Comparison of muscle activation of the transversus abdominis and muscle strength between individuals with low back pain, herniated disc and healthy individuals: a cross-sectional study.

Clecio Souza (cleciogabriel1@hotmail.com)
Federal University of Rio Grande do Norte

Sanderson Assis
Federal University of Rio Grande do Norte

Karinna Costa
Federal University of Rio Grande do Norte

Yago Medeiros
Faculty of Estacio do Rio Grande do Norte

Liane Macedo
Federal University of Rio Grande do Norte

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Abstract

BACKGROUND: Low back pain and disc herniation are common problems in the world population, being characterized by discomfort in the region of the spine, resulting in functional capacity and quality of life reduced. Some of the causes of these conditions seem to be associated with the biomechanical imbalance of the muscles that act in the spine. There are methods to assess the level of activation and strength of the stabilizing muscles of the spine, such as the Pressure Biofeedback Unit (PBU). This study aims to compare the level of activation of the transverse abdomen muscle and back strength in healthy, low back pain and herniated disc individuals.

METHODOS: a cross-sectional study was carried out with 30 men that were homogeneously distributed in three groups: healthy (HG), with low back pain (LBPG) and with herniated disc (HDG). The primary outcomes were the level of activation of the transversus abdominis, assessed by PBU, and back strength, assessed by dynamometry. Pain, flexibility and disability were evaluated as secondary outcomes.

RESULTS: The mean age of the participants in this study was 30.47 ± 9.74 years. Regarding the activation of the transversus abdominis, no differences were found between groups ($p = 0.155$). For strength, LBPG and HDG were different compared to HG ($p = 0.028$ and $p = 0.045$, respectively). Pain was different between the HG and both LBPG and HDG (all $p < 0.001$). Regarding flexibility, no differences ($p > 0.05$) were found. The HDG had the highest disability score and was statistically different of the HG ($p = 0.005$), but with no difference from LBPG ($p = 0.087$).

CONCLUSION: the activation of the tranversus abdominis is similar between healthy, non-specific back pain and herniated disc individuals; however, the latter presents a reduced level of strength and more disability.

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 [4].

LBP can be classified as specific, those that have a defined cause, and non-specific, when the pathoanatomical cause cannot be determined [5]. The most common condition among people with specific back pain is disc herniation; however, the majority is classified as non-specific [5, 6].

It has been demonstrated that individuals with LBP present musculoskeletal dysfunctions, such as delayed recruitment, insufficient muscle control, and reduced cross-sectional area, strength, endurance, and flexibility [7, 8, 9, 10]. The musculoskeletal system composing the core muscles related to the spine consists of global muscles (rectus abdominis, 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 are associated with the development of LBP [9, 12].

One of the methods used to assess 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 dynamometry is a valid and reliable instrument that can be used and provides objective strength values [14]. Although these devices are widely used to evaluate back pain, 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 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 that was carried out in the city of Natal (Rio Grande do Norte - Brazil) from July to November 2016. The convenience sample was composed of male individuals aging between 25 to 60 years and intentionally divided into three groups: Healthy Group (HG), Low Back Pain Group (LBPG), and Herniated Disc Group (HDG). Those individuals with non-specific LBP for at least three months 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 low back pain 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 and containing individual, clinical, and and occupational data regarding weekly working hours was used to evaluate the participants. The pain was evaluated using the visual analog scale (VAS) [15], while flexibility was assessed using the Schober test [16], and disability through the Roland-Morris questionnaire [17]. A 300kgf 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 the back muscle strength, the participants were positioned with feet fully supported on the dynamometer platform, and knees extended. The trunk should be flexed at 120º, the cervical spine aligned to the trunk, and the dynamometer arms at knee-length. While holding the dynamometer arm with elbows extended and no shoulder movement, the participants were asked to perform three maximal voluntary isometric contractions (MVIC) for trunk extension, during 5 seconds, with a 60-s interval between each repetition (Fig. 1) and the highest value was used for data analysis.

The PBU was performed using a sphygmomanometer with a pressure range between 0 and 300 mmHg. For this, the participants were positioned prone on a plinth with the sphygmomanometer below the lower abdomen (at the level of the umbilicus), arms kept alongside the body, feet placed over the plinth, and head rotated to the right (Fig. 2). The sphygmomanometer was inflated to 70 mmHg, and the participants were instructed to move the abdominal wall uptwards and inwards without moving the spine and pelvis. This position was maintained for 10 seconds. An excellent contraction was considered if a variation of 4–6 mmHg was observed [18]. A variation above or below this pressure corresponded to an insufficient contraction.

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 *posthoc* test was performed to determine the homogeneity of the initial values and compare the differences between groups (HG, LBPG, and HDG) for the following variables: pain, flexibility, disability, and strength. Chi-Square test was used to analyze categorical variables. A significance level of 5% (two-tailed) was considered.

This study was approved by the Research Ethics Committee of the Federal University of Rio Grande do Norte (number 1659839), and conducted respecting the resolution 466/2012/CNS/MS/CONEP of the National Health Council and the World Medical Association Declaration of Helsinki. All individuals were aware of the research's objectives and procedures and signed an informed consent form with permission to publish identification images in an open access publication.

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.

