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Additional effects of transcutaneous electrical nerve stimulation associated with vertebral joint mobilization on musculoskeletal variables of individuals with low back pain

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ABSTRACT

Low back pain (LBP) is a musculoskeletal complaint that can be defined as pain or discomfort referred to the lower part of the spine, between the last thoracic vertebra and the first sacral vertebra, above the upper gluteal line, and which may or may not radiate to the lower limbs. Highly prevalent, it affects about 84% of the adult population at some point in life, being classified as acute when it lasts up to 6 weeks, subacute when from 6 to 12 weeks and chronic if for more than 12 weeks 2. LBP is a public health problem, as it is related to functional disability, decreased quality of life, social and economic losses, both indirect, as it leads to absenteeism, withdrawal from work activities and/or disability retirement, and direct, due to public health costs with medical care and procedures related to LBP and its biopsychosocial consequences 3,4. The etiology of low back pain is complex and multifactorial, and can be specific when due to a known pathology or factor, and nonspecific when the causes are inevitable 5. However, they are often associated with an imbalance between the effort required to perform the activities and the insufficient capacity of the musculoskeletal system to do so 6, as well as other agents of mechanical origin, such as disc, joint, muscle, ligament and nerve alterations.

Keywords: Low back pain, Spinal joint mobilization, TENS.

1 INTRODUCTION

Low back pain (LBP) is a musculoskeletal complaint that can be defined as pain or discomfort referred to in the lower spine, between the last thoracic vertebra and the first sacral vertebra, above the upper gluteal line, and that may or may not radiate to the lower limbs. Highly prevalent, it affects about 84% of the adult population at some point in life, being classified as acute when it lasts up to 6 weeks, subacute when it lasts up to 6 to 12 weeks and chronic if for more than 12 weeks. [1] [2]

LD is a public health problem, as it is related to functional disability, decreased quality of life, social and economic losses, both indirect, by leading to absenteeism, absence from work activities and/or disability retirement, and direct, due to the costs to public health with medical care and procedures related to LD and its biopsychosocial consequences. [3,4]

[5] The etiology of low back pain is complex and multifactorial, and may be specific when due to a known pathology or factor, and nonspecific when the causes are unevident. However, these are often associated with an imbalance between the effort required to perform the activities and the insufficient capacity of the musculoskeletal system to do so, as well as other agents of mechanical origin, taking for example disc, joint, muscular, ligamentous and nervous changes. In addition, there are risk factors related to health and behavior that favor the onset of LD, such as age, sedentary lifestyle, overweight, smoking and occupations. [6] [7]

Currently, there are numerous proposals for conservative interventions for the treatment of low back pain that aim at analgesia and increased functionality. Among them there are those that propose to act through the education of the individual and programs of exercises of stabilization, strengthening, stretching and mobility, such as kinesiotherapy. However, it is possible to observe a correlation between pain, decreased range of motion (ROM) and flexibility, which can increase the severity of the LD picture, lead to fatigue of the paravertebral muscles and limit functionality progressively, making it difficult to perform the proposed therapeutic exercises. [8,9] [10] [11] Thus, resources such as manual therapy and electrotherapy can act on the signs and symptoms, acting in a way to reduce the physical limitation generated by pain, thus enabling the practice of kinesiotherapy and other complementary techniques that would be limited, interrupted or postponed by the presence of pain. [12]

Transcutaneous electrical nerve stimulation (TENS) is characterized by being a current that produces electrical impulses of varying frequency, pulse duration, and intensity. Through the mechanism of the Theory of Gates, it acts by stimulating the myelinated fibers of type A, generating excitation of the interneurons in the posterior horn of the spinal cord and consequently inhibiting the nociceptive impulses of the A-delta and C fibers. There is evidence to suggest its ability to reduce pain during and after a certain time of application, and for this reason it is commonly used in clinical practice for CLBP, however there are few studies and consensus in the literature on its effects on fatigue and recovery of function. [8,13] [8] [14]

Among the techniques of manual therapy is the Central Postero-Anterior Joint (CAP) mobilization, with evidence of benefits of its application in individuals with CLBP. CAP is a mobilization technique that uses passive, rhythmic, oscillatory movements of low speed and low force, graduated in 5 levels that has its variation based on the ROM available in the joints. These movements aim to restore joint arthrokinematics, which improves mobility on joint surfaces that can result in decreased pain and greater performance of the segment where the technique is applied. [15] [16,17]

