks to ten repetitions. The PBM protocol (Table 1) was explained through an Ibramed® Laserpulse device of Gallium, Aluminum, and Arsenieto (GaAlAs) with infrared light in continuous emission mode. The pen was in direct contact, perpendicular to the individual's skin. Were performed at ten points in the voluntaries lower back, with irradiation performed bilaterally in the region of the vertebral foramina of the five lumbar vertebrae[20].

In the MT group, the individuals were submitted to vertebral mobilization maneuvers varying according to the pain degree of each evaluated individual. The maneuver was applied over the spinous process of the lumbar vertebrae, where the patients reported the biggest pain picture. Three series of 30 seconds each were realized for mobilizations of I and II degree, and 60 seconds for mobilizations of III and IV degree[14,21].

Table 1: Photobiomodulation parameters used.

Photobiomodulation Parameters	
Beam Area	0,11 cm²
Laser Power	30 mW
Wavelength	830 nm
Power density	0,27 W/cm²
The energy density per point	32,4 J/cm²
Energy per point	3,6 J
Energy per session	36 J
Total energy	576 J
Time per point	120 seconds

The treatment protocol for both groups was performed before the exercises, two times a week (with a minimum interval of 48 hours), with a duration of two consecutive months (eight weeks), totalizing 16 attendances of 60 minutes each. The attendances were performed by two trained people at the physiotherapy clinic of the Universidade Paulista.

Data collection

All volunteers were individually submitted to blind assessment before and after treatment protocols. The evaluations were made by the one trained evaluator, which was not aware of which group the participant would be referred to. In the initial evaluation, personal data, weight, BMI, pain level (visual analogic scale – VAS, primary outcome), and isometric muscle resistance (through side bridge and Sorensen test).

The tests and observation of muscle tension points performed in both initial and final evaluation characterized the studied sample. After the tests, an Oswestry questionnaire was applied to characterize the lumbar disability and an evaluation with superficial electromyography (EMG) was performed with two Miotec® Miotool 400 devices. The software used to observe the recruitment of muscle motor units was MiotecSuite 1.0, through the evaluation of the transverse abdominal muscles/internal oblique (TrA/OI) and lumbar multifidus (ML). The electromyographic data were analyzed through the software MatLab® (MathWorks Inc., Natick, MA, EUA) and processed through algorithms developed for this evaluation. Data was passed through a bandpass filter with cut frequencies from 20 to 500 Hz, then was performed the normalization of the signal of the right and left lateral and transverse abdominal muscles/right and left internal oblique, by the signal peak in the performed activity. Before performing the Sorensen test, the maximum voluntary isometric concentration of the lumbar extension movement was collected to quantify the strength of this musculature. The skin cleansing care and the positioning of the electrodes in the multifidus muscles were through the recommendations of SENIAM (Surface ElectroMyoGraphy for the Non-Invasive Assessment of Muscles)[22] and positioning in the transverse abdominal muscles/internal oblique muscles (TrA/OI) was recommended by Alves et al.[23].

Statistical analysis

Data were submitted to the Shapiro-Wilk test for the data normality. After that, an ANOVA Two-Way test was performed with a significance level of $p<0.05$, and effect size by g de Hedges. The statistical analyses were performed using the software GraphPad Prisma® 8.0 (GraphPad Software, La Jolla, California, USA). The delta consists of the difference between the final and initial evaluation, to demonstrate how much variation occurred in intergroup or between the groups.

Ethics

This research was approved by the ethical and research committee of the Universidade Paulista, under the number 1.041.755. The research was registered in the Brazilian registry of clinical trials (REBEC) under the number RBR-243w6r. The voluntaries read and sign an informed consent form before any methodological procedure.

