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# Efficacy of low level laser therapy associated with exercises in knee osteoarthritis: a randomized double-blind study

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## Abstract

**Objectives:** To estimate the effects of low level laser therapy in combination with a programme of exercises on pain, functionality, range of motion, muscular strength and quality of life in patients with osteoarthritis of the knee.

**Design:** A randomized double-blind placebo-controlled trial with sequential allocation of patients to different treatment groups.

**Setting:** Special Rehabilitation Services.

**Subjects:** Forty participants with knee osteoarthritis, 2–4 osteoarthritis degree, aged between 50 and 75 years and both genders.

**Intervention:** Participants were randomized into one of two groups: the laser group (low level laser therapy dose of 3 J and exercises) or placebo group (placebo laser and exercises).

**Main measures:** Pain was assessed using a visual analogue scale (VAS), functionality using the Lequesne questionnaire, range of motion with a universal goniometer, muscular strength using a dynamometer, and activity using the Western Ontario and McMaster Universities Osteoarthritis (WOMAC) questionnaire at

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three time points: (T1) baseline, (T2) after the end of laser therapy (three weeks) and (T3) the end of the exercises (11 weeks).

**Results:** When comparing groups, significant differences in the activity were also found ( $P=0.03$ ). No other significant differences ( $P>0.05$ ) were observed in other variables. In intragroup analysis, participants in the laser group had significant improvement, relative to baseline, on pain ( $P=0.001$ ), range of motion ( $P=0.01$ ), functionality ( $P=0.001$ ) and activity ( $P<0.001$ ). No significant improvement was seen in the placebo group.

**Conclusion:** Our findings suggest that low level laser therapy when associated with exercises is effective in yielding pain relief, function and activity on patients with osteoarthritis of the knees.

## Keywords

Osteoarthritis, low level laser therapy, exercises, knee

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## Introduction

Osteoarthritis is a rheumatologic disorder characterized by pain, joint inflammation, impairment of muscular stability and functional incapacity. It is a primary cause of impaired quality of life and is associated with morbidity and increased mortality risk.<sup>1</sup> The most common form of osteoarthritis affects the knee, and its prevalence is secondary to longer life expectancy and population ageing.<sup>2</sup>

In Brazil, osteoarthritis is a cause of 7.5% of all temporary absenteeism from work, as well as of 6.2% of all illness-related retirements.<sup>3</sup> Although commonly seen as a progressive and chronic disorder, the early therapeutic approach can minimize its symptoms.<sup>4</sup>

The European League Against Rheumatism (EULAR) suggests that low level laser therapy and exercises should be considered when planning optimal treatment for osteoarthritis.<sup>2</sup> Indeed, low level laser therapy induces photochemical physiological actions in living tissues at the cellular level. Some of these effects include cellular oxygenation, release of neurotransmitters associated with pain modulation and release of anti-inflammatory, endogenous mediators.<sup>5</sup> Nonetheless, the clinical efficacy of low level laser therapy in the treatment of osteoarthritis is still debatable; while some authors have

reported pain relief,<sup>6,7</sup> others have not.<sup>8,9</sup> These discrepancies may be associated with the parameters (wave length, dose, time, area, technique) used in treatments by different studies. Thus it is necessary to define which parameters should be used to achieve optimum therapeutic response in patients with osteoarthritis.

Strong evidence suggests that joint exercises reduce pain and disability in patients with osteoarthritis.<sup>10</sup> There is evidence that exercise is responsible for muscular strengthening and better flexibility, improved global function as well as better performance of activities of daily living (ADL).<sup>11</sup>

The efficacy of low level laser therapy in the treatment of osteoarthritis, as well as its association with exercise therapy has previously been questioned.<sup>6-9</sup> The aim of this investigation is to evaluate the effectiveness of this low level laser therapy and exercise in reducing pain, improving functionality, range of motion (ROM) and quality of life (QOL) in an osteoarthritis population.

## Methods

### Participants

Participants were recruited from the Special Rehabilitation Services in Taboão da Serra-SP Brazil.

