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Photobiomodulation Therapy Using Infrared (808 nm) Low Level Laser Therapy Associated with Strength Training in Knee Osteoarthritis: A Randomized placebo-controlled clinical trial

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ABSTRACT

Mechanisms for significant clinical and statistical benefits of photobiomodulation (PBMT) in the treatment of knee osteoarthritis (KOA) include anti-inflammatory effects, optimization of tissue repair, improved muscle function and analgesia. The effectiveness of (PBMT) associated with strength training (ST), in the form of strength training, has been investigated in randomized clinical trials, but the results are not well clarified. The aim of this study was to evaluate the effects of ST associated with PBMT on joint pain intensity, range of motion, physical function and muscle strength of the quadriceps femoris and hamstrings in patients diagnosed with KOA. Twenty-eight adult patients of both genders with KOA were randomly distributed in 2 treatment groups, performed 3 times a week, for 6 weeks: ST Group (ST), submitted to stretching, self- mobilization, muscle strengthening and sensorimotor training and ST and STP Group (STP), submitted to the same program as the ST followed by infrared laser irradiation (Therapy XT, DMC, São Carlos, Brasil, ?= 808 nm, P= 100mW, 5 points in the medial joint region and 4 points lateral, 3 J/point, 30 s/point). Blinded evaluators assessed pain at movent and no movement and range of motion using Analogic Visual Scale and goniometry, respectively. To assess physical function, the WOMAC questionnaire (Western Ontario and MacMaster University Osteoarthritis Index) and functional tests were used: Sit and stand test; 2 min-walk test. The muscular strength of the quadriceps and hamstrings were measured using an isometric dynamometer. The evaluations were performed in 4 moments: before (EV0), during (EV1: 3 weeks of treatment), at the end (EV2: after 6 weeks of treatment) and 30 days after the end of treatment (follow-up). The STP group showed a significant reduction in pain intensity at rest and at movement in EV1, as well as, significant improvement in relation to stiffness, total WOMAC and knee flexion amplitude, an improvement in physical function and an increase in muscle strength of quadriceps femoris when compared to ST group ($p < 0.05$). In the assessment of the strength of the hamstring muscles, there was no significant difference between the groups at any time evaluated (p? 0.05). ST associated with PBMT had greater effects in reducing joint pain intensity, active knee flexion, physical function and muscle strength, especially in the quadriceps femoris, than strength training alone in patients with KOA.

Keywords: Phototherapy; Exercises; Chronic pain

BACKGROUND

Knee Osteoarthritis (KOA) is a multifactorial condition characterized by pain, transient morning stiffness, crepitus on joint motion, that directly impact the quality of life of the individual[(1)]. KOA is furthermore associated with weakness of the quadricep and hamstring muscles due to atrophy caused by disuse and / or deficits in muscle activation, which promotes loss of balance and postural oscillation[(2)].

The diagnosis can be established based on the patient's symptoms and a radiographical assessment, which can be used to detect indirectly the cartilage degeneration and wear by the assessment of joint-space narrowing and bony changes, that is, osteophytes and subchondral sclerosis[(3)].

KOA is one of main causes of chronic disability and use of health care services. Normally, is disease evolution can be slow and the process takes place over many years, however, for some individuals, the progression can be fast, and early osteoarthritis is a growing phenomenon that will have significant social and economic impacts in the future[(4)].

Non-steroidal anti-inflammatory drugs, weight control, arthritis education and structured land-based exercise programs are recommended most KOA clinical treatment guidelines and is likely the most frequently prescribed intervention for osteoarthritis[(5)], even though intake of these drugs is associated with negative side effects[(5)].

Strength training (ST) has shown to be a promising method to influence cartilage morphology and chemical composition, promoting analgesic and functional effects of people with KOA[(6,7)]. However, initial pain intensity level can be is so high that prevents the individuals from exercising[(8)], and since KOA is a chronic disease, exercise-based rehabilitation may not be enough to reduce pain[(5)].

Although reduced leg strength is a common disabling feature in KOA, the effectiveness of photobiomodulation (PBMT) associated with ST, in the form of strength training has been investigated in randomized controlled trials (RCTs), however the results are not well clarified[(9-12)].

