Original article (short paper)

Proprioceptive evaluation in healthy women undergoing Infrared Low Level Laser Therapy

Grazieli da Silva
Hewelayne Suelyn Gomes
Morgana Neves
Jhenifer Karvat
Gustavo Kiyosen Nakayama
Gladson Ricardo Flor Bertolini
Universidade Estadual do Oeste do Paraná, Cascavel, PR, Brasil

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 determining the body position and movements in space[1]. It happens through the stretching of the muscle spindles, joint capsule and ligaments receivers, 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[2,4]. 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[5,6].

Among the proprioception 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[7-10]. 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[11,12].

The low level laser therapy (LLLT) has been used for repair and analgesic purposes[13]. 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[14], increase in the DNA activity and RNA and protein synthesis. When applied to stem cells it has been observed increased proliferation and cell differentiation[13].

In recent years, LLLT has been used aiming not only repair and analgesia, but to delay the levels of muscle fatigue[15], reduce lactate levels, creatine kinase and C-reactive protein after exercise, and to increase muscle resistance[16], increase muscle performance by delaying muscle fatigue[17] and increasing muscle torque[18]. 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[19] or with neurological disorders[20] and pain[21]; so 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.

Proceedings

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, and 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[22]. The dynamic evaluation was performed with the same previous standard, but the variables analyzed were maximum pressure and medium pressure (kPa), and the surface (cm^2) which assesses sensory information from the plantar surface, important factors for maintaining postural balance during normal conditions[23].

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[24]. 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/cm^2 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 ($F(4,1;95,4)=0,39$, $p=0,825$); ($F(11;253)=1,22$, $p=0,275$); ($F(4,4;100,8)=1,5$; $p=0,192$), respectively (Table 1).

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

		Placebo LLD	Placebo LLND	Laser LLD	Laser LLND
FOOT CENTER DISTANCE (cm)	EV1	8.2 ± 2.5	8.6 ± 2.4	8.7 ± 2.3	8.5 ± 2
	EV2	8.4 ± 2.9	8.0 ± 1.9	8.3 ± 2.1	8.3 ± 2.1
	EV3	8.0 ± 2.5	8.0 ± 1.5	8.2 ± 2.3	8.1 ± 2
MAXIMUM PRESSURE (kPa)	EV1	64.0 ± 29	54.5 ± 20.2	53.4 ± 16	56. 4± 22
	EV2	62.4 ± 41.7	55.4 ± 24.4	57.9 ± 23.5	56.8 ± 18.9
	EV3	53.8 ± 19.8	52.7 ± 21.6	47.8 ± 14.6	50.5 ± 23.4
MEDIUM PRESSURE (kPa)	EV1	17.6 ± 3.4	15.6 ± 3.4	16.4 ± 3.7	16.4 ± 3.6
	EV2	16.4 ± 4.0	16.7 ± 4.0	17.1 ± 3.5	17.3 ± 3.1
	EV3	16.5 ± 3.1	15.8 ± 3.6	16 ± 3.0	15.2 ± 3.7

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).

		Placebo LLD	Placebo LLND	Laser LLD	Laser LLND
AREA (cm^2)	EV1	72.3 ± 10.2	72.2 ± 16.7	73.9 ± 14.6	70.6 ± 9.6
	EV2	72.3 ± 13.4	66.6 ± 8.5	70.4 ± 11.2	72.2 ± 13.9
	EV3	70.5 ± 12.0	68.4 ± 8.9	69.3 ± 11.3	70.4 ± 8.9
MAXIMUM PRESSURE (kPa)	EV1	22.9 ± 4.7	23.6 ± 4.3	23.4 ± 4.4	24.2 ± 4.7
	EV1	114.0 ± 55.4	118.7 ± 63.6	109.6 ± 48.8	102.1 ± 46.7
	EV2	91.5 ± 21.0	109.7 ± 54.8	103.7 ± 41.5	129.9 ± 85.9
MEDIUM PRESSURE (kPa)	EV3	102.3 ± 46.4	103.5 ± 40.1	95.8 ± 31.6	114.9 ± 66.6
	EV2	22.1 ± 4.2	25.1 ± 3.8	24.1 ± 5.4	24.0 ± 5.2
	EV3	23.0 ± 3.8	24.0 ± 4.5	23.8 ± 4.3	24.4 ± 5.0

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.

