Proprioceptive evaluation in healthy women undergoing Infrared Low Level Laser Therapy

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Abstract — Aim: To evaluate if the application of infrared low-level laser therapy (LLLT) alters proprioception in young women. Methods: 26 female volunteers were evaluated statically and dynamically by means of electronic baropodometry in the variables: distance from the foot center, maximum and medium pressure, and surface. Proprioception was also functionally assessed by the Star Excursion Balance Test (SEBT). The intervention occurred in two distinct periods, separated by one week apart, as this was a crossover study, so volunteers were submitted to placebo or LLLT (830 nm, 8 J/cm²), on the muscles: gastrocnemius, soleus, tibialis previous and long and short fibular. Results: the analysis of baropodometry for both dynamic and static found no significant differences for the intervention group and the control group. Similar results were observed for SEBT. Conclusion: The application of the LLLT, in the proposed parameters, did not influence the proprioception in young women.

Keywords: laser therapy; postural balance; nervous system; kinesthesis.

Introduction

In many sports, balance improvement is one of the most important goals and it is associated with increased athletic performance and sports injuries reduction. In this context, proprioception plays an essential role, and is defined as the ability to integrate various sensory signals from the mechanoreceptors to determine the body position and movements in space. It happens through the stretching of the muscle spindles, joint capsule and ligaments receptors, and Golgi tendon organs. The inputs of these various receptors are processed in the brain and integrated with visual and vestibular information to generate a position sense and movement in space. The proprioceptive information triggered by joint and muscle receptors plays an integral role in neuromuscular control, which undergoes constant revisions and modifications, based on the integration and analysis of sensory input, efferent motor control, resulting in movements.

Among the proprioceptive evaluations, one can mention electronic baropodometry, which is an instrumental method, being a record posturographic technique used to evaluate the plantar pressure in both the static position and movement, which records the pressure points exerted by the body. On the other hand, the Star Excursion Balance Test (SEBT) is a functional balancing test used to assess proprioception considered modern, easy to handle, not instrumental, with a satisfactory cost-benefit, that evaluates the ability of the individual to maintain body balance, while making attempts to reach the longest distance possible with the contralateral limb in specific directions.

The low level laser therapy (LLLT) has been used for repair and analgesic purposes. The basic biological mechanism promoted by this electrophysical feature appears to be the absorption of red and infrared light by chromophores contained in the protein components of the respiratory chain located in the mitochondria, which, in turn, by absorbing the energy, trigger a cascade of biochemical events, resulting in increased enzymatic activity, production of adenosine triphosphate (ATP), protein synthesis, cell proliferation, collagen deposition and organization, increase in the DNA activity and RNA and protein synthesis. When applied to stem cells it has been observed increased proliferation and cell differentiation.

In recent years, LLLT has been used aiming not only repair and analgesia, but to delay the levels of muscle fatigue, reduce lactate levels, creatine kinase and C-reactive protein after exercise, and to increase muscle resistance, increase muscle performance by delaying muscle fatigue and increasing muscle torque. Although biostimulants effects, there is a lack of research linking LLLT effects with proprioception, balance and movement control in healthy young women, since the research to date sticks in evaluating elderly or with neurological disorders. Therefore, the aim of this study was to evaluate whether the application of infrared laser (830 nm) influence on proprioception in young women, given the potential both in sports and in athletes rehabilitation process.

Materials and Methods

The study was characterized as a clinical, quantitative, randomized, crossover, volunteers "blind" with respect to the effective output of the laser radiation. The sample was selected by convenience, totaling 26 volunteers, university students, distributed randomly in groups, it was subsequently carried out the calculation of the statistical power of the sample (shown in subsection statistical analysis). Inclusion criteria were: being female, aged between 18-25 years old, healthy, voluntary participation in the
research. Exclusion factors were: pain and/or recent injury in the lower limb, active or suspected carcinoma, pregnant women, the presence of hemorrhagic areas and sensory or motor abnormalities in the lower limb, vision deficit and dizziness.

Before starting the data collection procedure all volunteers signed the informed consent approved by the Research Ethics Committee of Unioeste, under protocol number: 1.134.647.