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PBMT involves the use of monochromatic light, in the wavelength spectrum red to infrared (660 to 950 nm), with a non-thermal effect, and has been proposed in the treatment of patients with KOA due to its analgesic effects[12] and ability to reduce a series of proinflammatory markers, such as IL-1β, cyclooxygenase-2 (COX-2) and prostaglandin E2 (PGE2)[13,14]. Furthermore, PBMT has shown to upregulate the proliferation of fibroblasts and proteoglycans in the synthesis of collagen, which slows down the deterioration of articular cartilage. Although meta-analyses indicate that these processes translate into pain and disability reduction in KOA, it is unclear to which extent due to statistical heterogeneity of the analyses[8,15]. Therefore, the effect of adding ST to a PBMT regimen in KOA is far from established[16].

In this context, the aim of this study was to evaluate the effects of strength training associated with PBMT on joint pain intensity, range of motion, physical function and muscle strength of the quadriceps femoris and hamstrings in patients diagnosed with KOA.

METHODS

Participants

This is a prospective blind randomized clinical trial, carried out at the Physiotherapy outpatient Clinic of the FUPAC School Clinic, Ubá-MG, Brazil. The project was approved by the Ethics Committee of Universidade Brasil (3.261.195).

Twenty-eight sedentary adult patients of both genders with KOA physiodiagnosis participated. The diagnosis was established using the criteria by the American College of Rheumatology (ACR), i.e., knee pain, osteophytes on radiography and at least one of the following items: crackling when moving, older age than 50 years and morning stiffness for less than 30 min[17]. Patients should report at least three months of pain and an intensity of at least 40 points on the Visual Analogue Scale (0-100) in the last 48 h[18].

Among the exclusion criteria adopted were those with body mass index (BMI) greater than 35 STG / m2, heart disease, hypertension and / or decompensated diabetes; use of cardiac pacemakers; neurological diseases that affect locomotion, use of antidepressants or anxiolytics in the last 6 months; performed physical activity or physiotherapeutic treatment in the last 3 months; underwent any surgical procedure on the lower limb in the last 12 months, or who had total or partial prosthesis on one or both knees and hips; and those who did not accept to participate in the research. Also excluded were those who were absent from the initial assessment, in two consecutive visits and those who were not available to perform the visits 3 times a week.

The study flowchart based on the consort guidelines is shown in Figure 1.

Initially, 47 patients were evaluated, of which 28 accepted to participate in the research through the informed consent and met the inclusion criteria of this study, and were then randomly distributed, from opaque and sealed envelopes, in one of two groups: Strength Training Group (ST: strength training) or: Strength Training and Photobiomodulation Group (STP: strength training and Photobiomodulation). The envelopes were chosen by the patients themselves, without interference from the researcher.

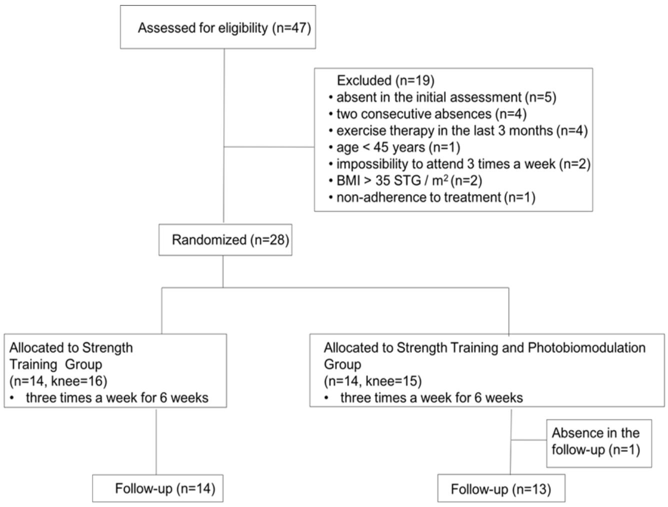

Figure 1: Flowchart of the study

Assessments

Two properly trained researchers conducted the treatment, while the examiners were responsible for the evaluations, remaining blind to the group's duties, not participating in the physical therapy treatment, therefore, all participants were assessed individually by a blinded physiotherapist at 4 time: 48 h before the start of treatment (Evaluation 0: EV0); 48 h after the end of the 3rd week (Evaluation 1: EV1); 48 h after the end of the 6th week of treatment (Evaluation 2: EV2) and 30 days after the last visit (Follow-up).

