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ÁREA DE ESPECIALIZAÇÃO EM TERAPIA MANUAL ORTOPÉDICA

Effects of low back pain in trunk muscles endurance and ratios

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Dissertação apresentada para cumprimento dos requisitos necessários à obtenção do grau de Mestre em **Fisioterapia** – Área de Especialização em **Terapia Manual Ortopédica** pela Escola Superior de Saúde do Instituto Politécnico do Porto.

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Resumo

Introdução: A dor lombar é a maior causa mundial de incapacidade, que afeta uma variedade de faixas etárias. Geralmente está associada a uma alteração no controlo motor e diminuição da *endurance* dos músculos do tronco, pelo que se torna fundamental utilizar testes de *endurance* a fim de detetar essas alterações que estejam associadas à dor lombar. **Objetivo:** Analisar e detetar variações nos tempos e rácios de *endurance* dos músculos do tronco entre indivíduos com e sem dor lombar. **Métodos:** Estudo observacional transversal, com 56 voluntários para o grupo sem dor lombar, e 59 voluntários para o grupo com dor lombar. Foram utilizados testes de *endurance* dos flexores, flexores laterais e extensores do tronco e analisados os tempos de *endurance* e os rácios entre os mesmos. **Resultados:** Os indivíduos do grupo com dor lombar apresentaram tempos de *endurance* e respetivos rácios inferiores aos indivíduos do grupo sem dor lombar ($p<0,001$).
Conclusão: Indivíduos com dor lombar apresentaram valores inferiores de tempos e rácios entre si. Em indivíduos com dor lombar, alguns rácios não foram concordantes com os valores normalizados sugeridos na literatura.

Palavras-chave: Dor lombar, *endurance* dos músculos do tronco, testes de *endurance*, controlo motor

Abstract

Background: LBP is the major cause of world disability, that affect since young at elderly population. Normally it is associated with motor control changes and lower trunk muscles endurance. Trunk muscles endurance has been estimated to be harmed in subjects with low back pain, so it is an essential resort to endurance tests to detect these changes that are in relation with low back pain.

Aim: To analyze and detect variations in trunk muscles endurance times and ratios in subjects with and without low back pain.

Methods: Cross-sectional study with 56 volunteers for the without low back pain group ($NLBP_G$), and 59 volunteers for the low back pain group (LBP_G). Flexors, lateral flexors and extensors endurance tests were performed and the endurance times and ratios between tests were analyzed.

Results: Subjects of LBP group presented all endurance test times and respective ratios significantly lower than subjects of NLBP group ($p<0,001$).

Conclusion: Subjects with low back pain present lower trunk muscle endurance time and ratios. Some endurance ratios, in subjects with low back pain, weren't in agreement with the standard values suggested in the literature.

Keywords: Low back pain, trunk muscles endurance, endurance tests, motor control

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List of Abbreviations

LBP – Low Back Pain

NLBP$_G$ – Non Low Back Pain group

LBP$_G$ – Low Back Pain group

ES – Erector Spinae

IO – Internal Oblique

TrA – Transversus

MF – Multifidus

RA – Rectus Abdominis

EO – External Oblique

MRI – Magnetic Resonance Imaging

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1. Introduction

Low back pain (LBP) is the leading cause of disability worldwide, being the biggest reason for activity limitation and work absence that impose a higher economic burden and a large impact on society (Buchbinder et al., 2018; Disease, 2010; Faur et al., 2019; Goossens et al., 2019; Hall et al., 2019; Hartvigsen et al., 2018; Rossi et al., 2015). Globally, disability caused by LBP increased 54% between 1990 and 2015, being in Europe the most common cause of medically certified sick leave and early retirement (Hartvigsen et al., 2018). It is estimated that 70% to 85% of the population experience an episode of LBP and 90% of these individuals will have more than one episode, being the ranges from 21% to 75% in the elderly individuals (Faur et al., 2019; Goubert et al., 2017; Merllin et al., 2019; Meucci et al., 2015).