To be included in the study, participants had to have knee osteoarthritis with osteoarthritis levels 2–4 according to Kellgren–Lawrence grade,<sup>12</sup> be aged between 50 and 75 years, both genders, have knee pain and functional disability for at least three months, and according to the criteria of the American College for Rheumatology.<sup>13</sup> The Kellgren and Lawrence grading of knee osteoarthritis is as follows: none (0), doubtful (1), minimal (2), moderate (3) and severe (4).

The ACR criteria of knee osteoarthritis are as follows:

- Using history and physical examination: knee pain and three of the following – over 50 years old; less than 30 minutes of morning stiffness; bony tenderness; bony enlargement; no palpable warmth of synovial.
- Using history, physical examination and radiographic findings: knee pain and one of the following – over 50 years old; less than 30 minutes of morning stiffness; crepitus on active motion; and osteophytes.
- Using history, physical examination and laboratory findings: knee pain and five of the following – over 50 years old; less than 30 minutes of morning stiffness; bony tenderness; bony enlargement; no palpable warmth of synovial; crepitus on active motion; ESR <40 mm/h; rheumatoid factor <1: 40; synovial fluid sign of osteoarthritis.

Participants were excluded if they had cancer, diabetes, symptomatic hip osteoarthritis, or used antidepressants, anti-inflammatory medications or anxiolytics during six months prior to enrolment.

The study was approved by the Research Ethics Committee and all participants signed informed consent forms.

### Randomization

Forty-six participants with osteoarthritis were randomized into one of two groups (laser or

placebo) by an investigator not involved in assessment, diagnosis or treatment. Randomization was performed by using sealed, randomly filled envelopes describing the treatment group. Patients and the physiotherapist responsible for the evaluation were unaware of randomization results.

### Sample size

Sample size was calculated assuming 80% power to detect a 20% improvement in pain (VAS), with a standard deviation of 2 points and a significance level of 5%. The required sample would be 17 patients per group.

### Assessment

All participants were evaluated by the same blinded physiotherapist at three different measurement intervals: baseline (T1), following the end of laser therapy after three weeks (T2) and the end of exercise therapy after 11 weeks (T3). The physiotherapist was trained to evaluate the same way all patients at all times.

- Pain was assessed using a visual analogue scale (VAS)<sup>14</sup> consisting of a 10 cm rule (without numbers). At the left side, ‘no pain’ is written, while on the right side, ‘unbearable pain’. Patients were instructed to mark on the rule what their level of pain was.
- Functionality was measured using the Lequesne questionnaire,<sup>15</sup> which consists of 11 questions about pain, discomfort and function. Scores range from 0 to 24 (from ‘no’ to ‘extremely severe’ dysfunction).
- Range of motion for flexion of the knees were measured with the universal goniometer (AESCULAP), according to the methods described by Marques.<sup>16</sup>
- Muscular strength was estimated at maximal isometric force for the quadriceps, using a portable dynamometer (Lafayette, USA). Under stabilized conditions, patients, sitting with knees flexed at 60° (measured by a goniometer),<sup>17</sup> were asked to extend the legs as far

as they could. Three trials were conducted and the mean value was obtained.

- Activity was measured using the Western Ontario and McMaster Universities Osteoarthritis (WOMAC) questionnaire,<sup>18</sup> which is self-administered and measures pain, frozen joints and physical activity. Increased scores suggest decreased activity.

In this study the most affected knee joint of each participant was included.

### Intervention

All patients were treated by the same physiotherapist who had not taken part in the evaluations.

Participants in the laser group received low level laser therapy while the placebo group received placebo therapy three times a week for three weeks following initial assessment. Both groups exercised three times a week for the remaining eight weeks of the programme.

In the laser group, energy was irradiated over the joint line onto five points of the synovial region of the medial side of the knee and in four points at the lateral side, at 3 J per point. Total dose per knee was 27 J per treatment and used previously calibrated equipment (Irradia Class 3B; Stockholm, Sweden). In the placebo group, procedures were identical but without emission of energy.