**Procedures**

The volunteers were, by lot in opaque envelope, randomly assigned into two groups of 13 subjects each (intervention group and placebo group) submitted to two interventions, performing the same activities, but in different weeks. They were evaluated by Electronic Baropodometry in two ways: statically and dynamically. At first, the volunteer remained with open eyes in bipodal support on the equipment, hands on her hips and staring at a specific point. Then, evaluation was performed dynamically, when the patient was advised to walk, and should initially step with the support of one foot on the equipment and return it to the contralateral foot. The information was sent to the computer for analysis in the program Footwork®.

For the static baropodometry analysis, the lower limb subjected to intervention was the dominant and the contralateral limb was used as control of this assessment. In the week that the volunteers were not subject to the active laser, they were also considered as placebo for the dominant and non-dominant limb. The variables analyzed were distance from the center of the foot (cm) referring to balance, maximum pressure and medium pressure (kPa) indicating the maximum value from the average behavior of the registered pressures in all sensors throughout the support phase. The dynamic evaluation was performed with the same previous standard, but the variables analyzed were maximum pressure and medium pressure (kPa), and the surface (cm²) which assesses sensory information from the plantar surface, important factors for maintaining postural balance during normal conditions.

Thereafter, SEBT was performed in the dominant leg. This test consists of a series of mini unilateral squats performed while trying to get as far as possible in a particular direction with the dominant leg. A large star was made on the ground, with eight different directions with a 45° angle away from each other. The volunteer was instructed to position themselves in the center of the star on one foot, with the hands on the waist and reach it as far as possible, with the non-dominant limb, in each of the eight directions, making a light touch on the tape that was staked out the scope of the volunteer with a permanent marker, and the test following directions: anterior, posterior, medial and lateral. All carried out with only one attempt in each direction in order to decrease the learning effects during testing. The distance measurement was carried out from the center of the star to the farthest point reached in each direction.

After the evaluations, the intervention group was stimulated with LLLT (Ibramed®) with 830 nm wavelength, output power 30 mw, fluency 8 J/cm² per point, total energy of 7.68 J, on the dominant leg. The application sites were four points in each muscle, for 16 seconds in each point, which were sanitized with alcohol gel. Muscles for application were: gastrocnemius, soleus, tibialis anterior, long and short fibular (in this study, considered as a unit). The placebo group underwent similar procedure in the first week, but without effective implementation of radiation. In the following week there was an exchange of groups. The volunteers were not informed if the equipment was either not producing effective radiation. Prior to the start of the stimulation device was measured by a radiation power meter.

Following procedures irradiation / placebo, there was a five minute interval for the 2nd evaluation, both in the baropodometry as SEBT. Then again there was a 25 minute interval, for resting, and the 3rd evaluation of the day. The following week, all these steps were repeated, changing only the irradiation group / placebo.

**Statistical Analysis**

Based on baropodometry data to the sample size used, with a standard deviation of 2.2, the difference being detected 1.5 and 5% significance level, the test power was 80%. Data were analyzed as its normality, by the Shapiro-Wilk test. It was used ANOVA repeated measures for comparisons within and between groups in assessments of baropodometry. For evaluations with SEBT was used the nonparametric Friedman test. In all cases, the significance level was set at p < 0.05.

**Results**

The variables of the distance from the center to the foot, maximum and medium pressure exerted by the volunteers in standing position on the platform, did not show significant differences (F(4,1;95,4)=0,39, p=0,825); (F(11;253)=1,22, p=0,275); (F(4,4;150,8)=1,5; p=0,192), respectively (Table 1).

**Table 1** – Baropodometry – Static Analysis. Assessments occurred in the lower limb dominant (LLD) and non-dominant (LLND).