Some subjects with chronic LBP might have alterations in muscle size, composition and coordination (Hartvigsen et al., 2018; Laird et al., 2019). The persistent LBP also has an influence on lumbar motor control, brain function and structure, spinal mobility and compromise postural control (Correia et al., 2015; Faur et al., 2019; Goossens et al., 2019; Goubert et al., 2016, 2017; Hildebrandt et al., 2017; Hirata et al., 2015; Laird et al., 2019; Massé-Alarie et al., 2015; Mitchell et al., 2019; Pillastrini et al., 2015; Ranger et al., 2017; Rezazadeh et al., 2019; Teichtahl, Urquhart, Wang, Wluka, Wijethilake, et al., 2015). Abdominal strength and endurance have been speculated upon as a predictor of musculoskeletal pathology of the lower back and lower extremity injuries, supported that have a relation with low trunk extensors muscles endurance (Dejanovic et al., 2014, 2015; Dieen et al., 2018; Emmanuel et al., 2009; Goossens et al., 2019; Jalayondeja & Kraingchieocharn, 2015; Learman et al., 2014; Shamsi & Rezaei, 2016). Biering-Sorensen in 1984, found in men that high isometric endurance of back muscles may prevent an episode of LBP, proving to be the test with more certain to evaluate low back muscle fatigue and endurance capacity (Biering-Sørensen F., 1984; Jalayondeja & Kraingchieocharn, 2015; Rossi et al., 2015). Along with Sorensen test, Stuart McGill suggested flexor and lateral flexor endurance tests, as well ratios between them (Bayraktar et al., 2015; Dejanovic et al., 2014; Jalayondeja & Kraingchieocharn, 2015; S. M. McGill, 1998b, 1998a; S. M. McGill et al., 1999; Tong et al., 2014; Tse et al., 2010). McGill describes that endurance ratios with presence of LBP correspond for flexors and extensors at a ratio greater than 1, lower than 0,95 and higher than 1,05 between lateral muscles, and higher than 0,75 for the right or left side flexors and extensors (S. M. McGill, 1998a, 2007, 2009; S. M. McGill et al., 1999).

There was found in the literature one study comparing trunk strength and endurance times between subjects with and without LBP (Pilz et al., 2019). The results showed that individuals with LBP have higher strength scores and deep abdominal function tests but lower endurance in the lateral and frontal bridge and lumbar flexor and extensor tests (Pilz et al., 2019).

There are different methods to quantify trunk muscle strength and endurance like sitting dynamometer tests, or isometric dynamometer, but they require a lot of costs and it is not accessible to all clinical environments (Juan-Recio et al., 2017; Moreau et al., 2001). Instead, the isometric endurance tests are safe, effective, cost-effective and a reproducible clinical tool for healthy individuals and patient populations (Dejanovic et al., 2015; Juan-Recio et al., 2017; Kahraman et al., 2015; Moreau et al., 2001; Pilz et al., 2019; Rossi et al., 2015).

Therefore, it is expected that individuals with LBP will have less endurance time and ratios of trunk muscle compared to healthy individuals.

Thus, it is pertinent in this study to understand if LBP has influence in ratios and times of the endurance trunk muscles.

2. Methods

2.1. Sample

Cross-sectional study with a final sample of 115 volunteered subjects, divided in two groups: 56 subjects (44 females) for the without LBP group ($NLBP_G$), and 59 subjects (46 females) for the with LBP group (LBP_G).

The target population consisted in volunteers subjects, aged between 18 and 30 years with and without chronic non-specific LBP.

In this study, the inclusion criteria for the LBP_G were: recurrent episodes of LBP for a period greater than three months, while for $NLBP_G$ could not have experienced pain in this region (Arab et al., 2011; *Low Back Pain and Sciatica*, 2016; Silfies et al., 2005).

Were excluded subjects who had: scoliosis, discrepancy of the lower limbs or postural asymmetries, history of spinal, abdominal or gynaecological surgery in the last year, neurological disorders and/or inflammatory or cardio-respiratory diseases, pregnancy or post-delivery in the last 6 months; practice exercise for core abdominal in the last year; receiving physiotherapy treatment in order to resolve the LBP; and subjects who did regular exercise, more than 45 minutes a day, three days a week for a period exceeding one year (Chanthapetch et al., 2009; Mew, 2009; Montes et al., 2017; Pilz et al., 2019; Reeve & Dilley, 2009).

2.2. Sampling processing

ESS's students, teachers and workers (209 subjects) answered an electronic questionnaire and were volunteers to participate in this study. Following the eligibility criteria, 133 subjects were selected and divided taking into account the presence of low back pain. The final sample was composed by 59 in Low Back Pain group (LBP_G) and 56 in Non Low Back Pain group ($NLBP_G$).

