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Reliability of the endurance test for the erector spinae muscle

Confiabilidade do teste de resistência dos músculos eretores espinhais

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Abstract

Introduction: The low resistance of the erector spinae has been seen as a risk factor for developing chronic low back pain. The test of the erector spinae muscle endurance advocated by Biering-Sorensen has been used to assess the strength of the erector spinae muscle. Modifications of the measuring instrument require reliability studies. **Objective:** To evaluate the measurement of the erector spinae muscle endurance and the standard error of measurement (SEM) of the modified Biering-Sorensen test of erector spinae in women with chronic low back pain. **Methods:** Forty-eight sedentary women, aged 52 ±7, suffering from chronic low back pain, were tested. The position adopted was the prone position without the trunk on the examining table. Fixations were performed with straps at the ankles, knees and pelvis. The patient was instructed to maintain the shoulder blades in contact with the stadiometer as long as possible. The measurement was repeated, with measures 15 minutes apart. **Results:** Considering the confidence limits of Bland & Altman, - 40 and 68 seconds, the SEM was13 seconds and SEM% was 22. The ICC = 0.87 with p = 0.001. The first test was equal to 54 ± 36 seconds, and the retest = 67 ± 40 seconds. **Conclusion**: The endurance test of the erector spinae showed moderate reliability. Therefore, we suggest that, despite its applicability in clinical practice, the results should be interpreted carefully because the differences in mean erector spinae endurance of up to 13 seconds may be related to measurement error.

Keywords: Spine. Reproducibility of results. Posture. Physical endurance.

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Resumo

Introdução: *A baixa resistência dos eretores espinhais tem sido visto como um fator de risco para desenvolver dor lombar crônica. O teste de resistência muscular preconizado por Biering-Sorensen tem sido utilizado na avaliação desses músculos. Modificações do instrumento de medida necessitam de estudos de confiabilidade.* ***Objetivo:*** *Avaliar a confiabilidade da medida de resistência muscular dos eretores espinhais e, o erro típico da medida (ETM) do teste de resistência Biering- Sorensen modificado em mulheres com lombalgia crônica.* ***Materiais e Método:*** *Quarenta e oito mulheres, com idade 52 ± 7 anos, portadoras de dor lombar crônica foram testadas. O posicionamento adotado foi o decúbito ventral com o tronco fora da maca. Foram realizadas fixações com cintos nos tornozelos, joelhos e pelve. A paciente era orientada a manter o contato das escápulas com um estadiômetro o maior tempo possível. A medida foi repetida após 15 minutos de intervalo.* ***Resultados:*** *Considerando os limites de confiança de Bland &Altman de – 40 e, 68 segundos, o ETM foi de 13 segundos e o ETM% = 22. O CCI = 0,87 para P = 0,001. O primeiro teste foi igual a 54 ± 36 segundos, enquanto que o reteste foi de 67 ± 40 segundos.* ***Conclusão:*** *O teste de resistência dos eretores espinhais apresentou uma moderada confiabilidade. Portanto, sugerimos que apesar de sua aplicabilidade na prática clínica, os resultados devem ser cuidadosamente interpretados, pois diferenças de médias de resistência até 13 segundos podem estar relacionadas ao erro da medida.*

Palavras-chave*: Coluna vertebral. Reprodutibilidade dos testes. Postura. Resistência física.*

Introduction

The erector spinae muscles play an important role in the upright posture of the individual (1). With modern living, every day, the spine has been burdened by the constant demand of inappropriate postures, demanding a search for the understanding of how these muscles behave in these situations (1, 2).

The low resistance of the spinal erector has been seen as a risk factor for developing chronic low back pain (2 - 4). Back pain has affected up to 85% of people at some moment in their lives, leading to high levels of functional limitation, causing absence from work, compromising the quality of life and, thereby, increasing the need for medical care (5).

There are some ways to measure the resistance of the erector spinae through static or dynamic tests (4, 6 - 8). The dynamic tests performed on isokinetic dynamometers allow the evaluation of the maximum voluntary contraction, often by analyzing the peak torque (6, 7). The static tests aim to evaluate muscle fatigue, by the ratio exerted of the holding time in the static posture (2). Despite the fact that isokinetic machines are considered the gold standard in measuring the resistance of the erector spinae, the high cost of these appliances, as well as difficulties for transportation and operationalization, hamper the use of such equipment in the clinical setting. Therefore, the static tests appear to be a more viable and cost-effective way for measuring the muscle resistance of the erector spinae.