The laser equipment had two identical pens, one for the active treatment and one for the placebo treatment (sealed). The pen's semi-conductor consisted of gallium arsenide with wave length of 904 nm, frequency of 700 Hz, average power of 60 mW, peak power of 20 W, pulse duration 4.3 ms, 50 seconds per point (area 0.5 cm<sup>2</sup>). The parameters followed the recommendation of the World Association of Laser Therapy (WALT)<sup>19</sup> for osteoarthritis.

### Exercises

All patients followed the same training programme (Table 1). The intervention was divided

into three phases: P-1, P-2 and P-3 during eight weeks with three sessions a week. Each session lasted 45 minutes:

- 10 minutes warming-up (treadmill, ergometer bike or rowing machine);
- 30 minutes 2–3 sets with P-1, P-2 or P-3;
- 5 minutes stretching (hamstrings, quadriceps, adductors, and gastrocnemius).

### Statistical analysis

Data normality was assessed using the Shapiro–Wilk test; homogeneity of data was estimated using the Levene's test. For the intergroup analysis the values were standardized as follows: For variables where reduction meant improvement (pain, function, WOMAC), we used the formula:  $(T1-T2) \div AV1$  and  $(T1-T3) \div AV1$ . For variables where increase meant improvement (range of motion and muscle strength), we used the formula:  $(T1-T2) \div AV1$  and  $(T1-T3) \div AV1$ . To compare the two groups, laser and placebo, we calculate the difference of their means. Negative values mean that laser is better than placebo and positive values mean that placebo is better. Analyses between groups were performed using the independent *t*-test for the conditions T1  $\times$  T2 and T1  $\times$  T3. For intragroup analysis, evaluation times were compared by repeated-measures ANOVA (single effect), followed by the Tukey post-test. Analyses were conducted using the Statistical Package for Social Sciences (SPSS version 17; SPSS Inc., Chicago, IL, USA). An alpha level of 0.05 was set for all comparisons.

### Results

Sixty-one subject were eligible to take part in study and 15 were excluded. Forty-six patients were assessed at baseline and randomly allocated in two different groups (laser group = 24 and placebo group = 22). Forty patients completed the treatment and attended the last assessment (Figure 1).

**Table 1.** Exercise programme conducted over the eight weeks of treatment

Phases	Exercises
P1 (week 1–week 2)  Objectives: Range of Motion  Motor Learning Balance Coordination	Each exercise had 30 repetitions and 2 sets: <ul style="list-style-type: none"> <li>• Sitting in the chair with a weight on the ankle, knee and stretch the foot to rotate alternately in and out then change legs</li> <li>• Lying prone. Bend the knee slowly as much as possible. Stretch the knee slowly</li> <li>• Standing with support. Bend the knees to approximately 60 degrees. Push up again</li> <li>• Walk on a 3 m line without stepping off the line</li> <li>• Walk–standing. Transfer your body weight from one leg to the other</li> </ul>
P2 (week 3–week 5) Objective:  Strengthening	Each exercise had 20 repetitions and 3 sets: <ul style="list-style-type: none"> <li>• Standing. Bend your knees to approximately 60 degrees, and up again</li> <li>• Walk sideways by crossing legs. To right and left</li> <li>• Standing on a balance board. Hold the balance</li> <li>• Lying prone. Bend one knee as much as possible</li> <li>• One foot-standing on a step. Bend your knee until the other foot touches the floor, push up again</li> </ul>
P3 (week 6–week 8) Objective: Strengthening	Each exercise had 20 repetitions and 3 sets: <ul style="list-style-type: none"> <li>• Walk sideward by crossing steps. To right and left</li> <li>• Standing on one leg. Bend the knee to approximately 60 degrees, and up again</li> <li>• Standing on a balance board. Keep the balance. More difficult if eyes are closed</li> <li>• Standing on the floor. Get up on your toes, hold 1–2 seconds, and get down again</li> <li>• Sitting with weight around the ankle. Stretch the knee slowly, hold the stretch 3–4 seconds, and slowly down again</li> </ul>

