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ORIGINAL PAPER

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Evaluation of the dose-response for electrostimulation with Aussie current in the core strength

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ABSTRACT

Introduction. Muscle strengthening to improve joint stability is widely used in the rehabilitation process, and the use of neuromuscular electrical stimulation is a useful tool, but the use of Aussie current still has little documentation about its effectiveness.

Aim. To verify if there is a dose-response effect to Aussie current, both in the strength and in the static and dynamic stability of the deep pelvic lumbar muscles.

Material and methods. 39 volunteers divided into four groups, one control and three electrostimulation with intensity variation, one with intensity at the contraction threshold (GT), another with intensity maintained at 20% more (G20), and another with intensity maintained at 30% more (G30) than the intensity at the contraction threshold. The intervention lasted four weeks, with three weekly sessions lasting 15 minutes. Initially and after the intervention period, the strength and stability of the deep muscles of the pelvic lumbar region were measured in a static and dynamic manner by a biofeedback pressure unit.

Results. There was a significant increase of pressure under the lordoses in the pre- and post-evaluation moments, there were no differences in the evaluation of indirect force (dynamic stability), but there was an increase in the time for GT. The effect sizes presented advantages for the electrostimulated groups in static stability.

Conclusion. The doses used did not promote significant statistical differences, but the effects were positive for the electrostimulated groups, especially with respect to static stability.

Keywords. muscle strength, paraspinal muscles, spine, stabilization, transcutaneous electric nerve stimulation

Introduction

The lumbar region is part of the lumbar-pelvic complex described as "core", and in this region most body movements are initiated. In view of this, the stabilization of this region is of great importance to promote a more effective transmission of force, distributing the loads generated equally to all joints, which prevent the overload of some structure of this complex.[1-4]

The muscles that promote the stabilization of the lumbar spine are the multifidus and abdominal trans-

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Participation of co-authors: A – Author of the concept and objectives of paper; B – collection of data; C – implementation of research; D – elaborate, analysis and interpretation of data; E – statistical analysis; F – preparation of a manuscript; G – working out the literature; H – obtaining funds

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verse, the multifidus present a predominance of type I fibers, with an important mechanical role in force transfer due to the important control of lumbar lordosis.[5,6] Thus, in order to have a previous recruitment of these muscle groups, providing static and dynamic control to the spine, central stabilization training is recommended, with techniques like core stability exercises, Isostretching, Global Postural Reeducation, and Pilates, to ensure functional stability and reduce the incidence of injuries and discomfort in the pelvic lumbar region.[1,7-10]

One of the therapeutic possibilities for strengthening important core muscles is neuromuscular electrical stimulation (NMES), which is widely used in rehabilitation, and has shown positive results for underutilized muscle groups, with joint stabilization, increased strength, tone and muscle trophism.[11-16] Among the forms the Aussie Current is considered comfortable and effective, with a medium frequency base current characteristic, modulated at low frequency.[17]

There are several studies that address joint strengthening and stabilization with the use of NMES, but the literature is still poor in relation to the use of the Aussie current in lumbar-pelvic stabilization, especially with variation in stimulation doses, since dose-response studies are more common with respect to low frequency stimulation.[11,12,15,16,18-21] Therefore, the present study aimed to verify if there is a dose-response effect for Aussie current electrostimulation applied to the low back muscles, both in the strength and in the static and dynamic stability of the deep lumbar-pelvic musculature.

Aim

To verify if there is a dose-response effect to Aussie current, both in the strength and in the static and dynamic stability of the deep pelvic lumbar muscles.

Material and methods

This is a quantitative, experimental, randomized study carried out at the Physical Rehabilitation Center of the Universidade Estadual do Oeste do Paraná – UNIOESTE, approved by the Research Ethics Committee of UNIOESTE, with opinion n. 2,676,740, in which all participants signed the Informed Consent form, was inserted with the Brazilian Registry of Clinical Trials (REBEC) under TRIAL number: RBR-2SV9GW.