RESULTS

The recruitment period and interventions occurred from November 2014 to July 2016. Only data analysis was carried out at the federal university of Santa Catarina, from August 2016 to June 2017. Twenty-three individuals were selected to participate in the research, but three did not finish the intervention. The individual characterization is described in Table 2, containing ten randomized individuals for each group (N=20) divided into MT and PBM groups, they are homogeneous in age and BMI with $p>0.05$. The Oswestry disability questionnaire resulted in average punctuation of 38% before intervention and 18% post-intervention in the MT group, reflecting minimal disability and presenting the effect size g=0,86. For the PBM group, the questionnaire resulted in average punctuation of 41% before intervention and 24% post-intervention, reflecting a moderate disability in the final evaluation and presenting the effect size g=0,64. In the intragroup analysis, there was a difference between the pre and post-intervention, in the analysis between the groups, there was no statistical difference. The analyzes of the maintenance time in the position of the side bridge and the Sorensen test were quantified by time (seconds) but without statistical differences between intragroup or intergroup. The greatest variation in time was observed in the Sorensen test of the MT group, which varied from 64 seconds in the initial evaluation to 85 seconds in the final evaluation (Table 2), of all the tests only the Sorensen and right side bridge of the MT group present the effect size g=0,85 and G=0,81 respectively.

Data referring to perceived LBP are presented in Figure 2, evaluated through the VAS. Data presented significant differences in intragroup GMT before and after intervention with $p<0.05$. Both groups showing effect size negative GMT g=-1,93 and GPBM g=-1,51.

The values of the RMS of the Sorensen test are shown in Figure 3A, indicating the variation in muscle activity. It showed that the activation of most of the evaluated muscles decreased, although for the PBM group there was an increase in the activation of the right transverse abdominal muscle, there was no statistical difference between the pre and post-intervention assessment. The left multifidus and the transverse left abdomen of the manual therapy group had a large effect size (g=0.73 and g=-0.93 respectively) and the right multifidus of the PBM group obtained moderate effect size, however negative with g= -0.46.

Table 2: Characterization of all individuals who completed the intervention.

Group	N	SEX	AGE	IMC (Kg/m²)	OSWESTRY*		RSB	LSB	Sorensen test
MT	10	M=5	23,1 (±2,94)	24,88 (±3,60)	18%	Pre	25	25	64
		F=5				Post	35	29	85
PBM	10	M=4	30,9 (±10,63)	27,39 (±8,12)	24%	Pre	21	24	57
		F=6				Post	27	30	63

IMC: body mass index; kg/m²: kilogram per square meter; RSB: Right Side Bridge; LSB: Left Side Bridge; *final evaluation

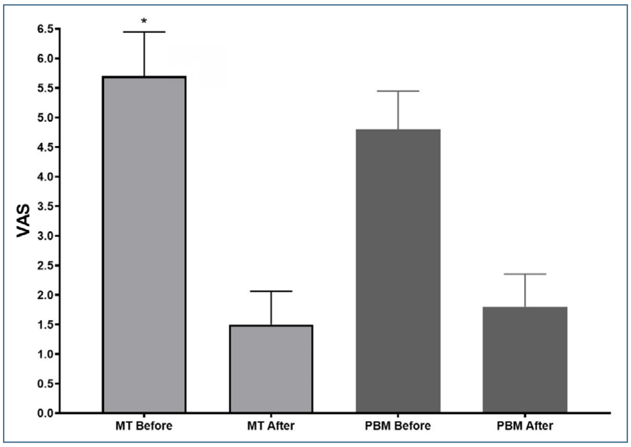

Figure 2: Comparison of VAS (visual analog scale), pre and post-intervention between groups (MT: Manual Therapy, PBM: Photobiomodulation). *p<0.01; **p<0.05.

Figure 3B showed the comparison between intergroup and intragroup, where the MT and PBM groups did not present a significant difference for the right side bridge test. Figure 3B showed a decrease in activation of MD, ME, and TrA/OI muscles, and an increase in inactivation of the right TrA/OI muscle in the MT group. A decrease in activation of MD and ME muscles was found for the group PBM, with an increase in inactivation of both left and right TrA/OI muscles. The GMT in the ML, TTR, and TRL muscles demonstrated a moderate effect size (g=-0.57, g=0.49, and g=0.48), in GPBM only TRL showed a moderate effect with g=0.52.