2.3. Instruments

An electronic questionnaire was given to the subjects in order to be sure that every participant fulfils the selection criteria of this study, as well as to gather some sociodemographic information and LBP duration. Pain intensity in LBP_G was evaluated by using the visual analogue scale (VAS), which consist in a horizontal line with 100 millimetres, from "No pain" to "Maximal pain" written in the extremities (Boonstra et al., 2014; Carlsson, 1983; Chiarotto et al., 2018; Ferreira-Valente et al., 2011; Hawker et al., 2011).

Anthropometric measures, height (meters) and body mass (kilograms), were measured by a Seca® 222 stadiometer with an accuracy of 1 millimetre and a Seca® 760 balance with an accuracy of 1 kilogram (Seca - Medical Scales and Measuring Systems ®, Birmingham, United Kingdom), respectively.

It was also used a Baseline® bubble inclinometer (Fabrication Enterpises Inc., White Plains, New York, United States of America) to measure and verify the angle maintenance when assessing extensors muscles endurance, and a stopwatch (Casio® HS-80TW-1, Casio Electronics Co. Ltd.) to measure the holding time in all endurance tests.

2.4. Procediments

2.4.1. Data Collection Protocol

Study procedures took place in biomechanical laboratory and were performed in a controlled environment.

In order to select and characterize the sample, an electronic questionnaire was given to all the subjects and that were selected and measured and weighted. Subjects in LBP_G also pointed a cross in the line from visual analogue scale, where they thought it represented their pain intensity. The value was considered the distance, in millimetres, between the start and the cross.

All participants had to perform the endurance tests for trunk flexors, extensors and lateral flexors.

For the trunk flexors endurance test the subjects were in a sit-up position with their upper body against a wedge supported at an angle of 60º from the floor. Both knees and hips were 90º flexed, arms folded across the chest with the hands placed over the opposite shoulder, and the feet stabilized in a Swedish bars. The test started when the wedge was pulled back 10 centimetres and the subject hold the initial position as long as possible. The test stopped when any part of the subject's back touched the wedge (Exercise, 2015; S. M. McGill, 1998a, 2007, 2009, 2016).

Regarding trunk extensors, they were tested in the "Biering-Sorensen position" with the upper body out over the end of a table, while the pelvic region, distal third of the thigh and legs were stabilized with support bands. The upper limbs were held across the chest with the hands on the opposite shoulders. The test stopped when the upper body dropped from the horizontal position. Were allowed during the test oscillations between -5º to +5º, measured with an inclinometer placed over the first thoracic vertebrae (Liu et al., 2018; S. M. McGill, 1998a, 2007, 2009, 2016).

The lateral musculature was tested with the subject lying in the full side-bridge position. Legs were in extension, and the top foot was placed in front of the lower foot for better support. Subjects support themselves with the lower arm under the shoulder and on their feet while lifting their hips off the floor to create a straight line over their body length while the upper arm held across the chest with the hand placed on the opposite shoulder. The test stopped when the subject lost the straight-back posture and the hip returned to the ground (S. M. McGill, 1998a, 2007, 2009, 2016; S. M. McGill et al., 1999).

The order of assessment was random, and there was 15 minutes resting interval between tests. The tests duration was registered in seconds and these values were used to calculate the ratios between flexors/extensors; right lateral flexors/left lateral flexors; right lateral flexors/extensors; and left lateral flexors/extensors.

3. Statistics

The descriptive and inferential statistical analysis of the data, was performed using the statistical program *IBM SPSS Statistics®* version 20 (IBM Corporation®, New York, United States), with a confidence interval of 95% and a significance level of 0,05 (Marôco, 2018).
Normality test was applied followed by parametric T-test for independent samples for group comparison (Marôco, 2018).

4. Ethics

The study was conducted in accordance with the declaration of Helsinki and awaits approval of the Institutional Research Ethics Committee. Each individual provided written informed consent before participation.

5. Results

The sample was selected by the following diagram (**Figure 1**):