Therefore, transcutaneous electrical nerve stimulation (TENS) and Central Posteroanterior Vertebral Joint Mobilization (CAP) are used recurrently in physical therapy practice for pain relief and recovery of segmental function in the short term and may be beneficial means of complementing other therapeutic interventions, such as kinesiotherapy. Although many studies address the application of these techniques individually in low back pain, few associate them in the same protocol. Therefore, the aim of this study was to analyze whether the acute effects of Central Posteroanterior (CAP) vertebral joint mobilization combined with transcutaneous electrical nerve stimulation (TENS) differ from placebo-associated CAP on lumbar spine pain, mobility, strength, and resistance in young adult individuals. The hypothesis is that associating the two techniques would potentiate the musculoskeletal benefits.

2 METHODS

This is a quantitative, randomized study, submitted to the local ethics committee, CAAE: 59134522.0.0000.5406 and approved according to opinion 5.502.507 All volunteers signed the Free and Informed Consent Form (ICF) when they agreed with the procedure and objective of the study informed by the researchers, as well as clarification of any doubts.

2.1 PARTICIPANTS

The sample consisted of 33 adult individuals aged between 18 and 35 years, of both sexes. A sample size calculation was performed using the data of the first 10 volunteers. The calculation of the sample size was performed using the software G*Power 3.1.9.7 and was based on the data obtained in the numerical scale of pain because it is the primary outcome of the research. A power of 0.80, probability of error α 0.05, effect size of 0.48 and a dropout rate of 15% were used, indicating a total sample of 30 volunteers. Two groups were formed: Joint Mobilization Group (GMA, n=16) and Joint Mobilization Group with TENS (GMAT, n=17). Sample recruitment and collection occurred between the months of August/2022 to November/2022.

2.2 INCLUSION AND NON-INCLUSION CRITERIA

We included participants of both sexes and aged between 18 and 35 years, who had the ability to perform the activities related to the research, and who had presented at least one episode of low back pain in the last year, whether it had become chronic or not.

Individuals with Body Mass Index (BMI) above 30 kg/m², subjects who had used analgesic, anti-inflammatory, myorelaxant or antipyretic drugs up to 24 hours before the research protocol, or who were unable to complete all stages of collection were excluded from the sample.

Volunteers who had neurological symptoms, a history of fracture related to the lumbar spine, cardiovascular or cognitive impairment, skin lesions in the lumbar region, and/or metal implants in the spine would also not be included in the sample. Finally, those who did not sign the ICF would not participate. [16] [18] [13,14]

2.3 RANDOMIZATION

Randomization was employed using a computer-generated table of random numbers from 0 to 100. A number was drawn for each volunteer, with even numbers indicating it for the GMAT group and odd numbers for the GMA group.

2.4 EVALUATION PROCEDURES

The evaluations and interventions were performed in a single collection. Initially, anamnesis was performed to obtain personal data and clinical history of the volunteers, and the International Physical Activity Questionnaire (IPAC), which estimates the weekly time spent in physical activities, was applied in order to characterize the sample [19]. Then, the following evaluations were performed in the following pre-established sequence: Numerical Pain Scale (NDS), Schober test, lumbar extension dynamometry, and Biering-Sorensen test. In the first stage, five minutes after the initial evaluation, an overload protocol was performed on the lumbar dynamometer. A second evaluation was performed five minutes after the overload sequence. In the second stage, the CAP joint mobilization protocol was applied for the GMA, and the PAC joint mobilization protocol associated with the TENS for the GMAT. At the end of the intervention, a final evaluation was performed.