The volunteers' perception of pain in the last 48 h was assessed using the Visual Analogue Scale (VAS - Visual Analogue. Scale), which is a scale ranging from 0 to 100, with 0 (no pain) and 100 (worst pain imaginable). Thus, pain intensity was measured in 6 daily situations: 'Rest'; 'Walk'; 'Sit on a chair'; 'Climbing stairs'; 'Descending stairs and 'Crouching', the pain score for Rest (VAS score at rest) and movement for the other 5 activities (VAS score at motion) being considered for assessment.

The goniometry was performed by the same evaluator, using a universal goniometer (Carci, 35 cm) with the patient in the supine position and the active and passive range of motion (ROM) of the knee flexion was measured[19], except in EV1.

To assess joint function, the WOMAC questionnaire (Western Ontario and MCMaster Universities Osteoarthritis Index) was used. This questionnaire assesses functional capacity in KOA and is divided into three parts with 24 questions, in the areas of pain (5 questions), stiffness (2 questions) and physical function (17 questions). In the present study, we used a five-point Likert scale (0 = none, 25 = little, 50 = moderate, 75 = intense, 100 = very intense). The patient answered the questions to better describe his symptoms and difficulties of the past 72 h. Higher scores indicate worse pain, stiffness and physical function[20].

Still for the evaluation of physical function, two functional tests were applied: the “2 Minute Walk Test” (The 2 Minute Walk Test), which measures the total distance covered by an individual during 2 min, where the patients were instructed to walk as quickly in such a way that they felt safe and comfortable and at the end the total distance in meters was measured. The data from this test were converted to average speed (m / s) to present the results.

The “Sit and Stand Test” was performed with the aid of a chair with a back and without arms, with a height of approximately 45 cm, leaning against the wall to prevent sliding and a stopwatch. The appraiser instructed the appraiser to sit in the middle of the chair, with his back erect, his feet fixed to the floor and shoulder-width apart and his arms crossed against his chest. Before starting the test, the appraiser performed a demonstration of the correct way to perform the movement and then the appraiser also made one or two complete movements for familiarization. The purpose of this test was to evaluate the performance of the complete sit and stand movement, as many times as possible in 30 s, at a speed that was self-selected by the subject and without the assistance of the subject. Patients were verbally encouraged to ensure faster movements. The test was performed 3 times, with 1 min rest between attempts and the average of the repetitions performed was considered[21].

To assess the muscular strength of the quadriceps and hamstrings, a portable dynamometer (Instrutherm, Model DD-300, Brazil) was used. The volunteers were instructed on how to perform the maximum contraction of each muscle group, to adapt with the procedures. The strength of the quadriceps femoris muscle was assessed as follows: patient sitting at approximately 45º with the resistance of the elastic on the edge of the stretcher, with hips flexed at 90º and knee flexed at 45º. The hamstring muscle strength was performed with the patient in prone position, hip in neutral extension and knee flexed at 30º of flexion. The non-elastic resistance brace was positioned in both groups above the malleoli of the ankle, and another non-elastic brace was used for proximal stabilization.

Maximum isometric contractions were requested, lasting 5 s, followed by 30 s of rest marked by a digital stopwatch. The procedure was performed 3 times for each muscle group, considering the average of each. The evaluation interval between the groups was 1 min. The equipment's strength indicator was calibrated in STG and normalized by body mass (STG) using the following formula: STGf (muscle strength) / STG (body mass) x 100. The minimum clinically important difference considered is that with a variation of 6 % compared to the initial assessment[22].

Interventions

The patients underwent outpatient treatment, with direct supervision, 3 times a week, for 6 weeks, with a total of 18 procedures. The average time of each session was 30 to 50 min.