In the left side bridge test the MT group presented a significant difference in activation of the MR muscle, while for PBM this difference occurred in the activation of the ML muscle ($p<0.03$). Figure 3C shows a decrease in activation of MR and ML muscles, with an increase in inactivation of both right and left transverse abdominal muscles in the MT group. Considering the PBM group, there was a decrease in activation of the MR, ML, and right transverse abdominal muscles, with an increase in inactivation of the left transverse abdominal muscle. In both MT and PBM groups, only the left multifidus muscle had a moderate effect size and negative with g=-0.55 and -0.58.

Lastly, there was an increase in the force value (Kgf) considering the evaluation pre-and post-intervention in the maximum isometric voluntary contraction of the groups Figure 4. However, there were no significant differences in intergroup between the MT and PBM. When evaluating the maximum voluntary isometric contraction (muscle strength) the two groups obtained large effect sizes, GMT with g=0.91 and GPBM with g=0.82.

DISCUSSION

The objective of this study was to analyze and compare the influence of manual therapy and photobiomodulation, associated with kinesiotherapy, on pain, CVIM test, disability questionnaire of Oswestry, and ML and TrA/OI muscle activation on individuals with non-specific LBP after eight weeks of intervention. In pain evaluation, it was observed a positive effect of the group submitted to manual therapy. When evaluating the electromyographic parameters, there were changes in muscle activation for both groups, but with no significant difference between them.

Costa et al.[19] evaluated 154 individuals with chronic LBP, which performed 12 exercise sections of motor control or placebo conducted through eight weeks. This study demonstrated that the motor control exercise leads to a decrease in persistent pain for 12 months, evidencing that this exercise was better than a placebo in people with chronic LBP. Our findings corroborate this study, since the individuals presented a decrease in pain after eight weeks of interventions with exercises, indicating that it can be useful for the treatment of chronic LBP by decreasing its intensity.

Ferreira et al.[24] compared a group treated with the Maitland method to another group treated with therapeutic exercises and concluded that both are efficient to decrease the pain chart in individuals with chronic LBP. This also corroborates our findings, since we verified that the vertebral mobilization associated with kinesiotherapy was efficient to decrease the pain chart in individuals with chronic LBP. The association of these two methods demonstrates significant statistical results when compared between groups.

Tavares et al.[25] conducted a study comparing joint mobilization of the lumbar region with two Sam and control groups and the mobilization group was more effective only when compared to the control group in the analysis of pain. In the present study, both groups were effective in altering muscle strength and improving pain. According to Isenburg et al.[26], joint mobilizations can increase cortical connectivity, causing modulation and decrease in pain.

Djavid et al.[27] performed a controlled and randomized study with 61 participants allocated to three intervention groups: low-intensity laser therapy of 810 nm GaAlAs, laser therapy and exercises, and placebo laser therapy and exercises for 12 sessions. There were no significant differences between groups for any measurement, but the pain decreased more in the laser therapy with exercises than in the placebo and exercises group, demonstrating that the low-intensity laser therapy associated to exercise is more promising in the treatment of chronic lower back pain than just exercises. We found that, although both groups decreased their pain chart, only the MT group was statistically significant, indicating better results for this evaluation.

Considering EMG for the evaluation of muscle activation, the results showed lower muscle activation for both groups, although non-significant when compared between groups. Machado et al.[28] used Pilates exercises for eight weeks, and the results also indicated a decrease in muscle activity comparing pre-and post-intervention, suggesting an improvement in motor