2.5 NUMERICAL PAIN SCALE (NDT)

The NDT was used and validated as a simple assessment instrument to quantitatively measure the perception of pain intensity. It is a scale ranging from 0 to 10 points, in which "0" represents no pain, while "10" represents the greatest possible pain. [20]

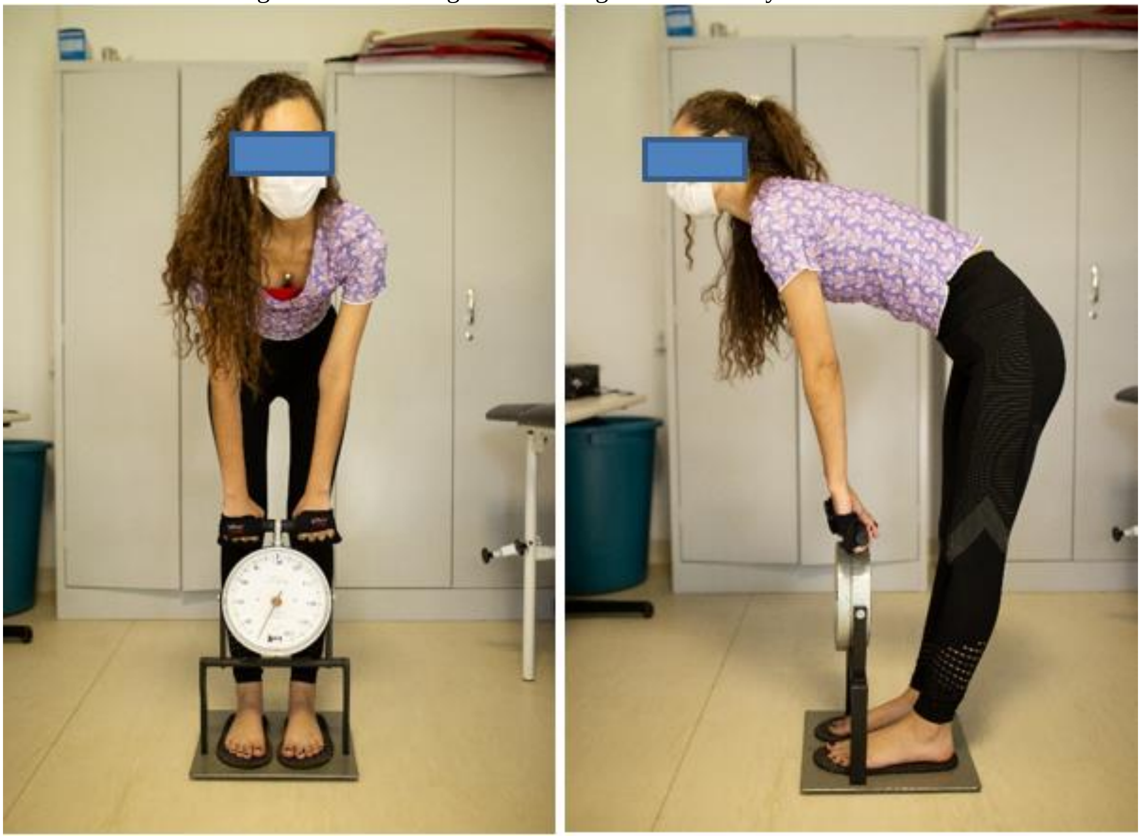
2.6 SCHOBER TEST

The Schober test was used to evaluate the mobility of the lumbar spine. With the volunteer in neutral position, a pen marking was performed in the lumbar region, taking as reference the superior posterus iliac spine. A second point was made ten centimeters above the first using a tape measure for measurement. The volunteer was instructed to flex the trunk in order to reach the ground, and in this posture the distance between the two points was verified. An increase equal to or greater than five centimeters in measurement is considered normal for lumbar spine mobility. [21]

2.7 LUMBAR DYNAMOMETRY

To measure the strength of the lumbar spine extensor muscles, the lumbar dynamometer was used. The volunteer was positioned in orthostatism on the platform of the equipment with total extension of knees, both hands supported on the bar of the equipment, elbows in extension, trunk in flexion, the head accompanying the prolongation of the trunk and gaze fixed in front (Figure 1).

Figure 1: Positioning for the strength test on the dynamometer.