Strength Training (ST): strength training group

The ST group underwent outpatient kinesiotherapeutic treatment, supervised 3 times a week, on alternate days, for 6 weeks, divided into 2 phases. In the first phase (first 3 weeks), the participants were submitted to: 1) passive stretching of the hamstrings and sural triceps, and the femoral quadriceps, being performed in 1 series of 30 s each; 2) active exercises with pressure from the patient to gain mobility for extension and / or flexion, seated, at the limit of pain, in 3 sets of 10 repetitions. Then, the patients started the muscle strengthening exercises with elastic resistance: 3) Straight Leg Raise (SLR) with hip flexion to strengthen the quadriceps: the participants in the supine position performed 3 sets of 15 repetitions of hip flexion with the knee extended, with a load of 12 to 15 maximum repetition (MR). 4) Strengthening of quadriceps in an open kinetic chain: the participants, seated on the stretcher, with knee and hip flexed at 90º, performed a knee extension up to 45º, unilaterally, with elastic resistance applied to the distal third of the leg. Three sets of 15 repetitions were performed with elastic load determined from 12 to 15 MR, maintaining isometry of 3 s at 45º of knee flexion. 5) Abductor strengthening exercise; with the patient in lateral decubitus, feet together, hips and knees flexed band around the knees. The patients abducted and rotated the hip laterally in 3 sets of 15 repetitions and maintained for 5 s. The resistance was adjusted daily according to the loads reached for each individual.

In a second phase, after the 4th week of treatment, the following exercises were added: 6) squat (0 to 60º of knee flexion) with 3 sets of 15 repetitions; 7) step-up exercise: in which the patient should ascend and descend from a step with a height of 15 cm in 3 series of 10 repetitions, with the limb with the affected knee being placed forward in the ascent / descent. Patients who had involvement in both knees were instructed to alternate the ascent / descent with each limb in front, holding a load of about 5% of the patient's body mass; 8) sensorimotor training with unipedal support, on a stable surface, 3 sets of 15 s on both lower limbs.

Strength Training and Photobiomodulation (STP): Strength training and Photobiomodulation Group

The STP group were submitted to the Strength training program mentioned above, with the addition of PBMT, also 3 times a week, on alternate days, for 6 weeks, after performing the exercises. The participants in this group received 9 points of irradiation in the knee joint, 5 points in the medial synovial region and 4 points in the lateral synovial region. Each point was irradiated for 30 s and received a total of 3 J. The light source used was a 100 mW continuous laser in the infrared (808 nm) spectrum, - Therapy XT, DMC, São Carlos, Brazil), with a fixed power of 100 mW, previously measured and calibrated.

Data analysis

The data were stored and analysed using the GraphPad Prism 5 software. The descriptive analysis of the variables was presented by means of standard deviation, absolute and relative frequency. The normality of the distribution of variables was assessed using the Shapiro-Wilk test. The Chi-square test was used to see the associations of qualitative variables. The comparison between the means of the variables between the groups was analysed using the Student's T-test or the Mann Whitney test, according to the normality of the data. To evaluate the treatment over time, the ANOVA Test with repeated measures or the Friedman Test was used, using Bonferroni or Dunn's post-hoc to identify the differences. P-values of < 0.05 were considered to be statistically significant.

RESULTS

Twenty-eight patients, randomly assigned to two treatment groups: ST and STP, participated in this study. Table 1 shows the characteristics of these participants. The results obtained, when comparing the characteristics of the participants of the two treated groups, showed no statistically significant difference in any evaluated characteristic: age, gender, body mass, height, body mass index, affected side of the KOA, pain initial and pain duration, which shows care in the division of groups, allowing the comparison of the different treatments proposed.

Table 1. Anthropometric and Clinical Characteristics of the participants with KOA in different treatment groups.

Characteristics	ST group	STP group	P-value
Age (years)	62.6 (7.5)	62.00 (9.60)	0.86*
Gender			0.28
Male	6 (42.86%)	8 (57.14%)	
Female	8 (57.14%)	6 (42.86%)	
Body Mass (STG)	80.50 (13.00)	77.30 (10.50)	048*
Height (m)	1.64 (0.08)	1.65 (0.07)	0.62*
Body Mass Index (STG/m^2)	29.90 (4.40)	28.10 (3.00)	0.22*
Affected Side			0.26
Right	8 (57.14%)	7 (50%)	
Left	4 (28.57%)	6 (42.86%)	
Bilateral	2 (14.29%)	1 (7.14%)	
Initial Pain (VAS)	71.40 (20.30)	63.50 (20.2)	0.31*
Pain duration (months)	44.50 (34.60)	45.80 (60.20)	0.94*

***Note:** Data expressed as mean (standard deviation) or number (percentage). ST (strength training group); STP (Strength training and Photobiomodulation group).