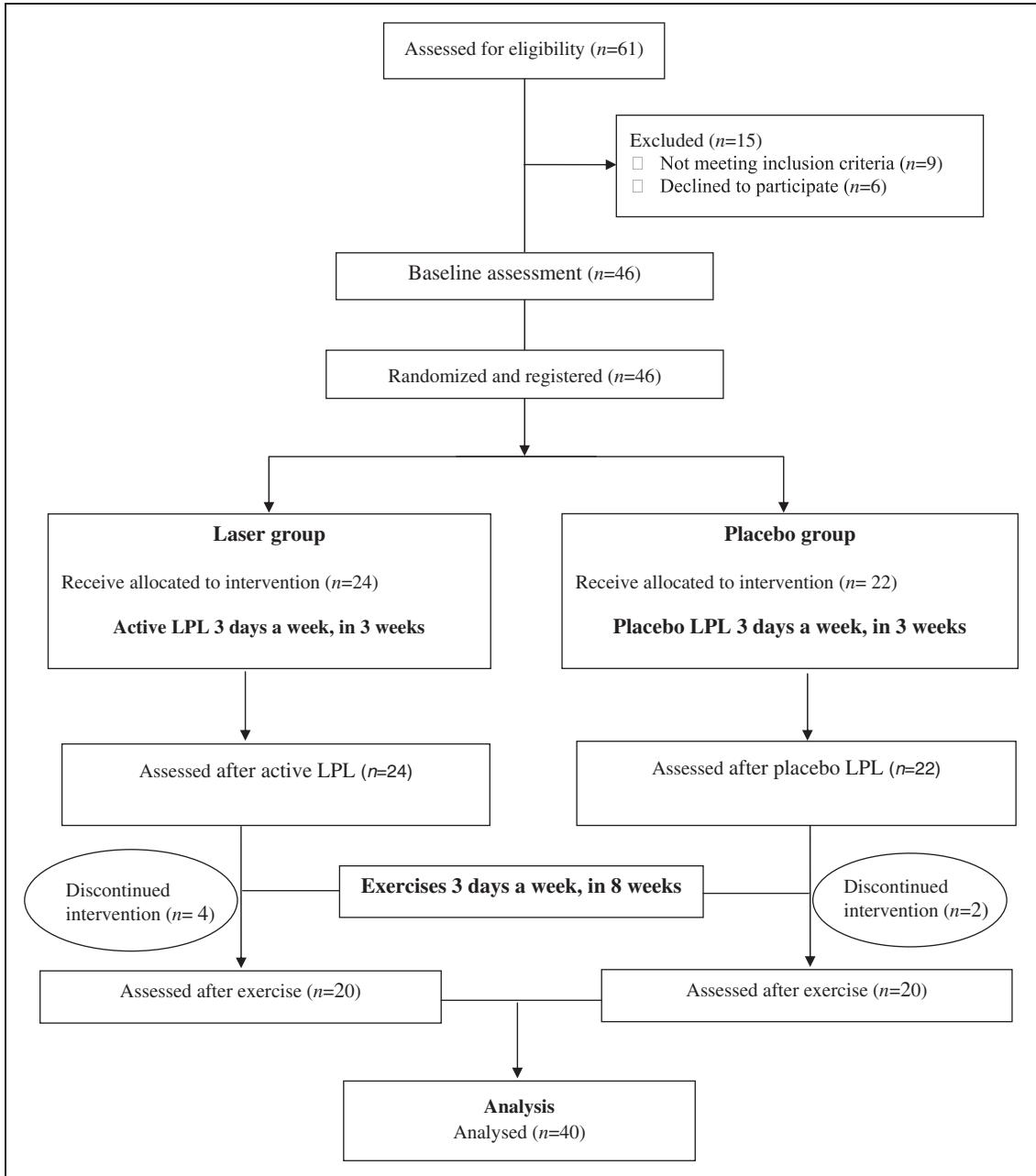
Table 2 displays the demographics of participants in each group. There were no statistically significant differences ( $P > 0.05$ ) for age, weight, height, body mass index, gender and osteoarthritis degree between the two groups.