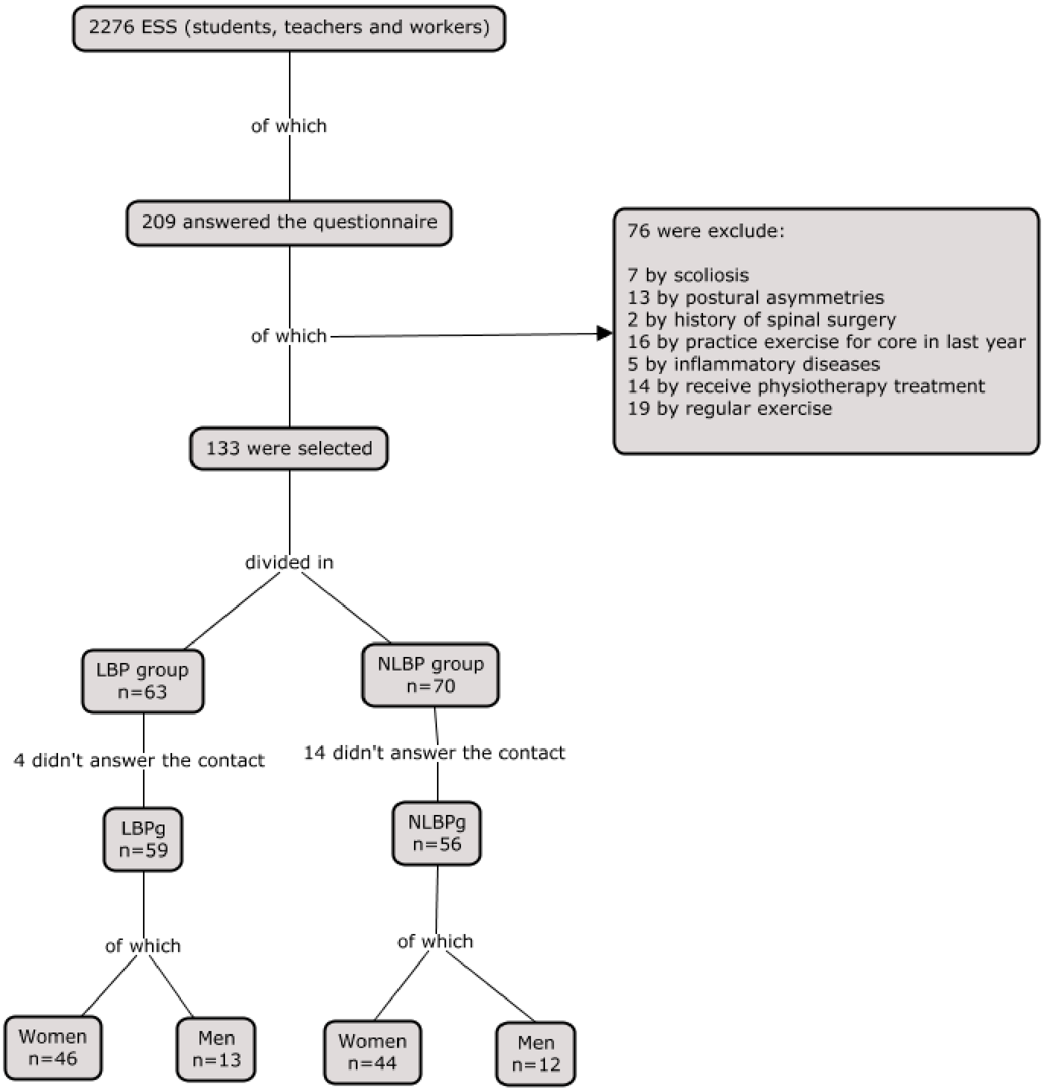

Figure 1. Sample selection diagram

In relation to weight and height, no statistically significant differences were observed between groups. While when it comes to age, statistically significant differences were found, although, the average difference was only 1 year so the groups were considered comparable. Demographic, anthropometric data, pain duration and intensity are presented in **Table 1**.

Table 1. Sample characteristics: demographic and anthropometric data of both groups and pain duration and intensity for LBP_G with the respective mean values, standard deviation (SD), test value (t) and p value ($NLBP_G$ – Non Low Back Pain group; LBP_G – Low Back Pain group)

	Age (Years)		**Body Mass** (Kg)		**Height** (m)		**Pain Duration** (Years)	**VAS Pain Scores** (mm)
	$NLBP_G$ (n=56)	**LBP_G** (n=59)	**$NLBP_G$** (n=56)	**LBP_G** (n=59)	**$NLBP_G$** (n=56)	**LBP_G** (n=59)	**$NLBP_G$** (n=56)	**LBP_G** (n=59)
Mean	23.60	24.66	61.49	62.23	1.66	1.67	7.50	53.70
SD	2.06	2.07	8.62	7.88	0.08	0.08	1.67	6.63
Minimum	21.00	22.00	51.80	52.30	1.58	1.58	5.00	36.00
Maximum	9.00	30.00	81.50	81.50	1.85	1.85	11.00	62.00
t-test	**-2708**		**-0.472**		**-0.351**			
p-value	**0.008**		**0.638**		**0.726**			

The comparison between groups showed that subjects of LBP_G had significantly lower endurance in left and right extensors, flexors and lateral flexors than subjects of $NLBP_G$ ($p<0,001$). The same was found in endurance ratios, specifically for flexors/extensors ($p<0,001$); right lateral flexor/left lateral flexor ($p=0,001$); right lateral flexor/extensors ($p<0,001$) and left lateral flexor/extensors ratios ($p<0,001$) that are presented in **Table 2**.

