



# The trunk extensor flexor relationship in men and women by isokinetic dynamometry

## Relação flexores extensores de tronco em homens e mulheres pela dinamometria isocinética

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### ABSTRACT

**Introduction:** The thoracolumbar musculature plays a key role in the balance and stability of the pelvis. The isokinetic dynamometer provides accurate assessment of muscle performance and treatment guidance. **Objective:** To compare the flexors / extensors of the trunk link between sedentary men and women, asymptomatic by isokinetic dynamometry. **Method:** An observational cross-sectional study. The sample consisted of 100 asymptomatic sedentary volunteers, 50 males and 50 females with a mean age of  $22.2 \pm 3.3$  years. The collection was made in the center of isokinetic dynamometry of the university gym. The Cybex Norm isokinetic dynamometer Model 7000™, trunk module was used. The subjects were weighed and measured, made global warming a 5 minutes cycle ergometer unloaded. Tested the flexor and extensor muscles in concentric and eccentric contractions, with an interval of three minutes between each assessment. We adopted a range of 10 degrees of extension to 70 degrees of flexion, with five repetitions at angular velocity  $60^\circ/s$  performing maximal strength. Familiarity with the equipment was done in the way of submaximal intensity contraction. The analysis was performed using SPSS, version 20.0 ( $p < 0.05$ ). **Results:** muscle ratio for females was higher compared to males, demonstrating in men greater deficit flexors compared to extensors of the trunk. **Conclusion:** no significant neither for females nor for males difference. Confirming that the ratio of muscle strength agonist/antagonist of a joint should not change regardless of the mode of contraction is tested.

**Keywords:** Isokinetic dynamometer; Isokinetic evaluation; Flexors and extensors ratio; Peak torque.

### RESUMO

**Introdução:** A musculatura tóraco-lombar desempenha papel fundamental no equilíbrio e estabilidade da pelve e o conhecimento da relação de força entre músculos flexores e extensores é fundamental para diagnóstico e planejamento terapêutico. A dinamometria isocinética fornece avaliação precisa do desempenho muscular e tem sido reportada como instrumento avaliativo válido e confiável. **Objetivo:** Comparar a relação flexores/extensores de tronco entre homens e mulheres sedentários, assintomáticos pela dinamometria isocinética. **Método:** Pesquisa transversal de caráter observacional. A amostra foi composta por 100 voluntários sedentários assintomáticos, sendo 50 do sexo masculino e 50 do sexo feminino com média de idade de  $22,2 \pm 3,3$  anos. A coleta foi realizada no centro de dinamometria isocinética da PUCPR. Foi utilizado o dinamômetro isocinético modelo *Cybex Norm 7000™*, módulo de tronco. Os indivíduos foram pesados e medidos, realizaram aquecimento global de 5 minutos em cicloergômetro sem carga. Testou-se a musculatura flexora e extensora em contração concêntrica e excêntrica, com um intervalo de três minutos entre cada avaliação. Adotou-se amplitude de 10 graus de extensão até 70 graus de flexão, com cinco repetições na velocidade angular de  $60^\circ/s$  realizando força máxima. A familiarização com o equipamento foi realizada no modo de contração em intensidade submáxima. A análise foi realizada no pacote estatístico SPSS, versão 20.0 ( $p < 0,05$ ). **Resultados:** A relação muscular para o sexo feminino apresentou-se maior se comparada ao masculino, demonstrando nos homens um maior déficit de flexores em relação a extensores de tronco. **Conclusão:** não houve diferença significativa nem para o sexo feminino, nem para o sexo masculino. Confirmando que a relação de força muscular flexores/extensores de uma articulação não deve alterar-se independentemente do modo de contração for testada.

**Palavras-chave:** Dinamometria isocinética; Avaliação isocinética; Relação flexores e extensores; Pico de torque.

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## INTRODUCTION

World Health Organization data show that, worldwide, about 80-85% of episodes of back pain has no known cause. And that low back pain is the most common disorder of the spine, affecting more than 80% of people at some point in their life, with 90% of them have more than one episode of low back pain. Besides showing that low back pain is the most common cause of disability among young adults.<sup>(1,2)</sup>

In this scenario, it is seen that there is a growing amount of research related to the search for methods of treatment, prevention and diagnosis of lumbar dysfunction. Much of these studies have examined the relationship trunk muscle strength with low back pain.<sup>(3,4)</sup>

The stability of the pelvis and lumbar spine is very important in body balance. The pelvis transmits forces from the weight of the head, trunk and upper extremities and the rising strength of the lower limbs. While the lumbar spine is the main area of the body responsible for the support of the charges. Furthermore, the lumbar and thoracic fascia its potent muscle inserts also have an important function in the stabilization of the lumbopelvic region.<sup>(4,2)</sup>