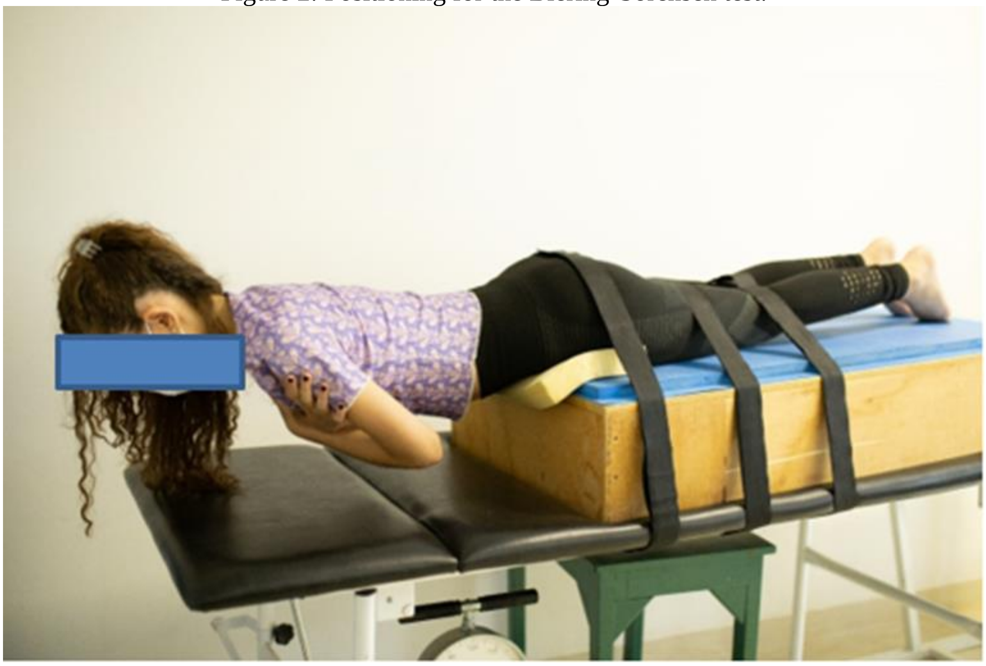


Once positioned, the volunteer was asked to perform the greatest possible force for the trunk extension movement. The commands "Strength!" and "More strength!" were standardized in order to encourage the volunteers. This test was performed three times with the submaximal strength for familiarization, and twice with the maximum force, with an interval of 1 minute between the tests. For data analysis, the highest value obtained was used. [22,23]

2.8 BIERING-SORENSEN TEST

The Biering-sorensen test was performed to evaluate the resistance of the trunk extensor muscles. The volunteer was positioned in ventral decubitus on a box above the stretcher, with the trunk suspended from the superior anterofacial iliac spine (ASIS) and with the lower limbs fixed by means of Velcro bands in the greater trochanter regions of the femur, biceps femoris and popliteal fossa. While the bands were fixed, the volunteers remained with their forearms supported in a step. At the beginning of the test, the hands were positioned touching the contralateral shoulder, and the trunk was suspended (Figure 2). [24]

Figure 2: Positioning for the Biering-Sorensen test.



It was requested to remain in the position for as long as possible until exhaustion, with the time measured in seconds by a stopwatch. The test would also be completed if the participant did not keep the trunk in a horizontal position, due to fatigue and/or pain. The commands "You're doing well!" and "Continue!" were standardized every 30 seconds to encourage the volunteers. [25,26] [27]

2.9 LUMBAR OVERLOAD PROTOCOL

In some studies, difficulties were reported in evaluating and interpreting the performance of volunteers due to the absence or low level of pain initially presented at the time of collection. Since the purpose of this research is to evaluate the effects of two interventions on, among other variables, the low back pain of the volunteers, a sequence of overload was performed on the dorsal dynamometer, with 5 repetitions of contractions sustained for 10 seconds, intervals of 30 seconds between them, and minimum load of 75% of the value obtained in the initial evaluation (maximum force). Thus, a sharpening of the LD framework would be simulated before the application of the interventions. [4,28]

2.10 INTERVENTION PROCEDURES

2.10.1 Joint mobilization protocol

For both groups (GMA and GMAT) the same protocol of Central Postero-Anterior (CAP) vertebral joint mobilization, grade III, was applied at all levels of the Lumbar Spine. In each of the vertebrae, from L1 to L5, 3 mobilization series were performed lasting one minute each. It was standardized to start in L5 and end in L1 each of the series.