An isometric endurance test that has proven to e valid and reliable is the test developed by *Biering-Sorensen* (2, 3). The test consists of measuring the time that the individual is able to maintain his trunk in a horizontal and prone position against the action of gravity. This position is held with the trunk of the individual free over the table, with the iliac crests aligned on the edge of an examining table, and the ankles, knees and buttocks fixed to the table by straps. An inclinometer is positioned in the interscapular region by an evaluator in order to observe variations above 10° in the sagittal plane. When these variations occur, the test is stopped.

Biering-Sorensen (3) obtained an intraclass correlation coefficient (ICC) of 0.85 for inter-evaluator testing. However, such reliability was obtained from a heterogeneous sample, with the participation of men and women, and wide-ranging age between 20-60 years (3).

Gruther et al (4) also conducted a reliability and accuracy test for endurance of the erector spinae, comparing the static test with the dynamometry in the isokinetic. Despite the excellent reliability found, with ICC equal to 0.93, the authors adopted only the criteria of fatigue and/or pain for the loss of the horizontal position, and therefore the test interruption.

The reliability of the measure is subject to several variables, such as the tool, evaluator and the subject tested (9). Reliability studies are important to provide the individual variations of the sample, test and systematic errors (9). In previous studies of reliability, the parameter for test interruption was the presence of fatigue and/or pain, or a 10º variation of inclinometer, which is not an instrument easy to obtain. Furthermore, the samples showed heterogeneity of gender and age.

This study proposes a more homogeneous sample, in terms of age and only women with nonspecific chronic low back pain; and modifications in the *Biering-Sorensen* test (3), replacing the inclinometer with a stadiometer. This apparatus, in addition to being inexpensive and easy to obtain, allows for the individualization of a parameter of the upper limit of its horizontal position.

Therefore, the aim of this study was to evaluate the intraday and intrarater reliability of endurance measurement of erector spinal muscle, and the standard error of measurement (SEM) of the modified *Biering-Sorensen* test for women with chronic, nonspecific low back pain, between 45 and 60 years old.

Material and Method

Study design

The study was performed using a test-retest design, separated by 15-minute intervals. The participants received instructions on the test and previewed a photo showing the position that would be adopted.

Sample

Forty-eight sedentary women, aged 52 ± 7 years, body weight 73 ± 13 kg and height 1.57 ± 0.05 m, with chronic low back pain (24 months) and functional limitation of 12 ± 3 were tested. All participants signed the Terms of Free and Informed Consent form.

The following inclusion criteria were used in the study: a) low back pain with a score between 3-7 points (according to the numeric pain scale of 0 - 10, where 0 means no pain and 10 is maximum pain (10); b) pain present for more than twelve weeks; c) pain of unspecified origin; d) functional limitation with a score between 8 and 15 points, according to the *Rolland Morris* Scale (11).

The exclusion criteria adopted were: a) pain from tumors; b) rheumatic diseases; c) surgery in the lumbar spine; e) cardiovascular and neurological diseases.

This study was approved by the Ethics Committee of the Gama Filho University, under CAAE number 0119.0.312.000-11, Protocol 171-2011.

Biering- Sorensen test for muscular endurance of the spinal erector

The positioning adopted was the prone position, with the trunk placed beyond the table edge, with the alignment of the anterior superior iliac spine with the edge of the table. Ankles, knees and pelvis were fixed with straps to the examining table. While these fixations were made, the patients maintained her forearms resting on a bench in front of her.

The horizontal position was adopted, and the patient was advised to keep her shoulder blades in contact with a stadiometer, which was parallel to the ground. She was guided to maintain the upper limbs crossed and in contact with the chest, with each hand touching the contralateral shoulder (Figure 1). Once positioned, a timer was triggered and the evaluator guided the patient to remain in that position as long as possible. The timer was stopped when the patient's shoulder blades lost contact with the stadiometer. Retesting was performed after a 15-minute interval. This range was adopted so that test performance was not affected by muscle fatigue (12).