The assessment of pain intensity during movement showed a significant reduction in both groups in EV1 in relation to EV0 ($p < 0.05$). STP group also showed gradual improvement in EV2, in relation to EV1 ($p < 0.05$), persisting until follow-up ($p > 0.05$) (Figure 2A). Regarding the intensity of pain at rest, the results showed a significant reduction in pain in both groups, in the evaluations after 6 weeks of treatment (EV2), and in the follow-up when compared to the initial evaluation ($p < 0.05$). When comparing the intensities of pain at rest in the different treatments, the evaluations showed that the reductions are more significant in the STP group after the 3rd week of treatment (EV1), remaining in EV2 and follow-up ($p < 0.05$) (Figure 2B).

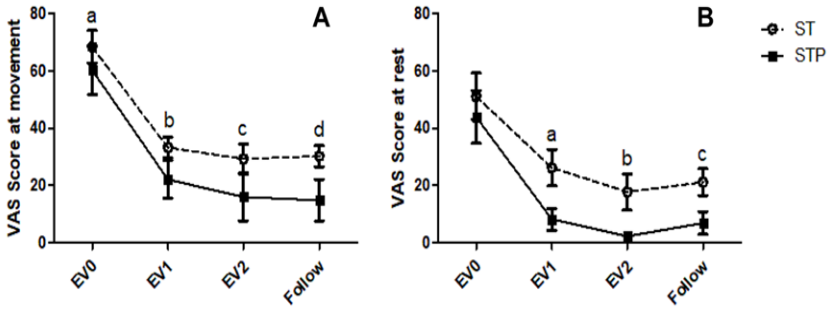

Figure 2: Scores of pain intensity in movement (A) and at rest (B); in the initial evaluation (EV0), after 3 weeks (EV1), 6 weeks of treatment (EV2) and 30 days after the end of the visits: Follow-up (follow) in both groups: ST: Strength training; STP: Strength training + Photobiomodulation. The vertical bars represent the mean and the standard error. Lower case letters represent a statistically significant difference between groups ($p < 0.05$).

In the intergroup analysis of the WOMAC questionnaire, it was shown that STP group showed reduction in the total score, in relation to ST group after 3 weeks of treatment (EV1) ($p < 0.05$), remaining until the follow-up (Figure 3D). In the pain domain, only at the end of the treatment (EV2) (Figure 3A) and for physical function only at follow-up (Figure 3B). Regarding joint stiffness, the groups showed statistically significant differences in the assessments: EV0, EV1 and EV2 ($p < 0.05$) (Figure 3C). However, at follow-up, no statistically significant differences were observed between the groups evaluated ($p > 0.05$) (Figure 3C).