The sample was composed of 39 participants, of both genders (6 men), with a mean age of 20.6±3.7 years, body mass of 65.7±13.3 kg and height 1.67±0.09 meters. They were divided into four independent groups, one control group (CG) and three electrostimulation groups with variation in intensity (dose effect): one with intensity maintained at the contraction threshold (GT); another with intensity maintained 20% above the contraction threshold (G20); and another 30% above the contraction threshold (G30). The volunteers were randomly assigned to the groups by means of electronic randomization with the help of the resource available on the graphpad website.

The mean intensities of the currents applied to the samples of each group were 40.42±8.37, 48.73±10.47 and 50.12±12.48 mA for GT, G20 and G30, respectively.

Inclusion and exclusion criteria

Sedentary participants were admitted, with no disease or musculoskeletal lesion in the spine, aged between 17 and 40 years. We excluded individuals with uncontrolled systemic diseases, practicing physical activity systematically for at least twice a week, participants who interrupted the sequence of the intervention, in addition to the specific contraindications of the Aussie current.

Intervention

The intervention period lasted four weeks with three weekly sessions of 15 minutes each. In all electrostimulation groups, the Aussie current was used (Ibramed®, Amparo, Brazil), with the following parameters: base frequency of 1000 Hz, modulated at 50 Hz, the cycle presented a rise of 1 s, maintenance of 8 s, decay of 1 s and 10 s of rest. These parameters were fixed in order to analyze only the differences in current amplitude. The upper electrodes were positioned just below the last ribs and the lower electrodes were aligned with the upper posterior iliac spine (UPIS) at the level of the L5 spiny process. The electrodes used were rubber-silicone with 2x4 cm (Carci®, São Paulo, Brazil).

For the determination of the current dose, it was initially identified the intensity at which the contraction threshold was observed, characterized by visual inspection, at the beginning of a vigorous and sustained contraction, the percentage variations were based on this intensity.

Dependent variables

An initial evaluation (PRE) of the strength and stability of the deep muscles of the lumbopelvic region was performed, and the reevaluation (POS) occurred at the end of the interventions. Indirect measurements of strength and dynamic and static stability of the deep pelvic lumbar muscles were evaluated by a MioStab (Miotec®, Porto Alegre, Brazil) pressure biofeedback unit (PBU) (figure 1).[22]

Prior to the tests, the volunteers were familiarized and trained in the movements necessary to carry out the tests. Compensatory movements were corrected and avoided during the tests. In all the tests, the evaluated volunteers were placed in the dorsal decubitus position, with their arms extended along the body, knees flexed at 90° and feet supported on the stretcher. The PBU pres-

Fig. 1. Pressure assessment equipment. On the left is the MioStab equipment, with its bag and manometer. On the right the equipment in use, under the lumbar region of the volunteer

sure bag was inflated to the pressure established for each test and positioned horizontally and centrally in the region that comprises the last ribs and the UPIS. After positioning, the subject was asked to perform a forced respiratory cycle and, when necessary, pocket pressure was adjusted again.

For the evaluation of static stability, the pressure bag was under a pressure of 40 mmHg and the volunteer was instructed to breathe normally and, upon exhaling, to contract the muscles in an attempt to raise the navel towards the spine in order to promote a decompression in the pressure bag, due to the extension movement of the lumbar spine (with increased lumbar lordosis), keeping it away from contact with the bag. This decompression lasted 10 s. Three attempts were requested, with a two-minute interval between each of them, and the minimum pressure peak values were recorded during each contraction and for statistical analysis the mean value of the three attempts was considered. The test indicated good static stability when the contraction generated a pressure decrease in the bag of at least 6 mmHg and this decrease was sustained for at least 5 seconds.

For the evaluation of dynamic stability (that is, even performing movement with the lower limb, there would be the possibility of maintaining the pressure force), the pressure bag was with a pressure of 40 mmHg and the volunteer was instructed to breathe normally and, upon expiration, performed the abduction of one of the lower limbs (associated with external rotation of the hip, since the hip was bent, knees at 90o and feet supported by the stretcher), with the intention of touching the lateral face of the limb on the stretcher keeping the footrest in maximum possible amplitude, returning to the initial position after that. Three attempts were sought, with an interval of two minutes between each of them. In this test, the volunteer's ability to at least maintain the established initial pressure was evaluated. When the subject could not maintain the minimum pressure of 40 mmHg during the test, the dynamic stability was considered deficient.