Figure 1 - Positioning of patient during the modified *Biering- Sorensen* endurance test of the spinal erector

Data analysis

The normal distribution of the measurements was verified using the Shapiro-Wilk test (13). The confidence limits of Bland and Altman were determined (14), the intraclass correlation coefficient and the relative and absolute typical (standard) error of measurement (SEM) were calculated. The SEM was calculated using the ratio of the standard deviation (SD) of the differences obtained from the pairs of measurements, and the square root of the number two ($SEM = SD / \sqrt{2}$), according to the equation proposed by *Hopkins* (13). Statistical analyses were performed using SPSS software, version 17. A significance level of $p \leq 0.05$ was adopted.

Results

The test was equal to 54 ± 36 seconds, while retest was equal to 67 ± 40 seconds. Considering the confidence limits of Bland and Altman (14) of -40 to 68 seconds, the SEM was 13 seconds and the SEM% was 22. The ICC was equal to 0.87 for p = 0.001 (Table 1) (Figure 2).

Table 1 - Mean, standard deviation, intraclass correlation coefficient absolute and relative standard error of measurement of the erector spinal endurance test

	Mean and sd (s)	ICC	P	SEM (s)	SEM %
Test	54 ± 36	0.87	0.001	13	22
Retest	67 ± 40				

Note: ICC = interclass correlation coefficient; SD = standard deviation; SEM (s) = absolute standard error measurement; SEM =% relative standard error measurement

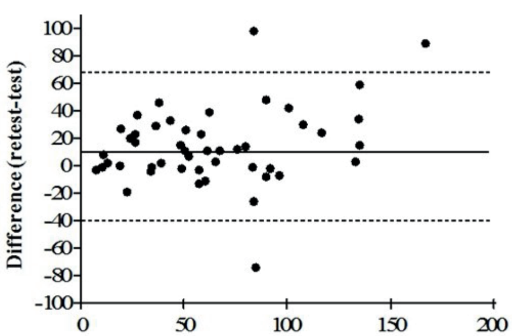

Figure 2 - Bland-Altman Confidence limits for test and retest of the endurance measurement of the spinal erector

Discussion

The results of this study indicated that the modified Biering-Sorensen test presented moderate intra-rater reliability, measured in women with nonspecific chronic low back pain. This result was similar (Table 1) to that observed by Moffroid et al (6), which obtained an ICC equal to 0.82 after evaluating 35 subjects, aged between 20 and 60 years, with chronic low back pain. Despite the similar ICC, the heterogeneous sample selection should be considered. In this study, the authors selected 14 men and 18 women, of which, seven were classified as active and 22 inactive. There was still a sub-classification for obese individuals. According to the authors, there was no significant difference between gender, obesity, or between active and inactive.

Latimer et al (3) did not find significant differences between subjects sub-classified as active and inactive. The authors evaluated 63 subjects, classifying them into three categories: those with chronic low back pain at the moment of evaluation, those who had experienced back pain at some point in life, and the asymptomatic. Small differences in reliability were found in the subgroups. The group of patients with low back pain had the best reliability, with ICC of 0.85; in those who had previous pain, the ICC was equal to 0.77, and the asymptomatic group presented an ICC equal to 0.83. Together, the three groups had an ICC of 0.85. This also shows a very similar reliability to this study.

The mean time of erector spinae endurance in healthy subjects is approximately three minutes (16). Some studies have attempted to establish a relationship between the endurance found in the test and the relative risk of developing chronic low back pain. Luoto et al (17) conducted a prospective study with 126 subjects without low back pain. After one year, the authors found a three times higher risk of developing low back pain in the subjects who had a test with values less than 58 seconds. Other tests were conducted by Nicolaisen et al (18) and Hultman et al (19). The authors found that when the results of the test were less than 85 ± 41 seconds, at least one episode of back pain was associated. However, those who could maintain the position for more than 150 seconds did not present back pain. For this explanation, Hultman et al (19) found significant differences in the measurement, in millimeters, in the thickness of the spinal erector for patients with low back pain.

The evaluation of the maximum voluntary contraction, through the exhaustion test, allowed De Vries (20) to conclude that muscle strength is directly related to disorders of the lumbar spine. The conclusion of this study was that when a muscle is not fatigued, the determination of maximal voluntary isometric contraction, by traction on a load cell, is unquestionably related to its basic physical capacity, while in a fatigue situation, there is reduction in the values of maximum voluntary isometric contractions obtained after exhaustion test in relation to the values achieved prior to its realization .