2.10.2 TENS Implementation Protocol

For both groups, the procedures for placing the electric current were identical, changing only the intensity. To apply the Transcutaneous Electrical Stimulation (TENS), the equipment Neurodyn III, IBRAMED®, Brazil was used. In the GMAT group, conventional TENS was used with the following parameters: continuous mode; frequency of 100 Hz; pulse duration of 100 µs; maximal sensory intensity, variable so that it was tolerable to the volunteer and adjusted every 5 minutes; no visible muscle contraction; Total duration of 30 minutes. In the GMA group, placebo TENS was used, in which the volunteers were previously informed that they could or could not feel any local sensation during the application of the current. The parameters were identical to the GMAT group, however the intensity was adjusted in the minimum sensory threshold of the volunteer and, after 2 minutes, it was zeroed until completing the 30 minutes. [29] [13]

In both groups, the volunteers were placed in ventral decubitus on the stretcher, and four rectangular silicone rubber electrodes (50x55mm) were cross-applied to the paravertebral muscles bilaterally from L1 to L5, fixed with adhesive tape and with the use of conductive gel.

2.10.3 Data analysis

To analyze the effect of the intervention protocols (lumbar overload, CAP mobilization and CAP mobilization associated with TENS) on the level of pain, mobility, strength and resistance of the lumbar spine, the Repeated Measures ANOVA was used, with a mixed design (2 groups x 3 moments), followed by Bonferroni's *post-hoc* approach. Sphericity was tested by Mauchly's test. The level of significance adopted was 5%. The effect size was calculated by eta squared ($\eta^2 < 0.06$ = weak; 0.06 - 0.13 = medium; $\eta 2 \geq 0.14$ = large) for the ANOVA comparisons. [30]

3 RESULTS

A total of 33 individuals were collected and separated into 2 groups: GMA and GMAT. The results presented in Table 1 characterize the volunteers of this study and demonstrate that the groups were homogeneous in terms of anthropometry.

Table 1. Characterization of the groups [mean (standard deviation)].

		GMAT	GMA	P
n		17	16	-
Men (%)		35,29%	31,25%	-
Women (%)		64,71%	68,75%	-
Age (years)		22,59 (2,72)	21,81 (2,23)	0,195 [A]
Body mass (kg)		68,21 (9,69)	63,97 (10,85)	0,244 [B]
Height (m)		1,70 (0,08)	1,64 (0,09)	0,070 [B]
IMC ($kg.cm^{-2}$)		23,62 (2,82)	23,60 (2,83)	0,981 [B]
IPAC (%)	very active	35,29	37,50	-
	active	47,06	37,50	-
	irregularly active A	5,88	25,00	-
	irregularly active B	11,76	0,00	-

GMAT= joint mobilization group associated with TENS; GMA= joint mobilization group; IPAC= International Physical Activity Questionnaire; BMI = Body Mass Index; Kg= kilograms; cm = centimeters. [The] Mann-Whitney test; [B] T test for independent samples.

Table 2 shows that the multivariate analysis showed no significant interaction between group and moment (F= 0.775, p= 0.628, η2= 0.205, power = 0.275), nor did it show a significant effect of the group (F= 0.187, p= 0.943, η2= 0.026, power = 0.084). On the other hand, it showed a significant effect of the moment (F= 12.887, p= 0.000, η2= 0.811, power= 1) on the variables analyzed.

Univariate analysis showed a significant effect of the moment on NDT and the Schober and Biering-Sorensen tests (Table 2).

