Transversus abdominis activation is similar in healthy and unhealthy individuals

Ativação do transverso abdominal é semelhante em indivíduos saudáveis e não saudáveis

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Abstract

Introduction: The transversus abdominis seems to be the key stabilizing muscle of the back, and its dysfunctions are associated with the development of low back pain (LBP). **Objective:** To compare the activation of the transversus abdominis and back muscle strength between self-reported healthy individuals, individuals with non-specific LBP, and individuals with disc herniation. **Methods:** This is a cross-sectional study carried out with male individuals intentionally divided into: healthy group (HG), non-specific LBP group (LBPG), and herniated disc group (HDG). The outcomes evaluated were pain, flexibility, disability, back muscle strength and transversus abdominis activation. **Results:** Thirty individuals were selected. Regarding the activation of the transversus abdominis, 60% of the HG had excellent activation, while for the LBPG and HDG it was only 30 and 20%, respectively. However, there were no significant differences between groups ($p = 0.155$). For strength, both the LBPG and the HDG were different compared to the HG ($p = 0.028$ and $p = 0.045$, respectively). **Conclusion:** The activation of the transversus abdominis seems to be similar between healthy individuals, individuals with non-specific LBP, and those with disc herniation. However, individuals with a herniated disc had less strength and greater disability.

Keywords: Abdominal muscles. Biofeedback. Chronic pain. Low back pain.

Resumo

Introdução: *O transverso abdominal parece ser o principal músculo estabilizador das costas e suas disfunções estão associadas ao desenvolvimento de dor lombar.* ***Objetivo:*** *Comparar a ativação do transverso abdominal e a força muscular da coluna lombar entre indivíduos saudáveis autorreferidos, indivíduos com lombalgia inespecífica e indivíduos com hérnia de disco.* ***Métodos:*** *Estudo transversal realizado com indivíduos do sexo masculino divididos intencionalmente em: grupo saudável (GH), grupo lombalgia inespecífica (GLP) e grupo hérnia de disco (GHD). Foram avaliados os desfechos dor, flexibilidade, incapacidade, força muscular das costas e ativação do transverso abdominal.* ***Resultados:*** *Foram selecionados trinta indivíduos. Em relação à ativação do transverso abdominal, 60% do GH teve excelente ativação, enquanto para o LBPG e o HDG foi de apenas 30 e 20%, respectivamente. Contudo, não houve diferenças significativas entre os grupos (p = 0,155). Para força, tanto o LBPG quanto o GHD foram diferentes em relação ao GH (p = 0,028 e p = 0,045, respectivamente).* ***Conclusão:*** *A ativação do transverso abdominal parece ser semelhante entre indivíduos saudáveis, indivíduos com dor lombar inespecífica e aqueles com hérnia de disco. Indivíduos com hérnia de disco, porém, apresentaram menos força e maior incapacidade.*

Palavras-chave: *Músculos abdominais.* Biofeedback. *Dor lombar. Dor crônica.*

Introduction

Low back pain (LBP) is a common condition in the world population.[1] It is one of the main causes of musculoskeletal diseases and demand for health care.[2,3] More than 80% of the population will experience this symptom at some time in their lives; of those, 95% will recover within a few months, while the others will develop chronic LBP, i.e, the pain will persist for a time longer than three months.[4]

LBP can be classified as specific, for those that have a defined cause, and non-specific, which corresponds to most cases, when the pathoanatomical cause cannot be determined.[5] The most common condition among people with specific back pain is disc herniation.[5,6] Individuals with LBP present musculoskeletal dysfunctions, such as delayed recruitment of transversus abdominis, insufficient muscle control of lumbar spine stabilizing muscles, and reduced cross-sectional area, strength, muscle endurance, and flexibility.[7-10] The musculoskeletal system composing the core muscles related to the spine consists of global muscles (rectus abdo-minis, external oblique, anterior fibers of the internal oblique, and the thoracic portion of the iliocostalis) and local stabilizing muscles (multifidus, psoas major, transversus abdominis, quadratus lumborum, diaphragm, internal oblique muscles, the lumbar part of the iliocostalis, and the longissimus muscles).[11] The transversus abdominis seems to be the key stabilizing muscle, and its dysfunctions may be associated with the develop-ment of LBP.[9,12]

One of the methods used to assess the activity of these muscles is the pressure biofeedback unit (PBU). This is a non-invasive technique considered valid, reliable, low-cost, and easy to handle that uses the tension generated by the muscle contractions to measure their activity.[13] The measurement of strength is another effective way to evaluate the functional ability of the back muscles. The dynamometer is a valid and reliable instrument that can be used and provides objective strength values.[14] Although these devices are widely used to evaluate muscle activation and muscle strength, there are no studies comparing individuals with specific and non-specific back pain.