The LBP_G had all inferior ratios compared to $NLBP_G$, but the left lateral flexors/extensors ratio was similar to the $NLBP_G$, with a value of 0,46 to 0,53, as well as lateral flexors ratio (LBP_G – 0,91; $NLBP_G$ – 0,95).

Table 2. Endurance times and ratios between group comparisons ($NLBP_G$ – Non Low Back Pain group; LBP_G – Low Back Pain group).

			Mean	Standard Deviation	t-test	p value
Endurance Time (in seconds)	Extensors	$NLBP_G$ LBP_G	139.81 34.21	34.69 7.83	21.471	< 0.001
	Flexors	$NLBP_G$ LBP_G	120.60 24.17	25.16 7.02	26.737	< 0.001
	Right lateral flexors	$NLBP_G$ LBP_G	72.03 14.00	23.75 3.63	17.440	< 0.001
	Left lateral flexors	$NLBP_G$ LBP_G	75.62 15.47	25.03 3.85	17.751	< 0.001
Endurance Ratios	Flexors/Extensors	$NLBP_G$ LBP_G	0.87 0.72	0.07 0.16	7.064	< 0.001
	Right lateral flexors / Left lateral flexors	$NLBP_G$ LBP_G	0.95 0.91	0.04 0.09	3.462	0.001
	Right lateral flexors / Extensors	$NLBP_G$ LBP_G	0.51 0.42	0.08 0.09	5.601	< 0.001
	Left lateral flexors / Extensors	$NLBP_G$ LBP_G	0.53 0.46	0.09 0.11	3.886	< 0.001

6. Discussion

The aim of this study was to understand the influence of low back pain by comparing trunk muscles endurance times and ratios in subjects with and without LBP.

Throughout this study, it was found that individuals with LBP had lower endurance time of all trunk muscle groups evaluated, which is in agreement with the literature (Correia et al., 2015; Denadai et al., 2017; Durall et al., 2012; Learman et al., 2014; Martinez-Valdes et al., 2019; Pilz et al., 2019; Rossi et al., 2015).

The literature reports that subjects with LBP, have an absent or delayed activation of the deep abdominal muscles such as erector spinae (ES), internal oblique (IO), transversus (TrA) and multifidus (MF), but the superficial muscles are more variable, more often activity is increased (Dieen et al., 2018; Hodges, 2019; Mannion et al., 2008; Massé-Alarie et al., 2015; Osuka et al., 2019). The global muscles like rectus abdominis (RA) and external oblique (EO) produce a larger torque on the spine, but are the local muscles that have a greater contribute to control inter-vertebral motion to provide inter-segmental stability, like TrA and IO (Denadai et al., 2017; Hodges, 2019; Ko & Song, 2018; Massoud et al., 2017; Mitchell et al., 2019; Shamsi & Rezaei, 2016). The coactivation of local stabilizers such as MF and TrA increases intervertebral stiffness creating the conditions for superficial muscles to perform spinal movement (Hildebrandt et al., 2017; Mitchell et al., 2019). If the recruitment strategies change in subjects with LBP, an global activation to compensate occurs, leading to an increase of stability, restrict spinal motion and function (Goubert et al., 2017; Hildebrandt et al., 2017; Mitchell et al., 2019).

In order to protect and attach stability of the lumbar spine, there is an increase activation of the global muscles, which will cause a load on the spine, resulting in dreamer pain and therefore a higher risk of injury (Hodges, 2019). A systematic review on reactive trunk motor control concluded that delayed onset or offset of muscle activity was found in subjects with and without LBP (Prins et al., 2018). Delayed offset of activity of the abdominal muscles following release of a load into trunk extension, has been associated with greater risk for a new episode of LBP (Dieen et al., 2018). This information shows a possible role of motor control changes in the development or recurrence of pain (Dieen et al., 2018).