For the indirect evaluation of the force, the pressure bag had a base pressure of 80 mmHg and the volunteer was instructed to breathe normally and, when exhaling together, to contract the muscles of the perineal and abdominal regions as intensely as possible in an attempt to bring the navel to the spine and promote a compression in the pressure bag. This contraction was sustained for as long as possible. For this evaluation only one attempt was requested and the inference of the force was based on the time of support of the contraction.

The control group participated in the initial evaluation and was reevaluate after one month, and electrostimulation groups were reevaluate in a period between one and seven days after the end of the session.

Statistical analysis

The SPSS 20 software was used for statistical analysis (IBM®, Armonk, USA). The significance level was 5% ($\alpha=0.05$). The analyses were performed using Generalized Linear Mixed-effects Models (GLMMs) with Bonferroni post-hoc. The Effect Size was also analyzed by Cohen's d, using page https://www.estimationstats.com/#/, defined as <0.2: trivial; 0.2-0.5: small; 0.5-0.8: moderate; >0.8: large.

Results

Forty-one individuals were evaluated for eligibility, among them there were sample losses (n=2), 1 before randomization and 1 for not completing the intervention period, resulting in 39 volunteers in the final sample.

Regarding static stability of the multifids, it was found that there was no group effect (p=0.573) or interaction (p=0.606), but there was a significant difference in relation to the time of evaluation (p=0.002). By