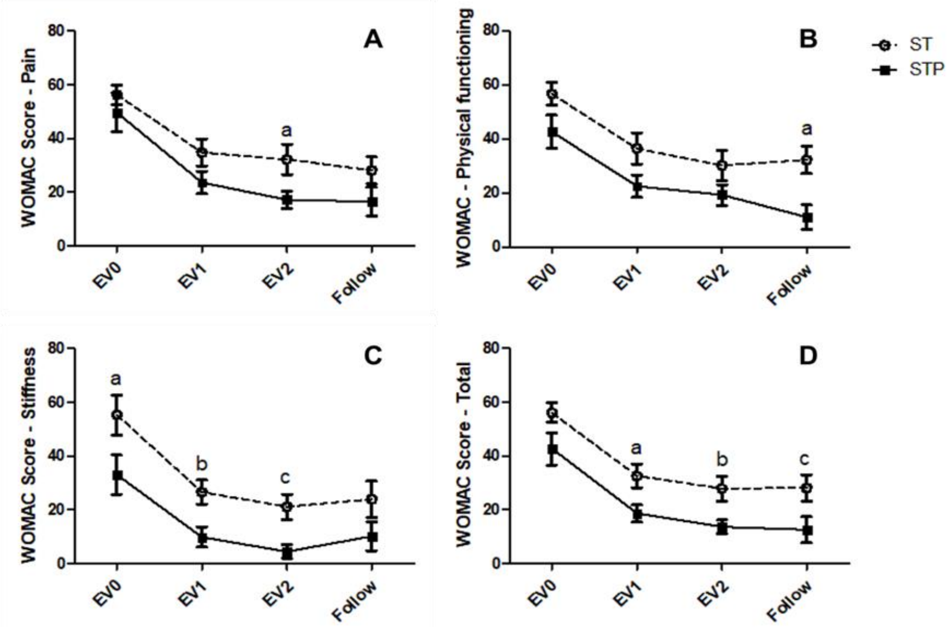

Figure 3: Scores of the WOMAC questionnaire (A: pain domain; B: physical function; C: stiffness; D: WOMAC Total) at the initial assessment (EV0), after 3 weeks (EV1), 6 weeks of treatment (EV2) and 30 days after the end of consultations: follow-up (follow) in both groups: ST: Strength training; STP: Strength training + Photobiomodulation. The vertical bars represent the mean and the standard error. Lower case letters represent a statistically significant difference between groups ($p < 0.05$).

In the assessment of physical function from the functional tests, it is observed that in both groups. Significant differences were observed between the groups, in the evaluations EV2 and follow, in the 2-min walk test ($p < 0.05$) (Figure 4A). In the inter-group analysis of the Sit and Stand Test, the ST group showed worse performance in relation to STP group in the initial evaluation ($p = 0.015$), and in the EV2 and follow-up evaluations ($p < 0.05$) (Figure 4B).

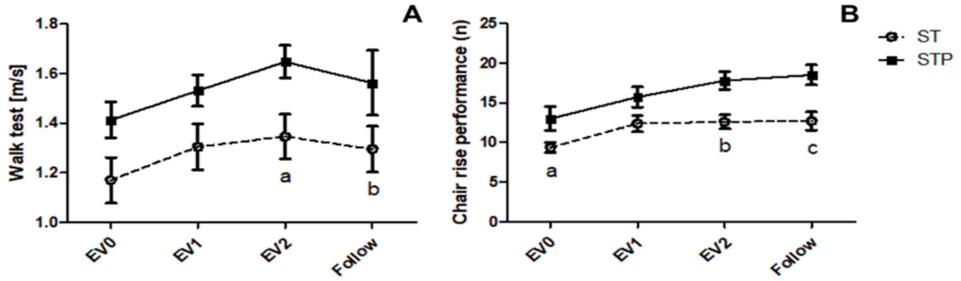

Figure 4: Physical function tests in the 2-minute walk test (A) and the sit and stand test (B) in the initial evaluation (EV0), after 3 weeks (EV1), 6 weeks of treatment (EV2) and 30 days after end of care: follow-up (follow) in both groups: ST: Strength training; STP: Strength training + Photobiomodulation. The vertical bars represent the mean and the standard error. Lower case letters represent a statistically significant difference between groups ($p < 0.05$).

Regarding the values of the range of motion of the knee, it can be seen that the group that had associated with photobiomodulation showed greater gains in knee flexion (active and passive) compared to the group treated only with physical exercise ($p < 0.05$), after 6 weeks of treatment, maintaining the follow-up (Figures 5A and 5B).

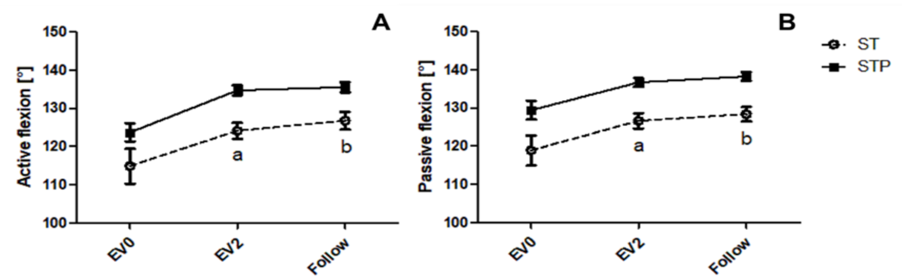

Figure 5: Means and standard error of the active (A) and passive (B) range of motion of the knee in the initial evaluation (EV0), after 3 weeks (EV1), 6 weeks of treatment (EV2) and 30 days after the end of the consultations: follow-up (follow) in both groups: ST: Strength training; STP: Strength training + Photobiomodulation. Lower case letters represent a statistically significant difference between groups ($p < 0.05$).