Some authors identified changed patterns of elasticity and CSA in MF (Chan et al., 2012). The stiffness was higher in individuals with LBP at 25° and 45° with forward stooping positions (Chan et al., 2012; Goubert et al., 2017; Hildebrandt et al., 2017; Ranger et al., 2017). Other authors didn't found significant difference in muscle activity between subjects with and without LBP (Lothe et al., 2019). Another studies revealed that subjects with LBP have different muscle activation between the synergy muscles group (Leung et al., 2019; Wattananon et al., 2019). Based on these facts, they hypothesized that it is unlikely that muscle properties and pain level aren't associated, being more strongly linked when the pain is during movement (Leung et al., 2019).

In search of understanding those activation patterns, with association with rapid movement of the upper and lower limbs, there are studies with different results (Dieen et al., 2018). Some studies reported late activation of TrA and MF in individuals with LBP (Dieen et al., 2018; Massé-Alarie et al., 2015). In contrast, another study showed no differences and two studies showed earlier activation of the oblique muscles in LBP (Beaulieu et al., 2014; Dieen et al., 2018).

A model for spinal stability was described, that consists in spinal control, spinal muscles and neural control unit that together create optimal spinal flexibility and dynamic stability (Hildebrandt et al., 2017). In presence of LBP, inhibition of neural control occurs, that prevents alfa motor neuron activity horn of the spinal cord and inhibits activity of MF (Hildebrandt et al., 2017; Massé-Alarie et al., 2015). That continuous process leads to changes in neuromuscular control that becomes chronic and can probably result in atrophy of MF, and in consequence, lead to instability (Hildebrandt et al., 2017; Pillastrini et al., 2015; Ranger et al., 2017; Rossi et al., 2015; Wan et al., 2015). Neuromuscular control is essential to produce strength during the performance of motor tasks and posture maintenance (Rossi et al., 2015). Subjects with LBP have a strategy to compensate the postural imbalance appealing to abdominal muscles, and using posterior trunk muscles during isometric extension to have force production capacity and maintain spinal stability (Rossi et al., 2015).

The main mechanisms for muscle atrophy are disuse, muscle denervation and reflex inhibition (Faur et al., 2019; Hodges et al., 2019). Signs of denervation are associated with paraspinals and are common in disc herniation and nerve root compression (Faur et al., 2019; Hodges et al., 2019).

The MF is specially important in case of LBP because it is exclusively innervated by the medial ramus of the dorsal root of the spinal nerve, without nerve supply, contrary to the other spinal muscles (Faur et al., 2019; Goubert et al., 2016; Pillastrini et al., 2015; Wan et al., 2015). After pain appears, a combination of reflex inhibition and disturbance in coordination of trunk muscles causes changes in MF structure and has the most effect at the lower levels (Goubert et al., 2016; Hodges et al., 2019; Pillastrini et al., 2015; Ranger et al., 2017; Rummens et al., 2019).

Injury or nociception can get directly involved with motor control as it can change excitability of motor pathways and have a role in the changes in muscle activation in presence of LBP, and obviously affect proprioceptive afference which cause lack of precision in the control trunk movement (Dieen et al., 2018; Emmanuel et al., 2009; Swain & Redding, 2014). There are modifications observed in LBP in sensory cortex, motor cortex, reduced corticomotor excitability, structural changes such evidences of presence of fat, connective tissue infiltration and fibrosis, so the lumbar spine intersegmental stabilization is compromised (Dieen et al., 2018; Emmanuel et al., 2009; Goubert et al., 2016; Hildebrandt et al., 2017; Hodges, 2019; Pillastrini et al., 2015).

It has been assumed that dysfunction of the paraspinal muscles leads to pain inhibition that cause fatty infiltration of the MF (Dieen et al., 2018; Faur et al., 2019; Goubert et al., 2016; Hildebrandt et al., 2017; Hodges et al., 2019; Pillastrini et al., 2015; Rezazadeh et al., 2019; Teichtahl, Urquhart, Wang, Wluka, Sullivan, et al., 2015; Wan et al., 2015). Normally, the presence of fat in MF is 14,5% and in subjects with LBP it can be higher than 23,6% and around 80% of these individuals have an increase of fat infiltration between levels L2 to L5 (Fortin & Macedo, 2013; Hildebrandt et al., 2017). Another study shows in transverse MRI scans of the lumbar spine that the major percentage of atrophy of MF is higher in the lower levels as L5-S1 (Faur et al., 2019). This facts explain the changes that occur mainly in MF and contributes to a decrease in the flexion range of motion of the lumbar spine (Fortin & Macedo, 2013; Hildebrandt et al., 2017).