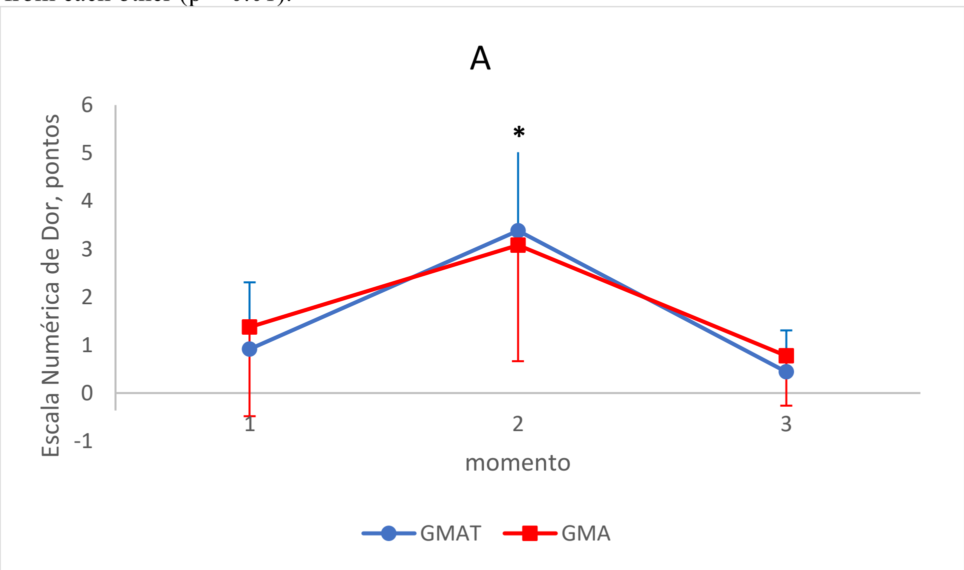
Post-hoc therapy showed a significant increase in pain level at moment 2 (p= 0.000) and, subsequently, a significant reduction at moment 3 (p= 0.000). There was no significant difference between moments 1 and 3 (p= 0.188), which indicates that the pain level was reestablished (Figure 3A). For the Schober test, it showed consecutive increases in measurements at moments 2 and 3, which resulted in significant differences for all comparisons (p= 0.000) (Figure 1B). For the Biering-Sorensen test, it showed a significant reduction at moment 2 (p= 0.001), followed by a significant increase at moment 3 (p= 0.008). There was no significant difference between moments 1 and 3 (p= 1,000), which indicates that performance was reestablished (Figure 3C).

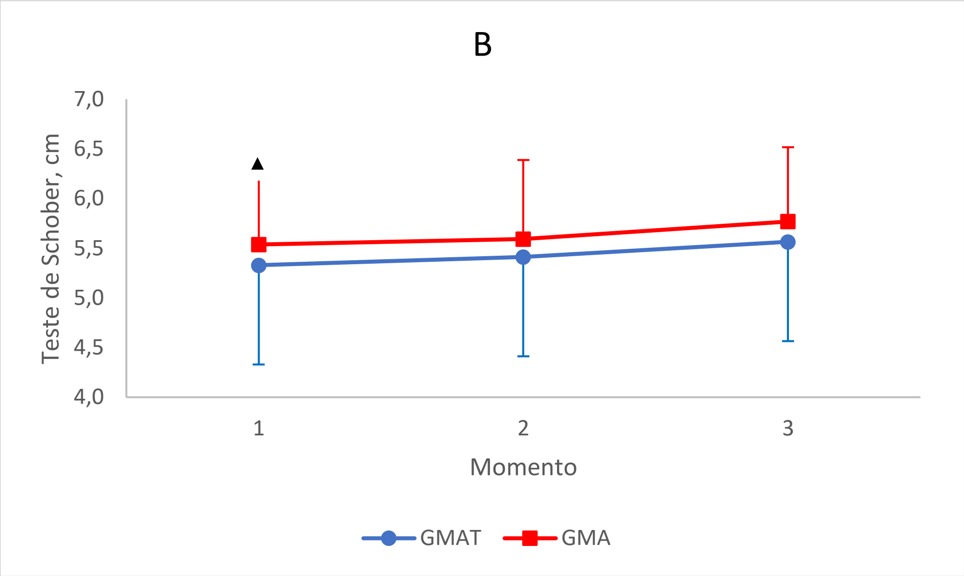
Table 2. Effect of intervention protocols on pain intensity, mobility, strength and resistance of the lumbar spine.