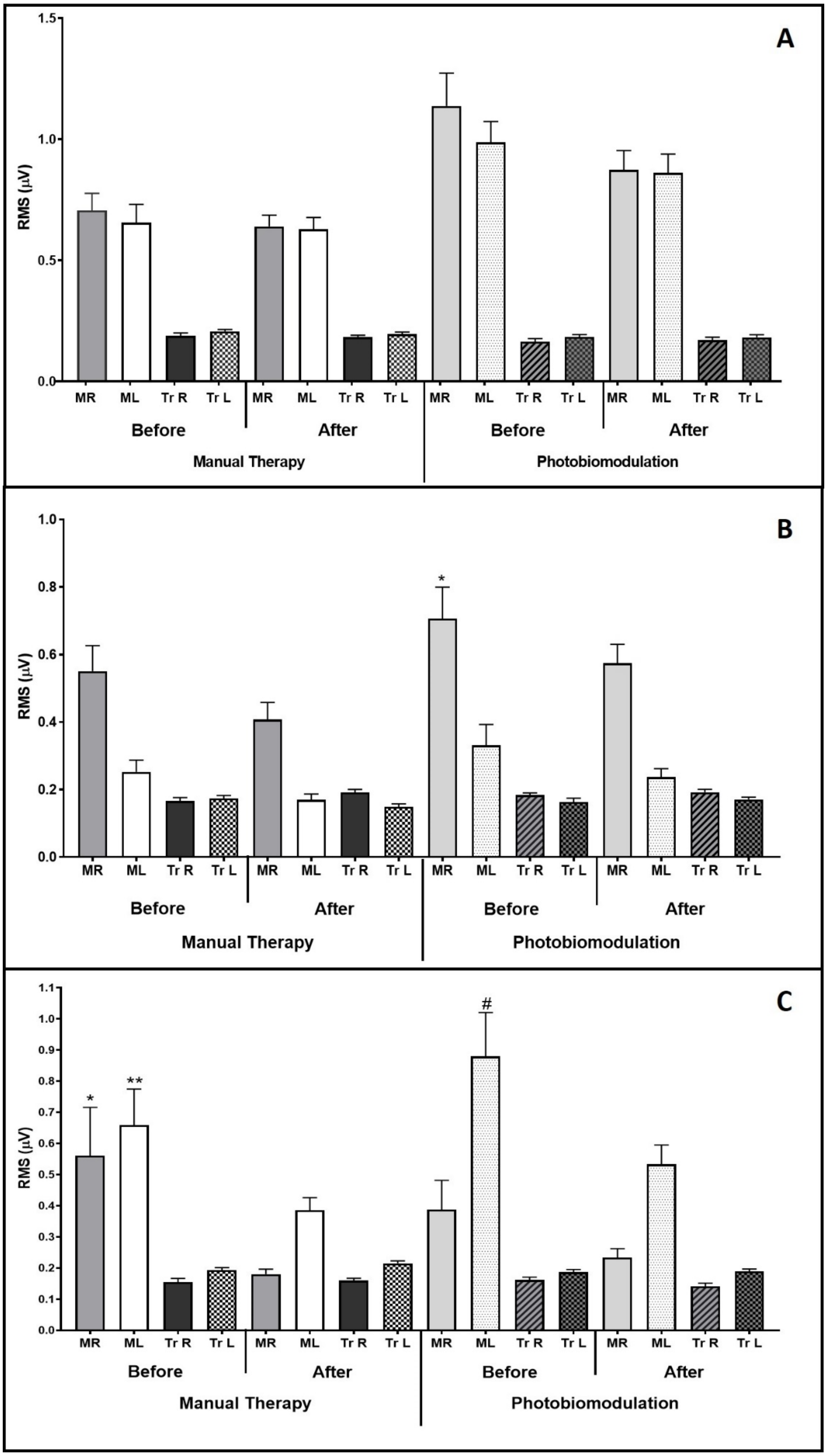

Figure 3: (A) Comparison Intra and intergroup of the data obtained RMS the initial and final evaluation of muscle activation during the Sorensen test. MR: Multifidus - Right; ML: Multifidus - Left; TTR: Transverse abdomen - Right; TRL: Transverse abdomen – Left; (B) RMS values of surface electromyography of the muscles in the right side bridge test in pre and post-intervention of the groups. MR: Multifidus - Right; ML: Multifidus - Left; TTR: Transverse abdomen - Right; TRL: Transverse abdomen - Left. *p<0.05; (C) RMS values of surface electromyography of the muscles in the left side bridge test in pre and post-intervention of the groups. MR: Multifidus - Right; ML: Multifidus - Left; TrR: Transverse abdomen - Right; TrL: Transverse abdomen - Left. * p<0.05; **p<0.05; #p<0.01.