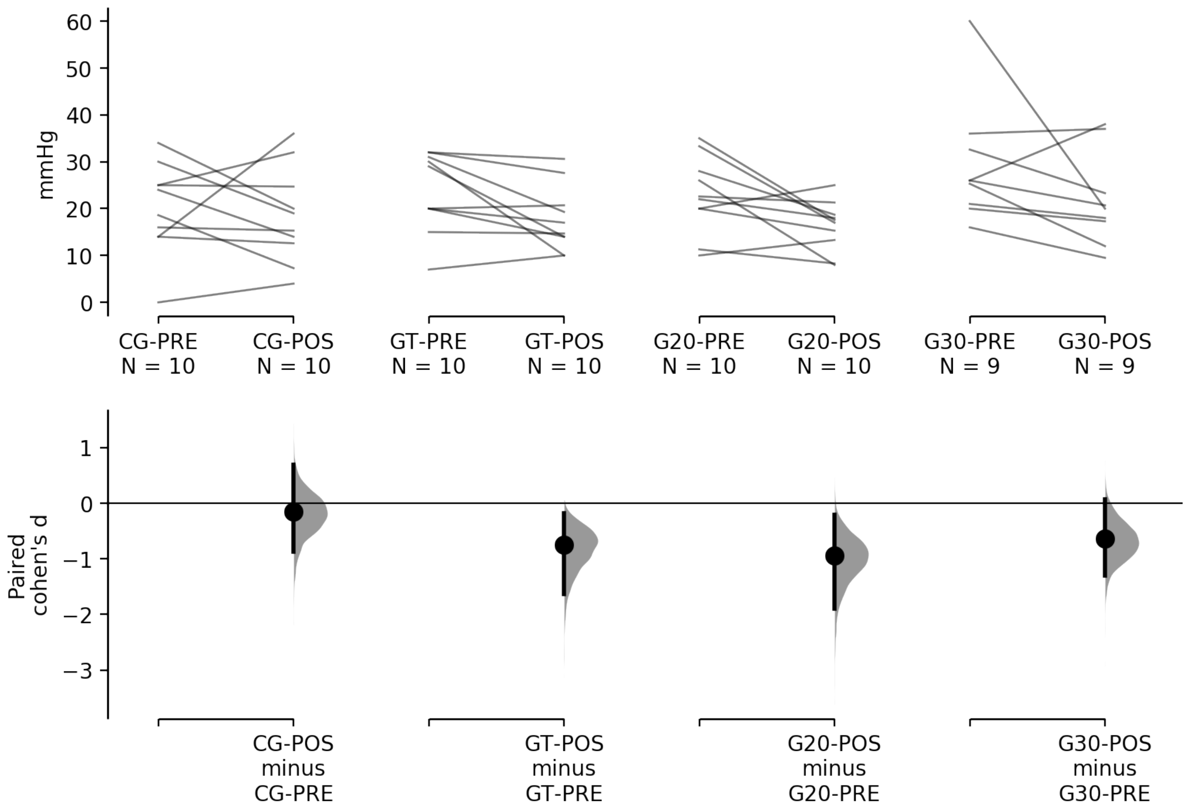

Fig. 2. Graphic demonstration of paired Cohen Effect Size d for the static stability of the multifidus. Raw data is plotted on the upper axes; each paired set of observations is connected by a line. On the lower axes, each mean difference is represented as a bootstrap sampling distribution. Mean differences are represented as points; 95% confidence intervals are indicated by the ends of the vertical error bars

analyzing the effect size, it was possible to observe that it was trivial for the control group (-0.16), moderate for GT (-0.75) and G30 (-0.64), and large for G20 (-0.95) (figure 2).

The second variable evaluated by the study was the indirect force with time as covariable, measured by the highest pressure peak and longest time contraction, acquired by the contraction of the abdomen transverse muscle. For this variable there was not any effect on comparisons between groups (p=0.363), moments (p=0.242) and interaction (p=0.839). The effect size found was considered trivial for GT (p=-0.04), small for CG (p=0.477), G20 (0.485) and G30 (0.346) (figure 3).

The third analysis of the study was linked to the evaluation of the contraction time. There were not any differences between the groups (p=0.230), but between the moments (p=0.041) and interaction (p=0.030). At the moment PRE the groups were similar, however, at the moment POS GT was higher than G20. Observing the moment, GT presented a significant increase comparing PRE and POS. Regarding the effect sizes, GC (0.259), G20 (0.382) and G30 (0.305) presented small effects, while GT (0.694) presented moderate effects (figure 4).

Discussion

In the present study, an increase in muscle strength and static stability of the multifidus muscles was obtained in the samples in relation to the moment PRE and POS intervention, regardless of the intensity that were submitted, however, there was no significant difference when compared between the groups, although different sizes of effect were found, which may point to practical differences, that is, clinical despite the lack of statistical differences.[23]

This result is contrary to the finding by Guirro, Nunes and Davini with the use of low and medium frequency currents in the quadriceps of healthy women for 5 consecutive days, for 3 weeks, for 30 minutes, with an interval of 24 hours between each application, in which the current intensity was increased to the maximum tolerance threshold and then there was an increase of 1 mA every 5 minutes of application.[24] The authors indicate that the increasing intensity caused an increase in the strength of the quadriceps of the samples. A hypothesis that can explain this contradiction is that the present study was based only on the muscular contraction threshold and not the maximum tolerance. This probably submitted the participants to intensities below the maximum tolerated. In addition, the cited article shows that at each session the intensity increased, being again