Thus, this study aimed to compare the activation of the transversus abdominis and the strength of the back muscle between self-reported healthy individuals, individuals with non-specific LBP, and individuals with disc herniation.

Methods

This is a cross-sectional study that was carried out in the city of Natal (Rio Grande do Norte - Brazil). The sample was recruited by convenience from the academic community and consisted male individuals aging between 25 and 60 years, recruited in the general population and intentionally divided into: healthy group (HG), non-specific LBP group (LBPG), and herniated disc group (HDG). The choice to use a exclusively male sample was made to ensure sample homogeneity and minimize potential variabilities associated with the menstrual cycle, which could interfere with the results if individuals of both sexes were included, making it a potential confounding variable.

Individuals with non-specific LBP for at least three months (i.e, chronic LBP) were included in the LBPG. For the HDG, the individuals should have a clinical diagnosis of lumbar disc herniation and magnetic resonance image with up to six months of validity after diagnosis. For the HG, those who did not have herniated discs or LBP in the past six months were included. The individuals who have undergone any physical therapy treatment in the last three months or did not perform the evaluation procedures correctly were excluded from the study.

An assessment form prepared by the researchers was used to collect individual, clinical, and occupational data regarding weekly working hours. In addition, pain was evaluated using the visual analog scale (VAS),[15] flexibility was assessed using the Schober test,[16] and disability through the Roland-Morris questionnaire.[17] A 300 kgf dorsal dynamometer (KRATOS®) was used to assess the back muscle strength,[14] and the activation of the transversus abdominis was assessed using the PBU.[13]

To measure back muscle strength, the participants were positioned with feet fully supported on the dynamometer platform, and knees extended. The trunk should be flexed at 120°, the cervical spine aligned to the trunk, and the dynamometer arms at knee-level. While holding the dynamometer, arms with elbows extended and no shoulder movement, the participants were asked to perform three maximal voluntary isometric contractions (MVIC) for trunk extension, during five seconds, with a 60-s interval between each repetition (Figure 1). The highest value was used for data analysis.

To analyse the activation of the transversus abdominis muscle through a PBU, a sphygmomanometer with a pressure range between 0 and 300 mmHg was used. For this, participants were positioned prone on a plinth with the sphygmomanometer below the lower abdominis (at the level of the umbilicus), arms kept alongside the body, feet placed over the plinth, and head rotated to the right (Figure 2). The sphygmomanometer was inflated to 70 mmHg, and the participants were asked to move the abdominal wall upwards and inwards without moving the spine and pelvis. This position was maintained for 10 seconds. The result of the PBU test was dichotomous: excellent or insufficient. An excellent contraction was considered if a variation of 4 - 6 mmHg was observed. A variation above or below this pressure corresponded to an insufficient contraction.[18]

Figure 1 - Assessment of back muscle strength.

Figure 2 - Muscle activation test for transversus abdominis using a pressure biofeedback unit.

All statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS) software, version 22.0 (IBM Corp., USA).

Data are shown as mean ± standard deviation, and data normality was performed using the Shapiro-Wilk test. One-way ANOVA with Tukey's post hoc test was performed to determine the homogeneity of the initial values and compare the differences between groups for the following variables: pain, flexibility, disability, and strength. Chi-square test was used to analyze categorical variable (transversus abdominis activation). A significance level of 5% (two-tailed) was considered.

This study was approved by the Research Ethics Committee of the Universidade do Rio Grande do Norte (No. 1659839). All individuals were aware of the research's objectives and procedures and signed an informed consent form.

Results

Thirty individuals, ten in each group, were selected and evaluated. There were no sample losses. The sample characterization and homogeneity are shown in Table 1.