In acute phase of LBP, the activation of MF depends of the task, but the neural mechanism is a inhibition of the spinal reflex and greater descending unit, that can cause a decrease in MF activation and has a protective strategy increase in the activation of the ES (Dieen et al., 2018; Freeman et al., 2010; Hodges, 2019; Martinez-Valdes et al., 2019; Wan et al., 2015). In subacute phase muscle inflammation sets in, deep MF is delayed, in spite of CSA recover, fat deposits become much greater, with presence of fibrosis and fast fibers turns into slow fibers (Hodges, 2019; Teichtahl, Urquhart, Wang, Wluka, Sullivan, et al., 2015). When the LBP becomes chronic, some studies show different things as a reduced CSA and atrophy of the ES and MF, or other muscles as psoas and quadratus lumborum, having more fat infiltration on the first muscles (Hodges, 2019; Wan et al., 2015). There is no evidence of the correlation between time of the pain and fibers type I, but there is a positive correlation with the fibers type II (Hodges, 2019). This information proves that the function of the MF is compromised, leaving the spine in a fragile state (Hodges, 2019).

The healthy individuals have more fibers type I in paraspinal muscles than other muscles (Goubert et al., 2016). This facts show that with these changes, in a case of chronic LBP that could lead to lowered fatigue endurance of the paraspinal muscles that compromises the lumbar spine (Adedoyin et al., 2011; Goubert et al., 2016; Rezazadeh et al., 2019; Wan et al., 2015).

A magnetic resonance imaging (MRI) study showed that paraspinals and MF fat is associated with high-intensity LBP, and fat replacement of ES was associated with reduced intervertebral lumbar disc (Teichtahl, Urquhart, Wang, Wluka, Wijethilake, et al., 2015).

Animal models carry sustained low load compression as a cause of intervertebral disc degeneration, allegedly due to disrupted fluid flow into and out of the disc (Dieen et al., 2018; Paul et al., 2013). In studies with humans, during the recovery after exercise, was observed that in LBP the water capture to the intervertebral discs was lower and was correlated to trunk muscle activity during rest (Dieen et al., 2018). This suggests that sustained muscle contractions in individuals with LBP have an adverse effect on disc (Dieen et al., 2018).

Thus, if local muscles are weak and dysfunctional, during the endurance tests the spine stabilization is promoted by global muscles (Hodges, 2019). These muscles have the responsibility to assure the mobility, are composed manly by fibers II, that have lower endurance during endurance test times in subjects with LBP (Hodges, 2019).

One study that evaluate trunk endurance time in individuals with and without LBP, have similar endurance ratios when compared with the present study (Pilz et al., 2019).

A study in Chinese adults was done, with application of plank, side plank and Biering-Sorensen test, and the results between group with and without LBP weren't different, however, they presented a combination of the endurance times of less than 288 seconds for the four tests to differentiate participants with an history of LBP (Liu et al., 2018). Already, a study with athletes, with non-specific LBP and healthy, demonstrated lower endurance in subjects suffering from LBP in the same tests as the present study (Abdelraouf & Abdel-aziem, 2016).

McGill has developed trunk muscle endurance ratios by dividing any trunk endurance time by extensor endurance time to determine trunk muscle imbalance between extension-flexion and right-left lateral flexion (Bayraktar et al., 2015; S. M. McGill, 1998a, 2009; S. M. McGill et al., 1999). The side position has been shown to optimally challenge quadratus lumborum, as well oblique muscles and lumbar paraspinal with little psoas activity (Bayraktar et al., 2015; Correia et al., 2015; Swain & Redding, 2014). A variety of studies show that RA activity would be greater in a prone position than side position and oblique muscles and lumbar paraspinal activity will be the opposite (Czaprowski et al., 2013; Durall et al., 2012; Ekstrom et al., 2008; Escamilla et al., 2016; Teyhen et al., 2008; Youdas et al., 2014).

Different authors found that isometric endurance is more dominant then strength, when the spine stability is considered, and endurance deficits were more strongly associated with having recurrent LBP (Emmanuel et al., 2009; S. M. McGill et al., 2003).

The Biering-Sorensen test is a reliable predictor of LBP as well as a robust discriminator (Adedoyin et al., 2011; Applegate et al., 2018; Jalayondeja & Kraingchieocharn, 2015; Pilz et al., 2019). In one study was demonstrated significant hip extensor fatigue during the test, showing that paraspinals and hip extensors share the workload, and in presence of LBP the activity of paraspinals were lower than hip extensors (Applegate et al., 2018). This fact proves the dependence of hip extensors in this test and how the paraspinals are affected under this condition (Applegate et al., 2018).