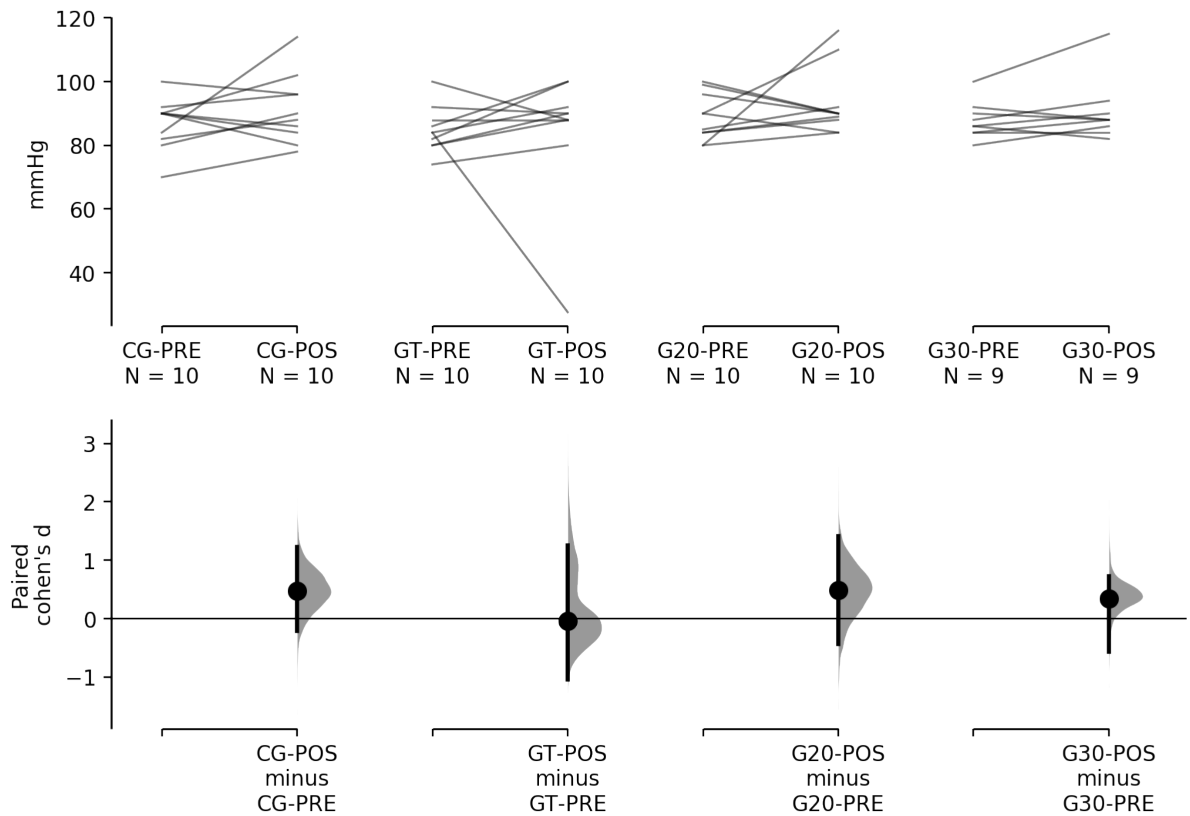

Fig. 3. Graphical demonstration of paired Cohen Effect Size d for indirect evaluation of dynamic stability. Raw data is plotted on the upper axes; each paired set of observations is connected by a line. On the lower axes, each mean difference is represented as a bootstrap sampling distribution. Mean differences are represented as points; 95% confidence intervals are indicated by the ends of the vertical error bars

different from the present study, in which the intensity did not increase between the sessions.

Marmon and Snyder-Mackler evaluated the dose-response curve in individuals after knee arthroplasty, and observed a significant correlation between current intensity with quadriceps force and voluntary activation.[19] Similarly, Almeida et al. used the NMES in individuals with rheumatoid arthritis, indicating for muscle strength gain, the use of intensities that produce between 15 and 50% of maximum voluntary contraction.[18] However, Hsu et al. reported that both low and high intensity NMES produce similar functional results in individuals with stroke.[21]

In relation to the increase in muscle strength of multifidus, Iijima et al. point out that the intensity of current affects muscle activation, influencing the recruitment of motor units during neuromuscular electrical stimulation.[25] This statement differs from the results obtained in this study, because the pressure peak did not show significant differences between the stimulated groups with different intensities, but it is noted that the sizes of the effect were greater than the control in the electrostimulated groups.

A systematic review aimed at pointing out the preconditions to generate a stimulus above the training threshold with NMES, pointed out that the choice of electrical parameters and the stimulation regimen are fundamental to obtain satisfactory results in force gain.[26] The authors related significant gains with stimulations above or equal to 50% of the maximum voluntary contraction of the individual, in addition, the values of frequency above 60 Hz, pulse duration between 200 and 400 μs and work cycle between 20 and 25% were important to optimize the results. The findings are in line with the results of the current study when considering the duration, both weighted on average, four weeks of training, with three sessions per week, but differs when analyzing the intensity, because in this study this effect was not evaluated. It is pertinent to highlight that the motivation and perception of discomfort of the individual may affect the ability to support higher intensities of stimulation, and consequently interferes in the results.