The muscular strength of the quadriceps showed a significant difference between the groups in the third week of treatment ($p < 0.05$), remaining until the follow-up (Figure 6A). As for the strength of the hamstring muscles, there was no significant difference between the groups at any time evaluated ($p > 0.05$) (Figure 6B).

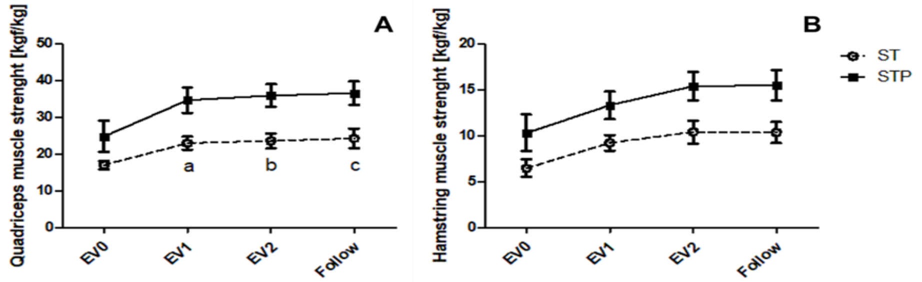

Figure 6: Means and standard error of quadriceps muscle and hamstring muscles at the initial evaluation (EV0), after 3 weeks (EV1), 6 weeks of treatment (EV2) and 30 days after the end of the visits: follow-up (follow) in both groups: ST: Strength training; STP: Strength training + Photobiomodulation. Lower case letters

represent a statistically significant difference between groups ($p < 0.05$).

DISCUSSION

The present study sought to verify the effect of PBM on pain, range of motion, physical function and muscle strength, associated with Strength training in the treatment of patients with KOA. It was hypothesized that PBM would increase the positive stimulus that Strength training would promote, improving the evaluated parameters. Our results indicated the superiority of the group that was added to PBM to the kinesiotherapeutic treatment program when compared with the group of Strength training alone. It is noteworthy that in the variables pain at rest, total WOMAC score and muscle strength of the quadriceps femoris, the greatest benefits in the group that had associated Strength training and photobiomodulation were present after 3 weeks of treatment.

The effects achieved in both groups, with an improvement in the parameters evaluated, indicate the importance of the strength training program inserted in the rehabilitation of patients with osteoarthritis. A systematic review demonstrated that the exercise program is effective in promoting the improvement of their clinical condition, which may be related to the increase in muscle strength, which would promote greater stabilization of the articular joint[(8,15,23-24)], reducing the inflammatory process, which culminate with decreased pain and increased function[(25,26)]. An exercise program decreases the synthesis of inflammatory joint markers, easing the process of cartilage proteolysis and pain levels in patients with osteoarthritis[(27)].

PBMT has been used in the treatment of degenerative and progressive diseases, such as osteoarthritis, and its effectiveness has been estimated in several systematic reviews[(8,15,23-25)]. In a review by Huang et al. (2015) of 9 placebo-controlled RCTs on the topic, the authors reported that PBMT was not significantly superior to placebo in terms of pain and physical function[(28)], however, this review has been criticized for lacking a handful of eligible trials and featuring a faulty dose-response subgroup analysis. Shortly hereafter, a review by Rayegani et al[(24)] of 13 placebo-controlled RCTs included in an all time-points meta-analysis, demonstrated that PBMT significantly reduced pain and disability compared to placebo, even without controlling for dose. More recently in 2019, a systematic and meta-analysis on the topic by Stausholm et al [(15)] of 22 placebo-controlled RCTs demonstrated that PBMT significantly reduced both pain and disability compared to placebo and that the doses recommended by the World Association for Laser Therapy yielded the best results. A RCT by Vassão et al. published after these reviews did not show beneficial effects of PBMT when added to an exercise program and they hypothesized that this was due to the relatively high dose of total energy emitted from the cluster probe (808 nm wavelength, 4 J per point, 56 J total per knee)[(11)].