Table 3 shows that there was no significant difference in any of the variables of both groups at the time of the baseline ( $P > 0.05$ ).

The intergroup analysis showed that the laser group presented significant improvement in the variables of WOMAC, as pain ( $P = 0.033$ ), function ( $P = 0.002$ ) and total score ( $P = 0.008$ ) at T2 compared to T1 and pain ( $P = 0.001$ ), function

(0.002) and total score (0.003) in T3 compared to T1. No other statistically significant differences were found in the other variables ( $P > 0.05$ ) (Table 4).

Table 5 shows the intragroup analysis at the different measurement intervals. The laser group had significant improvement in pain scores ( $P < 0.05$ ) and activity ( $P < 0.001$ ) between T1 and T2 and between T2 and T3 ( $P = 0.001$ ) as well as range of motion ( $P = 0.01$ ) and functionality ( $P = 0.001$ ) between T2 and T3. In the placebo group, no significant improvements were seen for any of the variables ( $P > 0.05$ ).



**Figure 1.** Participant flow diagram.

**Table 2.** Clinical and demographic characteristics of the participants in both groups

Characteristics	Laser group (n = 20) Mean (SD)/n (%)	Placebo group (n = 20) Mean (SD)/n (%)	P-value
Age (years)	61.15 (7.52)	62.25 (6.87)	0.63
Weight (kg)	76.27 (10.32)	74.9 (15.73)	0.74
Height (m)	1.59 (0.08)	1.59 (0.09)	0.94
BMI (kg/m <sup>2</sup> )	30.16 (4.12)	29.21 (4.95)	0.51
Gender			
Female	15 (75%)	16 (80%)	0.71
Male	5 (25%)	4 (20%)	0.71
Osteoarthritis degree			
2	4 (20%)	9 (45%)	0.09
3	9 (45%)	4 (20%)	0.09
4	7 (35%)	7 (35%)	1.00

SD, standard deviation; BMI, body mass index.

**Table 3.** T-test among the variables pain, functionality, range of motion, muscle strength and activity at the time of the baseline

Variables	Laser group (n = 20) Mean (SD)	Placebo group (n = 20) Mean (SD)	P-value
Pain (cm)	5.32 (3.55)	3.54 (3.06)	0.098
Functionality	11.88 (3.98)	11.55 (3.18)	0.776
Range of motion (degrees)	91.50 (13.79)	91.80 (20.42)	0.992
Muscle strength (H/kg)	11.63 (4.87)	9.96 (3.58)	0.207
Activity-WOMAC			
Pain subscale	9.10 (4.92)	7.30 (3.54)	0.192
Stiffness subscale	3.05 (1.96)	2.95 (2.14)	0.878
Function subscale	33.85 (16.93)	27.15 (11.32)	0.188
Total score	46.05 (22.99)	38.00 (14.91)	0.196

SD, standard deviation; P-value for t-test; WOMAC, Western Ontario and McMaster Universities Osteoarthritis Index.

## Discussion

The effects of low level laser, in combination with a programme of exercises in patients with knee osteoarthritis was assessed in this study. Positive results were found in low level laser therapy when associated with exercises in yielding pain relief, improvement function and activity compared to the placebo group.

We postulate that analgesia in the laser group after laser therapy may have been a consequence

of the anti-inflammatory properties of the low level laser at 3 J, applied onto specific points, suggested by WALT,<sup>19</sup> on the articular capsule. Similar results were found by Bjordal et al.,<sup>20</sup> including the pain relief and improvement in global health status of knee osteoarthritis patients. In a meta-analysis, Brosseau et al.<sup>6</sup> suggested that the significant pain relief associated with low level laser may have been due to increase in neurotransmitter levels, including serotonin, which is important in endogenous



**Table 4.** Comparison between the groups for the variables pain, functionality, range of motion, muscle strength and activity. Negative value suggests laser is better than placebo group