A current application with frequencies of several Kilohertz produce stimulation supra thresholds that are capable of producing multiple action potentials in the nerve fiber, producing long-lasting bursts that are adequate to maximize muscle torque.[25] This information is consistent with the results of a study that compared four different electric currents; two medium and two low frequency.[17] The authors points out that among them, the

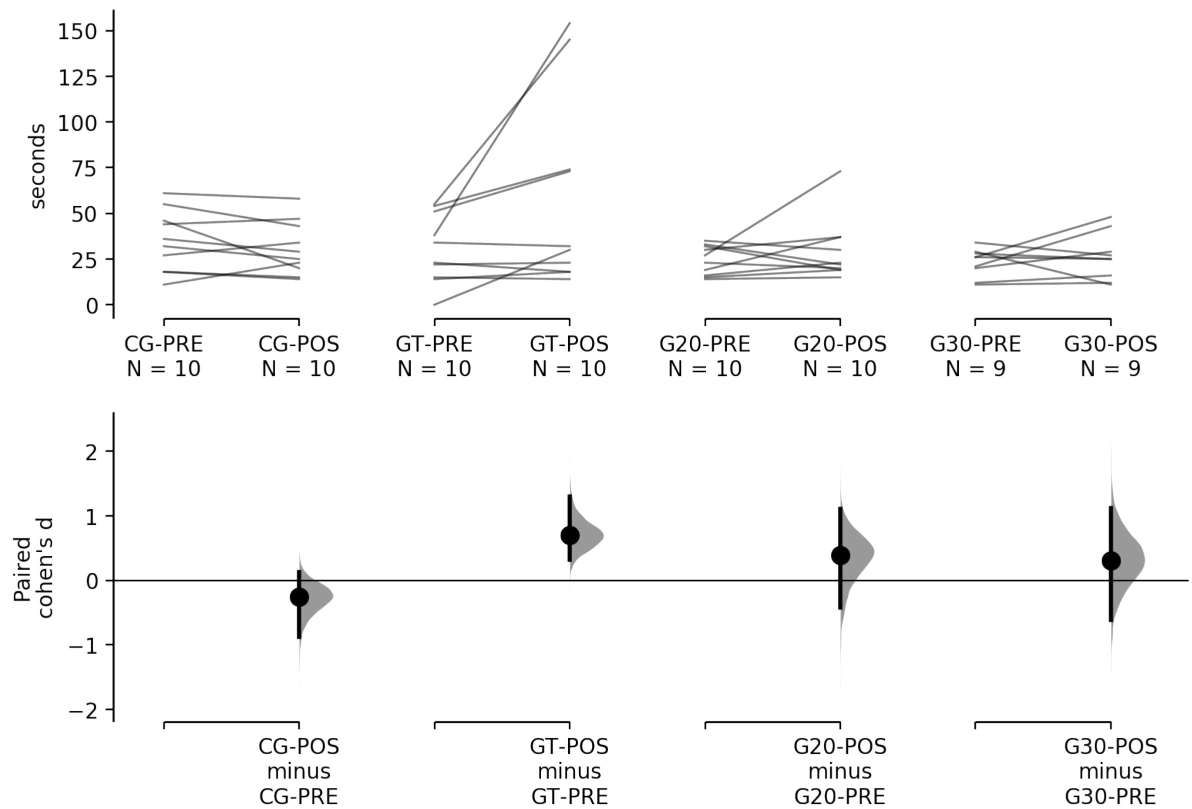

Fig. 4. Graphical demonstration of paired Cohen Effect Size d for the evaluation of contraction time. Raw data is plotted on the upper axes; each paired set of observations is connected by a line. On the lower axes, each mean difference is represented as a bootstrap sampling distribution. Mean differences are represented as points; 95% confidence intervals are indicated by the ends of the vertical error bars

Aussie current was the most effective in the production of knee extension torque. They also showed that NMES applied alone, was able to produce 66% of the maximum voluntary contraction torque, and although it is not a more effective method than voluntary exercise, NMES is able to produce more specific muscle fiber contraction than those activated by voluntary action; being an excellent supporting resource to strengthening programs for healthy individuals.