There was significantly less pain in the HG group when compared to LBPG and HDG ($p < 0.001$ for all comparisons). Regarding flexibility, no significant differences ($p > 0.05$) were found between groups. The HDG had the highest disability score and was statistically different from the HG ($p = 0.005$), but not from the LBPG ($p = 0.087$). For strength, the LBPG and GHD groups obtained minors values in relation to GH ($p = 0.028$ and $p = 0.045$, respectively), as shown in Table 2.

Regarding the activation of the transversus abdominis, 60% of the HG participants had excellent activation, while for the LBPG and HDG, only 30 and 20%, respectively, were classified as excellent. Besides that, no significant differences were found between groups ($p = 0.155$) (Table 3).

Table 1 - Sample characterization and homogeneity of the groups

Characteristics	Mean (SD)	p-value
Age (years)		
HG	31.4 (8.1)	0.004
LBPG	23.2 (2.2)	
HDG	36.8 (11.4)	
Total	30.5 (9.7)	
BMI (kg/m²)		
HG	26.4 (2.5)	0.806
LBPG	27.2 (6.7)	
HDG	27.7 (2.9)	
Total	27.1 (4.3)	
Weekly work hours		
HG	33.1 (10.8)	0.511
LBPG	28.2 (12.9)	
HDG	34.3 (13.0)	
Total	31.9 (12.1)	

Note: HG = healthy group; LBPG = low back pain group; HDG = herniated disc group; BMI = body mass index; SD = standard deviation.

Table 2 - Pain, flexibility, disability, and strength data of the three groups studied

Variables	Measuring instrument	HG	LBPG	HDG	p-value
Pain	Visual Analogic Scale	0.4 (0.8)	4.0 (1.4)	4.7 (2.3)	**< 0.001**
Flexibility	Schober's test	7.1 (1.1)	6.2 (1.4)	5.9 (0.8)	0.094
Disability	Roland-Morris questionnaire	0.7 (1.2)	2.9 (1.9)	6.9 (6.6)	**0.007**
Strength	Dynamometer	119.2 (21.2)	86.3 (30.7)	88.9 (27.5)	**0.018**

Note: Values of mean and standard deviation of all variables and groups and ANOVA comparison results between groups. HG = healthy group; LBPG = low back pain group; HDG = herniated disc group. The terms in bold correspond to the statistically significant values (< 0.05).

Table 3 - Transversus abdominis muscle activation in the three groups studied

Groups	Excellent contranction - n (%)	Insufficient contraction - n (%)	p-value
Healthy	6 (60)	4 (40)	0.155
Low back pain	3 (30)	7 (70)	
Herniated disc	2 (20)	8 (80)	

Discussion

The purpose of this study was to compare the activation of the transversus abdominis and back muscle strength between healthy individuals, individuals with non-specific low back pain, and individuals with disc herniation. No significant difference was observed in relation to the activation of the transversus abdominis between the groups evaluated. Although there is a significant difference in strength among these individuals, those in the healthy group were considered stronger compared to the other two groups.

Although the HDG presented the greater inability to maintain a sustained contraction of the transversus abdominis, no significant differences were observed between the three groups studied. The inability observed in HG can also be highlighted, as the movement required during the test execution is complex and can influence their results.[19]

Previous studies have shown that inadequate activation of the transversus abdominis is associated with back pain,[20-22] and its ineffective contraction may lead to hypotrophy and reduced firing rate.[23,24] Also, those individuals with a previous history of back pain that are now asymptomatic present deficits in the transversus abdominis activation.[25,26]

However, it was observed in a previous study[27] that even when a successful value is measured by PBU in individuals with LBP, this value does not seem to indicate a high activation of the transversus abdominis, since this test had a low sensitivity of 0.22 (range confidence [CI] of 95%: 0.10, 0.42), and a moderate specificity of 0.77 (95% CI: 0.58, 0.89). However, it is worth highlighting that the measurement method carried out in the study by Grooms et al.[27] was not consistent with the present one, given the individuals of this study adopted the prone position during the assessments. More recently, the concurrent validity between PBU and surface electromyography (EMG) in patients with chronic LBP was confirmed and found low specificity and sensitivity of PBU for assessing transversus abdominis activation.[28]

The reliability and reproducibility of the PBU to measure the transversus abdominis activity in both healthy[29,30] and individuals with non-specific LBP[31] has been evaluated in previous studies and showed good results. The reasons for this result were probably related to the depth of the muscle, the EMG crosstalk, and the different purposes of these tools since EMG evaluates the electrical muscle activity and PBU assesses the abdominal displacement caused by abdominal muscle contraction.