	LLLT			PLACEBO		
	EV1	**EV2**	**EV3**	**EV1**	**EV2**	**EV3**
First quartile (25%)	87.0	88.7	94.0	88.8	94.4	97.2
Median	96.1	98.9	99.8	98.8	99.9	103.1
Third quartile (75%)	104.8	108.2	112.5	106.4	109.7	107.8

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 animal[15,25] and human studies[17].

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 balance[26,30].

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 tissue[31], and in the present study the aim was to reach the muscle tissue by stimulating the proprioceptive components[2,3,6], 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 therapy[33,34].

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 reactions[35].

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, Gallamini[20], in case studies (unspecified dizziness 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, Scoppa [19], used the LLLT on acupuncture and auriculoacupuncture 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, Hsu, Hu, Shyu, Chang[21], 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[17], 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

1. Han J, Anson J, Waddington G, Adams R, Liu Y. The role of ankle proprioception for balance control in relation to sports performance and injury. Biomed Res Int. 2015;2015.
2. Wodowski AJ, Swigler CW, Liu H, Nord KM, Toy PC, Mihalko WM. Proprioception and knee arthroplasty. A literature review. Orthop Clin North Am. 2016;47(2):301–9.
3. Vassallo M, Mallela SK, Williams A, Kwan J, Allen S, Sharma JC. Fall risk factors in elderly patients with cognitive impairment on rehabilitation wards. Geriatr Gerontol Int. 2009;9(1):41–6.
4. Isotalo E, Kapoula Z, Feret PH, Gauchon K, Zamfirescu F, Gagey PM. Monocular versus binocular vision in postural control. Auris Nasus Larynx. 2004;31(1):11–7.
5. Riemann BL, Lephart SM. The sensorimotor system, part I: The physiologic basis of functional joint stability. J Athl Train. 2002;37(1):71–9.
6. Hung Y-J. Neuromuscular control and rehabilitation of the unstable ankle. World J Orthop. 2015;6(5):434–8.
7. Bankoff ADP, Ciol P, Zamai CA, Schmidt A, Barros DD. Estudo do equilíbrio corporal postural através do sistema de baropodometria eletrônica. Rev Conex. 2004;2(2):87–104.
8. Alfieri FM. Distribuição da pressão plantar em idosos após intervenção proprioceptiva. Rev Bras Cineantropometria e Desempenho Hum. 2008;10(2):137–42.
9. Alfieri FM, Teodori RM, Guirro RRJ. Pedobarometric study in elderly after physical therapy intervention. Fisioter em Mov. 2006;19(2):67–74.
10. Santos AA, Bertato F. T, Montebelo MIL, Guirro ECO. Efeito do treinamento proprioceptivo em mulheres diabéticas. Rev Bras Fisioter. 2008;12(3):183–7.
11. Meneghini T, Rempel C, Barnes DD, Duarte F, Périco E. Avaliação da ativação proprioceptiva em atletas amadoras de voleibol. Conscientiae Saúde. 2009;8(1):47–55.
12. Hertel J, Braham RA, Hale SA, Olmsted-Kramer LC. Simplifying the Star Excursion Balance Test: Analyses of subjects with and without chronic ankle instability. J Orthop Sport Phys Ther. 2006;36(3):131–7.
13. Ginani F, Soares DM, Barreto MP e V, Barboza CAG. Effect of low-level laser therapy on mesenchymal stem cell proliferation: a systematic review. Lasers Med Sci. 2015;30(8):2189–94.
14. Karu TI, Pyatibrat L V, Kalendo GS. Photobiological modulation of cell attachment via cytochrome c oxidase. Photochem Photobiol Sci. 2004;3(2):211–6.
15. Leal Jr ECP, Lopes-Martins RÁB, De Almeida P, Ramos L, Iversen V V., Bjordal JM. Effect of low-level laser therapy (GaAs 904 nm) in skeletal muscle fatigue and biochemical markers of muscle damage in rats. Eur J Appl Physiol. 2010;108(6):1083–8.
16. Leal Jr ECP, Lopes-Martins RÁB, Frigo L, Marchi T de, Rossi RP, Godoi V de, et al. Effects of low-level laser therapy (LLLT) in the development of exercise- induced skeletal muscle fatigue and changes in biochemical markers related to postexercise recovery. J Orthop Sport Phys Ther. 2010;40(8):524–32.
17. De Marchi T, Leal ECP, Bortoli C, Tomazoni SS, Lopes-Martins RÁB, Salvador M. Low-level laser therapy (LLLT) in human progressive-intensity running: Effects on exercise performance, skeletal muscle status, and oxidative stress. Lasers Med Sci. 2012;27(1):231–6.
18. Leal Jr ECP, Nassar FR, Tomazoni S da S, Bjordal JM, Lopes-Martins RÁB. A laserterapia de baixa potência melhora o desempenho muscular mensurado por dinamometria isocinética em humanos. Fisioter Pesqui. 2010;17(4):317–21.
19. Bergamaschi M, Ferrari G, Gallamini M, Scoppa F. Laser acupuncture and auriculotherapy in postural instability-A preliminary report. J Acupunct Meridian Stud. 2011;4(1):69–74.
20. Gallamini M. Treating balance disorders by ultra-low-level laser stimulation of Acupoints. J Acupunct Meridian Stud. 2013;6(2):119–23.
21. Chang CC, Ku CH, Hsu WC, Hu YA, Shyu JF, Chang ST. Five-day, low-level laser therapy for sports-related lower extremity periostitis in adult men: A randomized, controlled trial. Lasers Med Sci. 2014;29(4):1485–94.
22. Filippin NT, Barbosa VLP, Sacco ICN, Costa PHL. Efeitos da obesidade na distribuição de pressão plantar. Rev Bras Fisioter. 2007;11(6):495–501.
23. Perrin PP, Gauchard GC, Perrot C, Jeandel C. Effects of physical and sporting activities on balance control in elderly people. Br J Sport Med. 1999;33(2):121–6.
24. Earl JE, Hertel J. Lower-extremity muscle activation during the star excursion balance tests. J Sport Rehabil. 2001;10(2):93–104.
25. Lopes-Martins RAB, Marcos RL, Leonardo PS, Prianti AC, Muscará MN, Aimbire F, et al. Effect of low-level laser (Ga-Al-As 655 nm) on skeletal muscle fatigue induced by electrical stimulation in rats. J Appl Physiol. 2006;101(1):283–8.
26. Donath L, Kurz E, Roth R, Zahner L, Faude O. Different ankle muscle coordination patterns and co-activation during quiet stance between young adults and seniors do not change after a bout of high intensity training. BMC Geriatr. 2015;15:19.
27. Fong SSM, Ng SSM, Guo X, Wang Y, Chung RCK, Stat G, et al. Deficits in lower limb muscle reflex contraction latency and peak force are associated with impairments inpostural control and gross motor skills of children with developmental coordination disorder: a cross-sectional study. Medicine (Baltimore). 2015;94(41):e1785.