As for the variables analyzed, even with previous training, it is not possible to isolate a possible effect of motor learning in the procedures, generating an increase in mean values in the second evaluation, because all participants performed the evaluations, that is, they were taught to contract the muscle group studied, thus becoming aware of this contraction and the movements.[27] It is possible relate the unfavorable result of dynamic stability with the characteristic of stimulated muscles, because they are postural muscles, with this there was a significant increase in static stability. However, despite acting on pelvic stabilization during movement, it is not the only one that acts to generate dynamic stability, requiring a set of structures, such as the joints, neural system and various muscles (the main being the rectum and transverse abdomen, erector of the spine, multifidus and gluteus maximus), in addition, the multifidus have little biomechanical advantage, precisely because they are postural muscles, serving as decelerators of movement.[10,28] Since one of the limitations of this study was the absence of electroneuromyographic evaluation of the multifidus, it is not possible to discriminate only their action on the tests performed.

Another hypothesis may have been related to the training method, in which the stimulation was performed in a neutral position, in ventral decubitus, stimulating in only one degree, not having a dynamic training. This can be considered another limitation in the present study and suggestion to be addressed in future researches.

Conclusion

The results obtained indicated that the Aussie current has conditions to produce a strengthening of the lumbar multifidus muscles, generating static stability of the lumbar-pelvic region. However, the dose used in the different stimulated groups did not promote significant difference.

References

1. Wang X, Zheng J, Yu Z, et al. A meta-analysis of core stability exercise versus general exercise for chronic low back pain. *PLoS One.* 2012;7(12):1–7.