Regarding the back muscle strength during spine extension, a significant difference between LBPG and HG was found, but with no differences between LBPG and HDG. This fact was probably influenced by the pain level caused by the LBP. The fear of pain during maximum effort is an important factor taken into account by the patients. Therefore, those without pain felt safer and reached high strength values (119.2 ± 21.2 kgf), close to the reference values (114.0 ± 25.4 kgf) described by Eichinger et al.[14]

With regards to flexibility, there was no difference between groups, showing that this variable is not associated with LBP or herniated disc. This result corroborates Graup et al.,[32] who described no association between lumbar flexibility and pain in this region. As expected, back pain was significantly different between healthy individuals and those with specific or non-specific LBP ($p < 0.001$), and there was no difference between them regarding flexibility ($p = 0.094$).

Disability has been a widely used criterion to evaluate patients with LBP, and the Roland Morris questionnaire is a valid and well-accepted instrument for this outcome.[33] In the present study, it was observed that the HDG showed more disability than the LBPG and HG. Although disability has a direct relationship with pain, and both the LBPG and HDG presented significant pain levels, its conception in chronic conditions is multifactorial and does not present a linear and homogeneous behavior.[34] This may explain why no differences were found between LBPG and HG. Also, according to Porchet et al.,[35] the herniated disc is severily related to disability; thus, it can be concluded that individuals with disc herniation present more disability despite having pain levels similar to those with LBP.

The mean age was significantly different between groups, and the HDG had a higher value when compared with the HG and LBPG. This difference can be explained since older individuals are more prone to developing degenerative changes in the spine. This statement corroborates with Dammers and Koehler[36] and Taylor et al.,[37] which showed that spinal degeneration increases with age, and starts in both the caudal region (caused by the loss of proteoglycans) and in the lumbosacral region, due to its proximity to the sacrum. Moreover, disc herniation is uncommon in the first decades of life, being more prevalent in the subsequent four decades as a result of spinal overloading.[32]

The body mass index and the working hours evaluated in this study were homogeneous for all participants. These factors are associated with spinal problems[38] due to the overload imposed by the time of work, prolonged static position, lifting of intermittent loads,[39] and the own body structure in the case of overweight and obesity, resulting in musculoskeletal imbalances.[40]

The present study has some limitations. The cross-sectional design did not allow a direct causal inference, and the reduced sample may have minimized the interaction effects between groups. The sample consisted only of male individuals, which may compromise the generalization of the data to the general population. Moreover, both the PBU and the Schober test still present conflicting results, thus requiring further studies to confirm their validity. Further studies with larger samples and long-term follow-ups are needed to investigate the real effectiveness of these instruments.

Regarding clinical implications, the activation of the transverse abdominis muscle appears to be similar between individuals with pain and those without pain. This similarity can be utilized by physiotherapists and other healthcare professionals as a tool to enhance therapeutic approaches. The percentage of activation of the transverse abdominis can, therefore, serve as a useful indicator for the progression of exercises aimed at pain management, allowing the healthcare professional to use this marker as feedback for the patient. This, in turn, could potentially contribute to the effectiveness of therapeutic interventions.

Conclusion

The activation of the transversus abdominis seems to be similar between healthy individuals, individuals with nonspecific LBP, and those with disc herniation. However, participants with herniated disc have less strength and greater disability.

Authors' contributions

All authors contributed to the conception of this article. CAMS, VBL, YCM, SJCA, LBM and CGS were responsible for all stages of the article, namely: study conception and design, literature review, data collection and article writing. SJCA and CGS developed the study design, interpretation and analysis of data and critical review of the article. SJCA contributed to the interpretation and analysis of data and critical review of the article. Furthermore, they guided all stages of this study, being responsible for the conception, study design, statistical analyzes and criticism of the manuscript. All authors reviewed and approved the final version.

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