Available from: http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=4616810&tool=pmcentrez&rendertype=abstract
28. Fujiwara K, Kiyota N, Maekawa M, Prokopenko S V., Vasilyevna AM. Postural control during transient floor translation while standing with the leg and trunk fixed. Neurosci Lett. 2015;594:93–8.
29. de Oliveira DCS, de Rezende PAM dos SL, da Silva MR, Lizardo FB, Sousa G da C, dos Santos LA, et al. Electromyographic analysis of lower limb muscles in proprioceptive exercises performed with eyes open and closed. Rev Bras Med Esporte. 2012;18(4):261–6.
30. Yang WC, Cheng CH, Wang HK, Lin KH, Hsu WL. Multi-muscle coordination during a challenging stance. Eur J Appl Physiol. 2015;115(9):1959–66.
31. Kim T-H, Kim N-J, Youn J-I. Evaluation of wavelength-dependent hair growth effects on low-level laser therapy: an experimental animal study. Lasers Med Sci. 2015;30(6):1703–9.
32. De Almeida P, Lopes-Martins RÁB, De Marchi T, Tomazoni SS, Albertini R, Corrêa JCF, et al. Red (660 nm) and infrared (830 nm) low-level laser therapy in skeletal muscle fatigue in humans: What is better? Lasers Med Sci. 2012;27(2):453–8.
33. Maciel TD, Silva J, Jorge FS, Nicolau RA. The influence of the 830 nm laser on the jump performance of female volleyball athletes. Rev Bras Eng Bioméd. 2013;29(2):199–205.
34. Kakihata CMM, Malanotte JA, Higa JY, Errero TK, Balbo SL, Bertolini GRF. Influence of low-level laser therapy on vertical jump in sedentary individuals. Einstein. 2015;13(1):41–6.
35. Perry SD, McIlroy WE, Maki BE. The role of plantar cutaneous mechanoreceptors in the control of compensatory stepping reactions evoked by unpredictable, multi-directional perturbation. Brain Res. 2000;877(2):401–6.

Corresponding author

Gladson Ricardo Flor Bertolini. Address: Universitária St., 2069, Jd. Universitário, Cascavel, Paraná, Brazil
Email: gladsonricardo@gmail.com

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