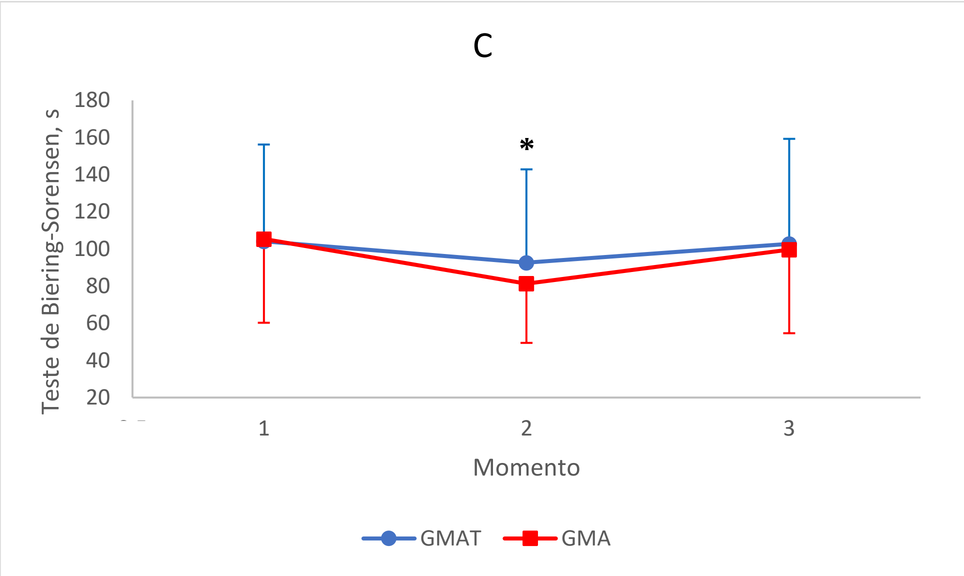
Variable	Groups		Repeated Measures Anova (ηp2)		
	GMAT	GMA	Group * Moment	Group	Moment
END 1	0,91 (1,39)	1,38 (1,86)	0,425 (0,027)	0,716 (0,004)	*0,000 (0,563)*
END 2 [A]	3,38 (1,86)	3,08 (2,42)			
END 3	0,44 (0,86)	0,78 (1,04)			
Teste de Schober 1 [B]	5,33 (0,88)	5,54 (0,83)	0,755 (0,005)	0,502 (0,015)	*0,000 (0,576)*
Schober test 2	5,41 (0,87)	5,59 (0,79)			
Schober test 3	5,56 (0,91)	5,77 (0,75)			
Dinamometria 1	78,26 (20,73)	71,16 (22,63)	0,663 (0,012)	0,520 (0,013)	0,498 (0,021)
Dinamometria 2	75,18 (23,04)	71,78 (26,21)			
Dinamometria 3	74,41 (24,63)	69,88 (22,56)			
Biering-Soresen 1	104,12 (52,10)	105,38 (45,12)	0,381 (0,031)	0,780 (0,003)	*0,001 (0,216)*
Biering-Soresen 2 [A]	92,62 (50,24)	81,31 (31,87)			
Biering-Soresen 3	102,79 (56,49)	99,56 (44,93)			

NDT = Numerical Pain Scale; GMAT= ; GMA= ; ηp2= effect size.
In italics: significant difference ($p < 0.05$).
Bonferroni post-hoc for momentum effect: [A] moment 2 is different from moments 1 and 3 ($p < 0.01$); [B] there was a difference between all moments for the Schober test ($p < 0.01$).

Figure 3. Behavior of pain level (A), mobility (B) and resistance of the lumbar spine (C) in the GMAT and GMA groups, in the three moments of evaluation. Momentum effect: * moment 2 is different from moment 1 and 3 ($p < 0.01$). ▲ all moments differ from each other ($p < 0.01$).







4 DISCUSSION

The aim of this study was to analyze whether the immediate effects of CAP joint mobilization combined with TENS differ from placebo-associated CAP on lumbar spine pain, mobility, strength, and resistance. The initial hypothesis was that the association of the two techniques would intensify the musculoskeletal benefits, however it was rejected, since there was no significant difference between the groups in the performance of the volunteers in the tests. In addition, other findings were significant: Decreased performance for the muscular endurance tests and increased pain level after the overload protocol, and improvement of GMA and GMAT for the variables of pain, mobility and muscular endurance after the interventions, suggesting the short-term efficacy of CAP mobilization in the lumbar.

Transcutaneous electrical nerve stimulation has been frequently applied as a resource for analgesia in different clinical conditions. Its application in low back pain, however, is controversial.

While some studies suggest its effectiveness in reducing pain and, consequently, increasing strength, muscular endurance and greater stabilization of the joint in the short term, others question its action when compared with the placebo effect, since they found no significant difference between both, which is similar to our results. [31,32] [33,34]

Considering the way this study was conducted, some factors may have influenced the final results. The placebo effect on TENS, as mentioned, may have influenced and been a response to the expectation and confidence of the volunteers in judging that they were receiving the treatment. Another item to be raised is the parameters adopted in the protocol, since there is no consensus in the literature on which would produce the best response, in addition to studies that indicate that the choice of the same should be made specifically for each individual, because even in similar conditions there are individual factors that can affect the TENS stimulus, taking as an example the type of pain. [33,35] [12,35] [36]

Moreover, in this study, only one CAP mobilization session associated with TENS was performed and, yet, there was no group where TENS was applied alone. For this reason, it is not possible to state whether the results would remain the same if the resource were used in isolation and/or in more sessions, as well as its long-term effects.