2. Coulombe BJ, Games KE, Neil ER, Eberman LE. Core stability exercise versus general exercise for chronic low back pain. *J Athl Train.* 2017;52(1):71–72.
3. Chang W-D, Lin H-Y, Lai P-T. Core strength training for patients with chronic low back pain. *J Phys Ther Sci.* 2015;27(3):619–622.
4. Joyce AA, Kotler DH. Core training in low back isorders: role of the Pilates method. *Curr Sports Med Rep.* 2017;16(3):156–161.
5. Hides J, Richardson C, Jull G. Multifidus muscle recovery is not automatic after resolution of acute, first-episode low back pain. *Spine (Phila Pa 1976).* 1996;21(23):2763–2769.
6. Shahidi B, Hubbard JC, Gibbons MC, et al. Lumbar multifidus muscle degenerates in individuals with chronic degenerative lumbar spine pathology. *J Orthop Res.* 2017;35(12):2700–2706.
7. Willson JD, Dougherty CP, Ireland ML, Davis IMC. Core stability and its relationship to lower extremity function and injury. *J Am Acad Orthop Surg.* 2005;13(5):316–325.
8. Adorno MLGR, Brasil-Neto JP. Assessment of the quality of life through the SF-36 questionnaire in patients with chronic nonspecific low back pain. *Acta Ortopédica Bras.* 2013;21(4):202–207.
9. Alves MC, Souza Neto RJ de, Barbosa RI, Marcolino AM, Kuriki HU. Effects of a Pilates protocol in individuals with non-speci fi c low back pain compared with healthy individuals: Clinical and electromyographic analysis. *Clin Biomech.* 2020;72:172–178.
10. Akuthota V, Ferreiro A, Moore T, Fredericson M. Core stability exercise principles. *Curr Sports Med Rep.* 2008;7(1):39–44.
11. Pelegrini ACA, Gasoto E, Bussolaro JM, et al. The analgesic action of Aussie current in women with non-specific chronic lumbar pain. *Int J Ther Rehabil.* 2019;26(7):1–10.
12. Coghlan S, Crowe L, Mccarthypersson U, Minogue C, Caulfield B. *Neuromuscular electrical stimulation training results in enhanced activation of spinal stabilizing muscles during spinal loading and improvements in pain ratings.* In: Conf Proc IEEE Eng Med Biol Soc. 2011:7622–7655.
13. Ludwig O, Berger J, Becker S, Kemmler W, Fröhlich M. The impact of whole-body electromyostimulation on body posture and trunk muscle strength in untrained persons. *Front Physiol.* 2019;10:1020.
14. Kemmler W, Weissenfels A, Bebenek M, et al. Effects of whole-body electromyostimulation on low back pain in people with chronic unspecific dorsal pain: a meta-analysis of individual patient data from randomized controlled WB-EMS trials. *Evidence-Based Complement Altern Med. 2*017;2017:8480429.
15. Mukaino M, Ono T, Shindo K, et al. Efficacy of brain--computer interface-driven neuromuscular electrical stimulation for chronic paresis after stroke. *J Rehabil Med.* 2014;46(4):378–382.
16. Mettler JA, Bennett SM, Doucet BM, Magee DM. Neuromuscular electrical stimulation and anabolic signaling in patients with stroke. *J Stroke Cerebrovasc Dis.* 2017;26(12):2954–2963.
17. Dantas LO, Vieira A, Siqueira Junior AL, Salvini TF, Durigan JLQ. Comparison between the effects of 4 different electrical stimulation current waveforms on isometric knee extension torque and perceived discomfort in healthy women. *Muscle Nerve.* 2015;51(1):76–82.
18. Almeida GJ, Khoja SS, Piva SR. Dose-response relationship between neuromuscular electrical stimulation and muscle function in people with rheumatoid arthritis. *Phys Ther.* 2019;99(9):1167–1176.
19. Marmon AR, Snyder-Mackler L. Quantifying neuromuscular electrical stimulation dosage after knee arthroplasty. *J Life Sci.* 2013;5(8):581–583.
20. Hsu S, Hu M, Wang Y, Yip P, Chiu J, Hsieh C. Dose-response relation between neuromuscular electrical stimulation and upper-extremity function in patients. *Stroke.* 2010;41(4):821–824.
21. Smith G V, Alon G, Roys SR, Gullapalli RP. Functional MRI determination of a dose-response relationship to lower extremity neuromuscular electrical stimulation in healthy subjects. *Exp Brain Res.* 2003;150(1):33–39.
22. Coracini CA, Bortoletto P, Provensi É, Furtuoso MV, Bertolini GRF, Carvalho AR de. Acute evaluation of static and dynamic stability of the lumbopelvic region after paravertebral stretching. *J Pre-Clinical Clin Res.* 2019;13(4):150–152.
23. Rosnow R, Rosenthal R. Effect sizes for experiemntal psychologists. *Can J Exp Psychol.* 2003;57(3):221–237.
24. Guirro R, Nunes C V., Davini R. Comparação dos efeitos de dois protocolos de estimulação elétrica neuromuscular sobre a força muscular isométrica do quadríceps [Comparison of the effects of two neuromuscular electrical stimulation protocols on the isometric muscular strength of the quad. *Fisioter e Pesqui.* 2000;7(1/2):10–15.
25. Iijima H, Takahashi M, Tashiro Y, Aoyama T. Comparison of the effects of kilohertz-and low-frequency electric stimulations: A systematic review with meta-analysis Data sources. *PLoS One.* 2018;13(4):1–19.
26. Filipovic A, Kleinoder H, Dormann U, Mester J. Electromyostimulation-a systematic review of the influence of training regimens and stimulation parameters on effectiveness in electromyostimulation training of selected strength parameters. *J Strength Cond Res.* 2011;25(11):3218–3238.
27. Crasto CFB, Montes AM, Carvalho P, Carral JMC. Pressure biofeedback unit to assess and train lumbopelvic stability in supine individuals with chronic low back pain. *J Phys Ther Sci.* 2019;31(10):755–759.
28. Huxel Bliven KC, Anderson BE. Core stability training for injury prevention. *Sport Heal A Multidiscip Approach.* 2013;5(6):514–522.