Variables		Laser group × placebo group Mean change score (95% CI)	P-value (intergroup)
Pain	T1 × T2	-0.43 (0.04)	0.071
	T1 × T3	-0.31 (0.08)	0.120
Functionality	T1 × T2	-0.08 (0.22)	0.602
	T1 × T3	-0.27 (0.04)	0.087
Range of motion (degree)	T1 × T2	0.04 (0.16)	0.404
	T1 × T3	-0.02 (0.08)	0.632
Muscle strength (H/kg)	T1 × T2	0.07 (0.25)	0.395
	T1 × T3	-0.12 (0.09)	0.266
Activity – WOMAC Pain subscale	T1 × T2	-0.29 (0.02)	0.033*
	T1 × T3	-0.33 (0.15)	0.001*
Stiffness subscale	T1 × T2	-0.24 (0.11)	0.173
	T1 × T3	-0.31 (0.17)	0.202
Function subscale	T1 × T2	-0.35 (0.14)	0.002*
	T1 × T3	-0.34 (0.13)	0.002*
Total score	T1 × T2	-0.30 (0.08)	0.008*
	T1 × T3	-0.31 (0.12)	0.003*

95% CI, 95% confidence interval; P-value for *t*-test; WOMAC, Western Ontario and McMaster Universities Osteoarthritis Index.

pain modulation. Hegedus et al.<sup>21</sup> and Montes-Molina et al.<sup>22</sup> carried out clinical trials according to the recommendations of WALT, using 830 nm laser with average power of 50 and 100 mW, respectively, with a dose of 6.0 J/point. Effective results were recorded in pain relief and improvements in microcirculation in the irradiated area in patients with osteoarthritis knee.

There is strong evidence that exercise reduces pain and improves function in patients with osteoarthritis,<sup>23,24</sup> and this may explain the maintained benefits even after laser therapy was discontinued. Our findings suggest that

analgesia induced by low level laser resulted in improved exercise performance and this combination resulted in prolonged analgesic effects.

We also demonstrated the functional improvement in the laser group in relation to placebo. Similar results were found by Stelian et al.,<sup>25</sup> who observed significant functional improvement and pain reduction in the laser group but not in placebo group in patients with osteoarthritis. However, Brosseau et al.<sup>26</sup> found no significant improvement in pain reduction and functional status for hand osteoarthritis patients for laser therapy versus placebo. These results may be because the laser was

**Table 5.** Within-group difference in change score (T1, T2 and T3) for laser and placebo groups

Variables	Groups (n = 20/group)	T1 Mean (SD)	T2 Mean (SD)	T3 Mean (SD)	P-value
Pain (cm)	Laser	5.32 (3.55) <sup>a</sup>	3.36 (3.47) <sup>b</sup>	2.58 (3.27) <sup>b</sup>	0.001*
	Placebo	3.54 (3.06)	3.15 (2.94)	2.30 (2.25)	0.230
Functionality	Laser	11.88 (3.98) <sup>a</sup>	10.78 (4.62) <sup>a</sup>	8.37 (4.27) <sup>b</sup>	0.001*
	Placebo	11.55 (3.18)	10.68 (3.08)	10.40 (3.91)	0.400
Range of motion (degree)	Laser	91.50 (13.79) <sup>a</sup>	91.40 (12.11) <sup>a</sup>	99.45 (12.89) <sup>b</sup>	0.010*
	Placebo	91.80 (20.42)	95.65 (17.25)	96.55 (15.28)	0.180
Muscle strength (H/kg)	Laser	11.63 (4.87)	11.8 (4.86)	12.52 (4.50)	0.700
	Placebo	9.96 (3.58)	11.51 (6.62)	9.68 (3.65)	0.230
Activity – WOMAC					
Pain subscale	Laser	9.10 (4.92) <sup>a</sup>	6.55 (3.32) <sup>b</sup>	4.80 (4.36) <sup>b</sup>	0.000*
	Placebo	7.30 (3.54)	6.55 (3.98)	6.35 (3.48)	0.370
Stiffness subscale	Laser	3.05 (1.96)	2.35 (2.30)	2.35 (2.21)	0.720
	Placebo	2.95 (2.14)	2.65 (2.23)	2.6 (2.11)	0.200
Function subscale	Laser	33.85 (16.93) <sup>a</sup>	24.15 (13.58) <sup>b</sup>	19.50 (14.04) <sup>b</sup>	0.000*
	Placebo	27.15 (11.32)	27.40 (13.88)	23.35 (12.18)	0.190
Total score	Laser	46.05 (22.99) <sup>a</sup>	33.05 (18.62) <sup>b</sup>	26.65 (20.17) <sup>b</sup>	0.000*
	Placebo	38.00 (14.91)	36.60 (18.34)	32.30 (16.82)	0.22