Table 1
Sample characterization and homogeneity of the groups

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

HG: Healthy Group; LBPG: Low Back Pain Group; HDG: Herniated Disc Group; BMI: Body Mass Index; VAS: Visual Analogic Scale; RMQ: Roland-Morris questionnaire.

Pain was significantly different between the HG and both the LBPG and HDG (all $p < 0.001$). Regarding flexibility, no significant differences ($p > 0.05$) were found. The HDG had the highest disability score and was statistically different from the HG ($p = 0.005$), but not different from the LBPG ($p = 0.087$). For strength, both the LBPG and the HDG were different compared with the HG ($p = 0.028$ and $p = 0.045$, respectively), according Table 2.

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

Variables	HG	LBPG	HDG	p value
	Mean (SD)	Mean (SD)	Mean (SD)	
Pain	0.4 (0.8)	4.0 (1.4)	4.7 (2.3)	< 0.001
Flexibility	7.1 (1.1)	6.2 (1.4)	5.9 (0.8)	0.094
Disability	0.7 (1.2)	2.9 (1.9)	6.9 (6.6)	0.007
Strength	119.2 (21.2)	86.3 (30.7)	88.9 (27.5)	0.018
Values of mean and standard deviation (SD) of all variables and groups and ANOVA comparison results between groups.				

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

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

	Transversus abdominis activation		
	Excellet contranction	Insufficient contranction	p
	n (%)	n (%)	
Group			
Healthy	6 (60,0)	4 (40,0)	
Low Back Pain	3 (30,0)	7 (70,0)	
Herniated Disc	2 (20,0)	8 (80,0)	0,155

Discussion

The purpose of this study was to compare the activation of the transversus abdominis and the back muscle strength between healthy individuals, individuals with non-specific low back pain, and individuals with disc herniation.

The mean age was significantly different between groups, and the HDG had a higher value when compared with the HG and LBPG. Thus, age can be considered an important factor since older individuals are more prone to developing degenerative changes in the spine. This notion corroborates

with Dammers [19] and Taylor et al. [20], which showed that spinal degeneration increases with age, and starts in both the caudal region (caused by the loss of proteoglycans) and in the upper and lower discs of 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 [21].

The body mass index and the working hours evaluated in this study were homogeneous for all participants. These factors are associated with spinal problems [22] due to the overload imposed by the time of work, prolonged static position, lifting of intermittent loads [23], and the own body structure in the case of overweight and obesity, resulting in musculoskeletal imbalances [24].

Although the HDG presented the greater instability to maintain a sustained contraction of the transversus abdominis, no significant differences were observed between the three groups studied. The instability observed in the HG can also be highlighted since its presence is probably involved in the complexity of low back pain[25].

Previous studies have shown that inadequate activation of the transversus abdominis is associated with back pain [26, 27, 28], and its ineffective contraction may lead to hypotrophy and reduced firing rate [29, 30]. Also, those individuals with a previous history of asymptomatic back pain and flares present deficits in the transversus abdominis activation [31, 32].

The reliability and reproducibility of the PBU to measure the transversus abdominis activity in both healthy [33, 34] and individuals with non-specific LBP [35] has been evaluated in previous studies and showed good results. However, more recently, the same research group conducted another study to verify the concurrent validity between PBU and surface electromyography (EMG) in patients with chronic LBP and found a low specificity and sensitivity of the PBU to evaluate the transversus abdominis activation [36]. 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 strength during spine extension, a significant difference between the 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 low back pain or herniated disc, and corroborating with Graup et al. [21], who described no association between lumbar flexibility and pain in this region. However, pain is a predisposing factor for decreased lumbar flexibility, as stated by Toscano [37], who showed that the range of motion was associated with acute or chronic LBP relief. As expected, back pain was not different between healthy individuals and those with specific or non-specific LBP.

Disability has been a widely used criterion to evaluate patients with LBP, and the Rolland Morris questionnaire is a valid and well-accepted instrument for this outcome [38]. 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 behaviour [39]. This may explain why no differences were found in the LBPG. Also, according to Porchet et al. [40], the herniated disc severity is 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 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. 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.

Conclusion

We can conclude that the activation of the tranversus abdominis is similar between healthy, non-specific back pain and herniated disc individuals; however, the latter presents a reduced level of strength and more disability.

Declarations

Ethics approval and consent to participate

This study was approved by the Research Ethics Committee of the Federal University of Rio Grande do Norte (number 1659839), and conducted respecting the resolution 466/2012/CNS/MS/CONEP of the National Health Council and the World Medical Association Declaration of Helsinki. All individuals were aware of the research's objectives and procedures and signed an informed consent form with permission to publish identification images in an open access publication.

Availability of data and materials

The data for this research are available in the database attached in the related files section.

Conflict of interests

The authors declare that they have no conflict of interests.

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Authors' contributions

CGS was responsible for the study design and data collection. Performed data analysis and final writing.

YCM conducted the data collection and the writing of the manuscript.

SJCA performed statistical analysis and participated in the writing of the manuscript.

KSAC organized the data and methodological aspects for submission of the manuscript.

LBM reviewed the manuscript and the translation criteria.

All authors approved this final version of the manuscript.

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Figures

Figure 1

Assessment of the back muscle strength.

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Assessment of the back muscle strength.

Figure 2

Muscle activation test for transversus abdominis using a Pressure Biofeedback Unit.

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Muscle activation test for transversus abdominis using a Pressure Biofeedback Unit.

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