These observations on the quantitative assessment of the erector spinae endurance provides a great value in the clinical setting from the *Biering-Sorensen* test (3). This is critical, considering that the gold standard test for such evaluation is performed with an isokinetic dynamometer, whose high cost hinders its diffusion in the clinical setting. Gruther et al (4) found a strong reliability of the *Biering-Sorensen* test (ICC equal to 0.93), very close to the dynamometry test for isokinetics (ICC equal to 0.89). This analysis was completed after the evaluation of 32 patients, aged 18-60 years, where individuals were also divided into groups of patients with or without chronic low back pain. The authors, in addition to reliability, were able to establish a relationship between the lower endurance time, or lower peak of torque of the erector spinae, with low back pain.

This relationship between time and back pain was not found in the study by Pitcher et al (21). Nevertheless, the authors found good reliability for the electromyography (EMG) test in all six explored sites. An interesting observation found in this study (21), is that the electrodes placed bilaterally in the femoral biceps, showed greater fatigue in subjects who had low back pain, which can be explained by the synergistic effect of the muscles used in the extension of the trunk (20). Many strategies for the muscular replacement pattern for better motor control may be used during a low intensity fatigue test to maintain a desired static posture (23, 24). These changes in fatigue of the biceps femoris and also the gluteus medius, along with the lumbar extensors, already observed in previous studies (22 – 24, 25) should be considered. Therefore, this fact challenges the *Biering-Sorensen* test, that intended specifically to evaluate the muscle fatigue of the erector spinae (3).

Differences between genders were found in the study conducted by Ito et al (8). Among 190 subjects tested, 113 were women, of whom 60 were symptomatic for low back pain (35-48 years). The women remained in the test position for 70.1 ± 51.8 seconds, vs. 85.1 ± 55.6 seconds for men. For healthy men, it was possible to reach an upper limit of 208.2 ± 66.2 seconds as compared to a maximum of 128.4 ± 53/2 for healthy women. The ICC of 0.97 for asymptomatic subjects, and ICC of 0.93 for patients with low back pain, was the best of all studies. Note that a different position than that described by *Biering-Sorensen* (3) was adopted. In this proposal, the subject laid down in a prone position on the floor, with a pillow placed under the abdomen, and was asked to maintain the lumbar extension as long as possible without any fixation.

Gender variation was found in other research evidence (26). However, the differences can be explained by muscle, anatomical and functional characteristics of these muscles. Differences from the cross-sectional area of the fibers resistant to type I fatigue were present in 73% of women, versus 56% of men (27).

The need to study the reliability of the test of the erector spinae was driven, not only by cost effectiveness, but also to identify a test that could assist in the quantitative assessment of fatigue, rather than the subjective complaints reported by patients. In this study, quantification of the SEM of 13 seconds confirms the need to consider the clinical significance only for larger changes in the SEM. This enables us to eliminate the interference caused by evaluator inaccuracy and biological measurement variability. The confidence limits of *Bland and Altman* (14) (Figure 2) showed that the error obtained in this modified *Biering-Sorensen* test was homoscedastic, namely, the error does not change according to the worst or best test results.

A limitation of this test, also reported by other authors (4, 6, 28, 29), is that the reliability of the measure seems also to be subject to individual motivation, due to the fact that the subject can voluntarily control the movements. As the present study did not control for emotional or motivational variables, such as fear of performing the test or of increasing the pain, this factor may have affected the variability of the measure. Another limitation of this study was that it a familiarization test was not conducted, which could have generated learning effects upon retest.

It is believed that, after an episode of back pain, a rapid atrophy of erector muscles in the lumbar spine occurs, and that it persists even after regression of the symptoms (30). With strength and isometric resistance exercises directed at these muscles, the atrophy is reversible, and the recurrence of low back pain is reduced. Therefore, the proposal of protocols to assess the strength and isometric resistance of the erector muscles of the spine seems to be very useful, enabling a more precise intervention in training programs for the prevention or rehabilitation of low back pain.

To summarize, according to the results described, the modified *Biering-Sorensen* test can be a good alternative for clinical follow up of subjects with and without low back pain, for monitoring the muscular endurance of the erector spinae. Moreover, the test is simple to perform, inexpensive, and does not require special or sophisticated equipment.

Conclusion

The modified Biering-Sorensen test showed a moderate reliability for measuring endurance of the erector spinae. Therefore, despite its applicability in clinical practice, the results must be carefully interpreted, as differences in mean muscle endurance of up to 13 seconds may be related to measurement error.

Conflict of Interest

The principal researcher and other researchers of this study declare that we have no conflicts of interest.

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