<table>
<thead>
<tr>
<th>FOOT CENTER DISTANCE (cm)</th>
<th>Placebo LLD</th>
<th>Placebo LLND</th>
<th>Laser LLD</th>
<th>Laser LLND</th>
</tr>
</thead>
<tbody>
<tr>
<td>EV1</td>
<td>8.2±2.5</td>
<td>8.6±2.4</td>
<td>8.7±2.3</td>
<td>8.5±2</td>
</tr>
<tr>
<td>EV2</td>
<td>8.4±2.9</td>
<td>8.0±1.9</td>
<td>8.3±2.1</td>
<td>8.3±2.1</td>
</tr>
<tr>
<td>EV3</td>
<td>8.0±2.5</td>
<td>8.0±1.5</td>
<td>8.2±2.3</td>
<td>8.1±2</td>
</tr>
<tr>
<td>MAXIMUM PRESSURE (kPa)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EV1</td>
<td>64.0±29</td>
<td>54.5±20.2</td>
<td>53.4±16</td>
<td>56.4±22</td>
</tr>
<tr>
<td>EV2</td>
<td>62.4±41.7</td>
<td>55.4±24.4</td>
<td>57.9±23.5</td>
<td>56.8±18.9</td>
</tr>
<tr>
<td>EV3</td>
<td>53.8±19.8</td>
<td>52.7±21.6</td>
<td>47.8±14.6</td>
<td>50.5±23.4</td>
</tr>
<tr>
<td>MEDIUM PRESSURE (kPa)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EV1</td>
<td>17.6±3.4</td>
<td>15.6±3.4</td>
<td>16.4±3.7</td>
<td>16.4±3.6</td>
</tr>
<tr>
<td>EV2</td>
<td>16.4±4.0</td>
<td>16.7±4.0</td>
<td>17.1±3.5</td>
<td>17.3±3.1</td>
</tr>
<tr>
<td>EV3</td>
<td>16.5±3.1</td>
<td>15.8±3.6</td>
<td>16±3.0</td>
<td>15.2±3.7</td>
</tr>
</tbody>
</table>
The variables area, maximum pressure and mean pressure were analyzed as carried out by the volunteers, when touched the platform with one foot at the time of going and return, also showed no significant differences (F(4.5;103.5)=1.7;p=0.157); (F(6.3; 146)=1.9; p=0.078); (F(5.1;118.3)=1.9;p=0.091), respectively (table 2).

Table 2 – Baropodometry – Dinamic Analysis. Assessments occurred in the lower limb dominant (LLD) and non-dominant (LLND).

<table>
<thead>
<tr>
<th></th>
<th>Placebo LLD</th>
<th>Placebo LLND</th>
<th>Laser LLD</th>
<th>Laser LLND</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>AREA (cm²)</strong></td>
<td>EV1</td>
<td>72.3 ± 10.2</td>
<td>72.2 ±16.7</td>
<td>73.9 ± 14.6</td>
</tr>
<tr>
<td></td>
<td>EV2</td>
<td>72.3 ± 13.4</td>
<td>66.6 ± 8.5</td>
<td>70.4 ± 11.2</td>
</tr>
<tr>
<td></td>
<td>EV3</td>
<td>70.5 ± 12.0</td>
<td>68.4 ± 8.9</td>
<td>69.3 ± 11.3</td>
</tr>
<tr>
<td><strong>MAXIMUM PRESSURE (kPa)</strong></td>
<td>EV1</td>
<td>22.9 ± 4.7</td>
<td>23.6 ± 4.3</td>
<td>23.4 ± 4.4</td>
</tr>
<tr>
<td></td>
<td>EV2</td>
<td>114.0 ± 55.4</td>
<td>118.7 ±63.6</td>
<td>109.6 ± 48.8</td>
</tr>
<tr>
<td></td>
<td>EV3</td>
<td>91.5 ± 21.0</td>
<td>109.7 ± 54.8</td>
<td>103.7 ± 41.5</td>
</tr>
<tr>
<td><strong>MEDIUM PRESSURE (kPa)</strong></td>
<td>EV3</td>
<td>102.3 ± 46.4</td>
<td>103.5 ± 40.1</td>
<td>95.8 ± 31.6</td>
</tr>
<tr>
<td></td>
<td>EV2</td>
<td>22.1 ± 4.2</td>
<td>25.1 ± 3.8</td>
<td>24.1 ± 5.4</td>
</tr>
<tr>
<td></td>
<td>EV3</td>
<td>23.0 ± 3.8</td>
<td>24.0 ± 4.5</td>
<td>23.8 ± 4.3</td>
</tr>
</tbody>
</table>

In the analysis performed by the SEBT, the results did not show significant differences in the eight directions, according to the Friedman test (Fr= 18.5; p=0.0024) (Table 3).