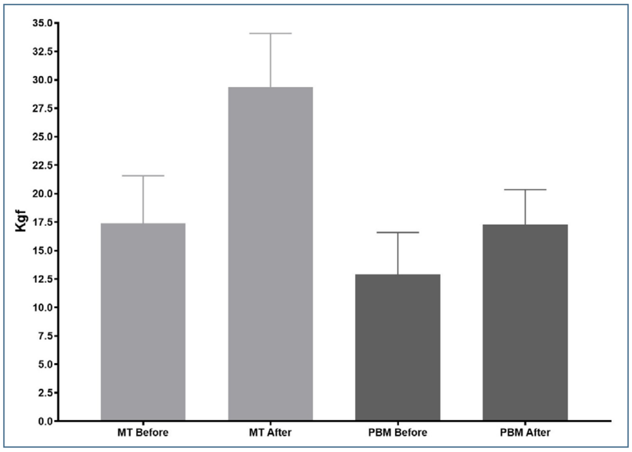

Figure 4: Data referring to the strong muscle extensors in the lumbar in both groups in this study. *p<0.05. (MT: manual therapy; PBM: Photobiomodulation).

control, since fewer motor units were recruited to perform the activities. The results of the present study also demonstrated less recruitment of motor unities in the test performance, leading to the improvement of motor control, which is expected in healthy and painless individuals.

An eight-week intervention study compared a group with stability exercises and another group with balance exercises[29]. The results of the EMG evaluation showed that the activity of TrA/OI muscle decreased and the external oblique and erector spine muscles increased for the stability group, suggesting an appropriate muscle co-contraction effect as a strategy of motor control, thus reducing pain and increasing muscle functioning[29]. In the present study, we showed an increase in activation of the abdominal transverse for the Sorensen test and side bridge in both evaluated groups, indicating a greater activation of these fibers to perform the movement not only of the extensor musculature, with a rebalancing and appropriate distribution of muscle activation, generating greater lumbar stability and large effects size for the strength of the muscle and in EMG evaluation any muscles obtained moderate effect size.

Bae et al.[30] compared a training device with a conventional trunk stabilization exercise in 12 sections, and both groups demonstrate statistical differences in the activation level of the external oblique compared to the rectus abdominis, corroborating our findings in the present study and indicating a change in the patterns of activation. Our results showed greater activation of the abdominal transverse muscle in pre and post-intervention, with simultaneous of these muscles together with the multifidus to perform the activity. This led to a distribution of activity between the muscle groups, tending to balance between the evaluated muscles.

Considering the motor control in the lumbar region, some evidence indicates that the capacity of the central nervous system in regulating agonist-antagonist muscle activity may be impaired in people with chronic LBP. This leads to a disharmony in the activation of the superficial and deep muscles responsible for the movement and stabilization of the lumbar spine, reducing the quality of the movement and increasing the spine compressive load, thus reflecting in the control of the forces acting on the lumbar spine[10,31].

We can highlight some limitations of this study, such as the non-assessment of Onset and the co-contraction of the muscles acting in the lumbar spine, the low number of participants, and the lack of a control group. The impossibility of blinding can also be considered a limitation.

Conclusion

From the results obtained in the present study, we can conclude that an exercise program associated with manual therapy or photobiomodulation for eight weeks is efficient to decrease pain and improve electromyographic parameters. We observed statistical difference in any parameters with moderate effect size in any evaluations in this study and observed greater trunk strength, a decrease in the activity of the multifidus muscle, and an increase of activity of the abdominal transverse/internal oblique after the treatment, leading to an appropriated redistribution of activation between muscle groups and consequently rebalance of muscle activation, improvement of motor control and greater stabilization of the lumbar region compared to the preintervention. This suggests that both interventions are efficient and can be indicated as effective options for the treatment of individuals with non-specific chronic LBP.

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