The objective in performing lumbar overload, previously exposed, was partially achieved in the results, since there was a decrease in muscle endurance and an increase in the level of pain after the protocol. The stability of the spine is due to the balance in the action of passive elements, such as ligaments, intervertebral discs and joint capsules, and active, represented by the musculature. When there is impairment in the function of the active components, through the induction of muscle overload, there is excessive demand on the passive components, generating structural deformations and, as a result, pain and decreased resistance, which was observed in this study. [37] [38]

It was also expected, however, a decrease in performance in the muscle strength test after the overload protocol, which did not occur. During the use of the dorsal dynamometer as a means of strength evaluation, despite the pre-test position and familiarization adjustments, activation of accessory muscles for the requested movement may occur and, thus, generate a transfer between muscle activations, making it difficult to obtain significant differences between moments. On the other hand, subjective elements such as fear of performing maximum force during the first evaluation may also have influenced. Finally, there was a significant increase in mobility after overload, which may have occurred due to the volunteers' own movement during the execution of the tests after the first evaluation, generating an increase in range of motion. [37] [39]

Although there was no significant difference between the groups, this was obtained in both for the variables of mobility, muscular endurance and, in particular, for pain level, in which a 2-point change in the NDT was observed after the interventions, which is a result considered clinically relevant. Considering that the CAP joint mobilization intervention was performed in both groups, the efficiency of the technique is suggested. In individuals with low back pain reduced vertebral joint mobility, paravertebral muscle inhibition and functional losses are commonly found. In view of this, the mechanisms of action of mobilizations may be biomechanical and/or neurophysiological. [40] [15]

Passive and repetitive movements lengthen the contracted tissues, increase the lubrication of the articular cartilage with the redistribution of synovial fluid, as well as nutrition of the intervertebral disc, allowing greater amplitude and efficiency of movement with less pain. Hypoalgesia, in turn, can occur by the mechanism of pain gates, through the repetition of proprioceptive stimuli in the medulla during mobilizations and/or local release of endogenous opioids. The literature also points out that the technique can increase muscle recruitment, increasing the ability to produce force through the stimulation of mechanoreceptors mediated by the spinal cord, having the effect of decreasing muscle inhibition. In the present study, [41] [15] [42,43] [44] an improvement in the parameters of mobility, muscular endurance and pain level was verified after joint mobilization, which is similar in the scientific literature. However, for muscle strength there was no significant difference after a single intervention, which suggests the need to verify in future projects how this variable behaves after a greater number of sessions. [15,42,43]

The results obtained in this work contribute to the reports of previous investigations: Shum, Tsung and Lee (2013), as well as Powers et al. (2008) reported immediate effects of an intervention session with vertebral mobilization on pain reduction and stiffness in the lumbar spine; Shah and Kage (2016), as well as Cruz and Boleli (2020) found significant differences for decreased pain, increased range of motion, and increased spinal function; finally, Navega and Tambascia (2011) concluded that the technique was effective for improving quality of life, flexibility, pain and functional disability. On the other hand, our findings diverge from other studies, such as those by Thomas et al. (2020) and Tavares et al. (2017), which suggest a placebo effect of joint mobilization in chronic low back pain. [45] [46] [42] [47] [16] [4815]

The scientific data published so far are not sufficient to agree that CAP joint mobilization and TENS are effective resources for the treatment of low back pain. Therefore, future randomized clinical trials are necessary, with a greater number of sessions, long-term reevaluations and the presence of a control group, both for the techniques in isolation and for their association in the same protocol. Given the above, the present study corroborates and adds to the literature relevant data for the conservative treatment of low back pain.

5 CONCLUSION

The data of the present study, under the methodological conditions used, allow us to conclude that the musculoskeletal performance of young adults with low back pain submitted to PAC vertebral joint mobilization improved in relation to pain, mobility and lumbar muscular resistance. The additional application of TENS did not result in higher gains.

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