Table 3 - Results observed in the Star Excursion Balance Test (SEBT), the distance is displayed in cm.

<table>
<thead>
<tr>
<th></th>
<th>LLLT</th>
<th>PLACEBO</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>EV1</td>
<td>EV2</td>
</tr>
<tr>
<td><strong>First quartile (25%)</strong></td>
<td>87.0</td>
<td>88.7</td>
</tr>
<tr>
<td><strong>Median</strong></td>
<td>96.1</td>
<td>98.9</td>
</tr>
<tr>
<td><strong>Third quartile (75%)</strong></td>
<td>104.8</td>
<td>108.2</td>
</tr>
</tbody>
</table>

**Discussion**

The LLLT is an important and effective tool, which interacts with biological tissue, produces various physiological and therapeutic effects, including improving muscle performance in both animal15,25 and human studies17.

Because of all these effects and by increasing cellular metabolism, when the LLLT penetrate the tissue, could interfere on the movement control and postural stability, improving balance and position sense, which is given by the mechanical stimulation of the muscles and joints. Therefore, the leg muscles were chosen for the application of LLLT, they are responsible for a number of movements, that together assist to maintain the body balance26,30.

One of the most important parameters to the LLLT is the wavelength, which can determine the depth of penetration and absorption, thus their effects. Since longer wavelengths are absorbed into the deeper layers of biological tissue31, and in the present study the aim was to reach the muscle tissue by stimulating the proprioceptive components23,34, it was chosen infrared 830 nm wavelength. Similar to the wavelength used by Almeida et al.32, comparing the 830 nm to 660 nm, but found that both wavelengths promoted increased peak power and delayed fatigue of the biceps muscle. As noted above, recent studies have addressed the efficacy of LLLT in muscle performance, however, other studies did not show superior effects to the control with laser therapy, mainly due to enormous parameters variation of therapy33,34.

In the present study, it was sought to use a commercial equipment with routinely used parameters in order to analyze if the LLLT application provide any change in proprioception, improving balance, and other variables, data from baropodometry referring to pressure from the feet were analyzed, distance from the center and even to the plantar surface, since the skin sensory stimulation plant contributes to the march and postural control, providing information on the compensatory reactions35.

Proprioceptive data on the direction of movement, speed and joint position, analyzed by SEBT did not show any differences between the placebo compared to LLLT, and both the functional analysis as performed in baropodometry showed that the LLLT had no effect on proprioception. However, divergent from what was observed here, Gallamini30, in case studies (unspecified dizzi- ness and moderate Parkinson), points out that the very low power laser (0.01 mW average power) used in acupuncture points, can be an effective resource in the improvement of body balance.

On the other hand, Bergamaschi, Ferrari, Gallamini, Scoppa19, used the LLLT on acupuncture and auriculocupuncture points, with power of 30 mW and energy 0.3 J, in a group of institutionalized elderly; report that pain affects postural control, and that the sample investigated there was reduction of pain conditions, and thus improves the balance verified by force platform. This proposition is also reported by Chang, Ku, Hu, Shyu, Chang21, in patients with leg periostitis, they reported that the pain produce proprioceptive changes, thus, the use of cluster with 5 diodes 850 nm (laser) and 28 LEDs, improves proprioception, produced due mechanoreceptors recovery in injured myotendinous transition.
It is noteworthy that, assessing only healthy individuals, similar studies were not found in literature to perform comparisons, despite the literary wealth and clinical studies on the LLLT application. Therefore, despite the LLLT is a widely used resource, it is in constant process of evaluating its various parameters and it needs more controlled studies to confirm their mechanisms of action in the various fields. The use of a single LLLT session has been used to assess their effects on endurance\(^{16}\), muscle performance, oxidative stress and fatigue\(^{15}\), however note that the use of only a therapeutic session is considered a limitation of this study, and that further studies could assess whether the sum therapies could significantly influence proprioception in healthy subjects.

**Conclusion**

The application of infrared laser (830nm), in the proposed parameters, did not influence the proprioception in young women.

**References**

Laser Therapy and Proprioception


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