Pain is the main reason why people with musculoskeletal disorders seek health care professional help[(28)]. In the placebo-controlled trials on the topic by Alfredo et al [(12)] and Fukuda et al [(29)], PBMT was applied three times per week, like in the current study, and both research groups found that this reduced pain and disability significantly beyond placebo immediately after completed therapy. Moreover, Alfredo et al [(12)] found that the PBMT significantly reduced consumption of analgesics (paracetamol) 34 weeks after completed therapy. One discrepancy in the PBMT doses is that a continuous light was applied in the current study whereas super pulsed light was applied in the aforementioned studies, and this is important to note as super pulsed light penetrates the skin approximately 2.4 times better than continuous light[(30)].

Regarding the functional tests in the current study, in both groups there was a significant increase in the distance covered in 2 min- test walk. The STP showed greater increases at the end of the 6-week treatment program (EV2), remaining in the follow-up. In a RCT by Gur et al[(31)], ninety KOA patients followed a home-based exercise program and here it was found that a relatively small dose of super pulsed laser (1 J or 1.5 J per treatment spot per session) significantly reduced pain and increased pain-free walking distance on foot, compared to placebo.

Joint stiffness and decreased range of motion are signs present in individuals with KOA. The present study points to superior gains in STP in the active and passive range of knee flexion after 6 weeks of treatment, as well as changes in the WOMAC stiffness domain. In the study by Alfredo et al. (2012) and Alfredo et al[(12,32)], no significant between-group differences were found in range of motion. However, at baseline the participants in that study had substantially less flexion than in the current study and this may be the reason why.

Reduced muscle strength, and especially that of the quadriceps muscle, is another common KOA feature[(33)]. The quadriceps is the largest antigravitational muscle of the lower limb and it is involved in protecting the knee, reducing the swinging movement of the limb during gait and minimizing the forces propagated to the proximal joints in the initial gait contact, for example.

Therefore, reduced quadriceps strength may be partly responsible for the deterioration of cartilage and knee pain as a consequence[34].

In the current study, the quadriceps strength had improved by more than 30% in both groups on average at all the reassessments. De Paula Gomes et al. (2018)[10] did not identify any between-group differences in quadriceps muscle strength (exercises associated with PBMT vs only exercises vs exercises and placebo PBMT). Interestingly, it has been found that at least 30%, and 40% increase of quadriceps strength is required to experience a significant reduction in knee pain and disability, respectively[33].

It is suggested for the next studies the addition of a placebo group and an increase in the follow-up time of the patients (follow-up), to verify when there is a possible loss of the benefits achieved with the treatment programs. Therefore, PBMT combined with Strength training can expand the range of treatment of professionals present in the labour market, in addition to encouraging further research on these treatment modalities in other clinical conditions. From the data from the present study, it is possible to conclude that PBMT combined with Strength training had greater effects in reducing the intensity of joint pain, knee flexion, physical function and muscle strength, especially of the femoral quadriceps in patients with KOA.

CONCLUSION

Strength training associated with PBMT had greater effects in reducing joint pain intensity, active knee flexion, physical function and muscle strength, especially in the quadriceps femoris, than strength training alone in patients with KOA.

Authors' contribution: Geovane Elias Guidini Lima – Physiotherapist responsible for the study and Master Student. Daniel Souza Ferreira Magalhães – Statistical analysis. Ariane Martins Bovareto, Laiana Carmanini Teixeira, Mariane Silva Teixeira Rocha, Karina Oliveira Martinho, Martin Bjørn Stausholm, Patricia Sardinha Leonardo L. Martins, Amanda Farage Frade de Barros – Associate Researchers. Alessandra Baptista and Rodrigo Alvaro B. Lopes-Martins – team leaders of the study and General Coordinator and Chiefs of the Research Groups. Silvia C. Nuñez and Jan Magnus Bjordal – Critical reviewers of the study.

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