\*P-value for ANOVA.

<sup>a,b</sup>Identify which values are statistically different between after multiple comparison test.

WOMAC, Western Ontario and McMaster Universities Osteoarthritis Index.

applied on painful osteoarthritis-affected finger joints (chronic stage) as well as three superficial nerves innervating the painful area and not in specific regions of the joint capsule.

In our study, parameters associated with activity also improved in the laser group, corroborating the findings of Gur et al.<sup>27</sup> in a similarly conducted study (low level laser and exercises also improved pain, functionality and activity of patients with osteoarthritis). Tascioglu et al.<sup>28</sup> however, did not find significant improvement in the activity assessed by WOMAC of patients receiving laser with a wavelength 830 nm, 50 mW of mean power, with doses ranging from 1.5 to 3 J. They believe that this fact may be related to the laser modality, dosages and wavelength selection used.

In patients with knee osteoarthritis, quadriceps strength is decreased by 50–60%, mainly

because of atrophy and arthrogenic inhibition.<sup>29</sup> It has been suggested that sensorimotor dysfunction of the quadriceps may be relevant to osteoarthritis progression<sup>30,31</sup> as a risk factor for disability. We did not demonstrate improvements in quadriceps muscle strength, however functionality improved in the laser group following the exercise therapy. We believe these results are due to the fact that the exercise programme was focused not only on quadriceps muscle strength gain, but on the overall strengthening of the lower limb. Montes-Molina et al.<sup>22</sup> used 830 nm laser at a dose of 6.0 J per point and concluded that low level laser associated with quadriceps exercise was effective in reducing pain, a conclusion supported by our study. Similar results were found by Hurley and Scott,<sup>32</sup> who suggested that the improvement of strength and functionality in knee

osteoarthritis was so substantial that it could postpone or totally avoid surgical interventions.

Although no significant difference was observed between groups for range of motion, in intra-group analysis improvement in the laser group after exercise was observed. Corroborating our findings, Gur et al.<sup>27</sup> also found statistical significant improvement in the flexion of the knee in all groups treated with laser except the placebo group. However, Bulow et al.<sup>9</sup> failed to demonstrate significant improvement in pain and range of motion when comparing laser and placebo. However, they used very low doses of laser (less than 3 J) over pain points, and not necessarily over the soft periarticular tissues.

Our findings suggest that low level laser therapy when associated with exercises is effective in yielding pain relief, function and activity in patients with knee osteoarthritis.

The major study limitations were the small number of patients, the absence of a control group, which would allow us to assess the natural course of the disease, and the absence of follow-up. Future studies should increase the number of patients, include a control group, add a group which receives low level laser therapy and exercise simultaneously from the very beginning and a long-term follow-up assessment.

### Clinical messages

- The application of low level laser three times per week for three weeks can assist in the execution of exercises in patients with knee osteoarthritis.
- The combination of laser and exercise can improve pain, function and activities in subject with knee osteoarthritis.

### Disclosure statement

No competing financial interests exist.

### Clinical trials

[Low power laser and exercise in osteoarthritis of the knee: a randomized clinical trial, CT01306435.]

### Conflict of interest

There is no conflict of interest.

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