Another study shows that are direct relationships of muscle fatigue with the isometric endurance of the paraspinals and endurance time on Biering-Sorensen test (Rossi et al., 2015). Chronic LBP can be related with proprioceptive dysfunction due to disability of the paraspinal muscles feel the changes of the lumbar position (Rossi et al., 2015; Swain & Redding, 2014).

The results of this study show that who suffer LBP had all inferior ratios compared to $NLBP_G$, being the values of flexors/extensors ratio (0,72±0,16) different from the values of Stuart McGill (greater than 1 with LBP) (S. M. McGill, 1998a, 2007, 2016). Stuart McGill mentioned about the ratios normalized the trunk extensor endurance test as 1 for extensor, 0,99 for flexors and 0,64 for right/left side bridge for males and 1 for extensor, 0,79 for flexors and 0,38 for right/left side bridge for females (S. M. McGill et al., 1999). He confirm that for the LBP_G the ratio is higher than 1, that is consequence of a marked decrease of both trunk flexors and extensors, but in similar proportions (S. M. McGill, 2009, 2016). On LBP_G the lateral flexors/extensors ratios were also differed from the proposed that instead of being higher then 0,75, was similar to the $NLBP_G$ with a value close to 0,5, as well as lateral flexors ratio that was almost the same (LBP_G - 0,91; $NLBP_G$ - 0,95) (S. M. McGill, 1998a, 2007, 2009, 2016). The lateral flexors ratio of subjects with LBP and all ratios for healthy subjects were in agreement with this author. Stuart McGill showed that those with pain had less back extensor endurance when expressed as a ratio with flexor endurance, when compared with those performing the same job and without pain (S. McGill et al., 2003).

A study in healthy tennis players and with LBP, showed higher values in flexor test, side bridge and extensor test, but only the flexor test and right side bridge achieved a significative difference when compared with players that have LBP (Correia et al., 2015). For holding the position and increase stability, the asymptomatic players appeal an agonist-antagonist activation (Correia et al., 2015; Hirata et al., 2015). On the other hand, symptomatic players inhibited extensor muscle activity in order to avoid painful contraction and achieve higher endurance time (Correia et al., 2015). Thus, individuals with LBP showed lower activation of extensor muscles, less co-contraction patterns and less abdominal resistance, consistent with the results of the present study (Correia et al., 2015). Was also verified similar results in a study that evaluate the rate of force development and the rate of electromyography rise of global and local trunk muscles in women with and without LBP (Denadai et al., 2017). The control group presented greater activation amplitude for both agonist and antagonist trunk muscles, mainly the global ones and the symptomatic women showed lower rate of force development and it was correlated to a reduced capacity of rapid muscle activation mainly in the trunk extensor musculature (Denadai et al., 2017).

Over the years, there are a variability of authors that establish some relations around LBP that support the answers and some results of this study.

Some authors found that who has a decreased of static endurance have more probably of intolerance to LBP (Andersen et al., 2006; Biering-Sørensen F., 1984; Dejanovic et al., 2014; Evans et al., 2007; S. M. McGill, 2007; S. M. McGill et al., 1999; Pereira et al., 2011; Smith et al., 2010). Others support that adolescents share relationships between LBP and trunk endurance when they become adults (Dejanovic et al., 2014). In adolescents with an age between 11 and 19 years, lower endurance and increase lumbar mobility might have influence in spine stability and consequently LBP (Dejanovic et al., 2014; Johnson et al., 2009; Sjolie & Ljunggren, 2001). Was reported yet that high ratios difference between trunk flexion and back extension might be a predictor of LBP in adolescents (Dejanovic et al., 2014).

This is the first study to provide trunk muscles endurance times and ratios in subjects with and without LBP in a portuguese population.

No sample size determination was considered a study limitation, yet it was found statistical differences in all variables. It is still necessary to conduct a longitudinal study to assess whether a motor control exercise program is able to counteract the differences between the groups with and without LBP with regard to trunk muscles endurance times and ratios.

7. Conclusion

In this study it was recognized that subjects with low back pain presented lower trunk muscle endurance and inferior endurance ratios. Some of the endurance ratios in subjects with low back pain weren't in agreement with the standard values referenced by Stuart McGill.

In order to achieve better and specific results, a longitudinal study should be done with application of a motor control exercise program to neutralize the differences between the groups with and without LBP with regard to trunk muscles endurance times and ratios.

8. References

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