The spinal stability depends on the integration of three elements: the passive system, active system and neural control. The neural control receives information from the passive and active systems by means of receptors, and has the role of capturing the balance alterations and determine specific adjustments by the trunk musculature, restoring stability. When one of these systems fails the other two reorganize to continue and homeostasis. But often, this reorganization is inadequate overloading the subsystems, promoting a chronic spinal dysfunction-instability.<sup>(3,4)</sup>

The spinal stabilization incapacity caused by the imbalance between the function of the extensor and flexor muscles of the trunk is a strong clue to the development of low back pain.<sup>(5)</sup> Considering the muscle as a biological system that transforms chemical energy into mechanical. The evaluation of its function involves determining the variables: force, work, power and endurance.<sup>(6)</sup>

Ratio flexors/extensors is the division between the value of agonist and antagonist, is related to the peak torque, work or power, expressed as a percentage. Therefore, it is the ratio between such groups exist for each joint. It is usually assessed in the smaller angular speeds for peak torque and work and higher angular speeds for power. It proves helpful in individuals who had the locomotor system injury.<sup>(7)</sup> The relationship flexor/extensor is the ratio between the peak torque of the agonist muscles and the antagonist muscles and serves as parameter for evaluating muscular balance of a joint.<sup>(8)</sup> The relationship between muscle groups agonists/antagonists can be used to verify imbalances and weaknesses in certain muscle groups that may predispose the subject to injury.<sup>(9,7,10)</sup>

Electromechanical dynamometers allow measurement of parameters such as torque production capacity, muscle power,

fatigue and ability to generate work for several musculature. The data obtained from the use of these dynamometers have had major impact on clinical decision-making.<sup>(11,12)</sup> When you measure the forces exerted on the joint systems through isokinetic, it takes into account the time or torque developed by the muscle groups. Torque or moment is when a force acts on a body, and tends to produce an angular movement. The angular movement always occurs around the center of rotation, called the axis. The torque of a force on an axis is the product of force and its lever arm.<sup>(6,13)</sup>

These electromechanical dynamometer offer resistance to joint movement over a certain range in order to be always equal to the force exerted by the individual. Thus dynamometer prevents the movement speed exceeds the predetermined value, so that this is maintained constant. This technology allows the muscles to produce maximum muscle strength in all parts of the range of motion in concentric and eccentric contractions, which can not be obtained with tests with constant load.<sup>(13,14)</sup>

Theoretically, the values obtained in isokinetic tests are more realistic in relation to muscle performance and helps to identify differences in the flexor and extensor muscles of the trunk and can these be crucial for analysis and stability control as seen for other joints.<sup>(15,9,16,4,17)</sup>

Therefore, this study aimed to evaluate and compare the relationship flexors/extensors of the trunk muscles in sedentary men and women, asymptomatic through the isokinetic dynamometer.

## METHODS

The study was conducted by a cross-sectional study, exploratory, observational and descriptive (18). The project followed all the rules governing research with human beings (Resolution 466/12). Data collection was performed at the Center for Isokinetic dynamometry the physiotherapy clinic of the Pontificia Universidade Católica do Paraná - PUCPR, after approval by the Research Ethics Committee in Human Beings at the same institution, by the number: 249771. The sample of convenience and consists of 111 asymptomatic sedentary individuals for low back pain. Of these, 11 were excluded in the familiarization process for failing to perform the test. So it was taken 100 participants, 50 male and 50 female. Inclusion criteria were: individuals aged between 18 and 30 years and sedentary. Were defined in the survey as sedentary non practitioners of physical exercise (weight training, fitness classes in general, walking, jogging, cycling, swimming, sports in general) regularly, that is, less than twice a week.

Were not included in the study individuals presenting postural change identified by the inspection,<sup>(19)</sup> musculoskeletal injury history of spine and hip region, history of abdominal surgery and spine, pain in the lower back, injuries and misalignments of knees and pregnant women. And the tests

were excluded from subjects who have failed to realize the continuously test, ie, stopped or reversed to push the direction of force during testing. This was seen by locking the equipment during the test and the discontinuity of the torque curve generated by the individual test.

After being previously informed of the study purposes, the possible risks, benefits and procedures they would be submitted, volunteers signed a free and informed consent form. Only then filled out a form with your details to participate in the study and performed the test.

### Equipments

For the anthropometric measure it used a platform scale, Filizola and height was measured in a stadiometer accurate to 0.1 cm. All individuals were measured and weighted barefoot. For the previous global warming evaluation, we used a cycle ergometer of the Movement brand. For the evaluation of force was used the isokinetic dynamometer CYBEX brand Medical®, Cybex Norm™ 7000 model with use of its trunk module. Data from the evaluation of the force, are available through the computer coupled to the dynamometer at the end of the evaluation.

### Evaluation protocol

Each participant underwent an evaluation protocol in dynamometer trunk module, held only once in each participant.

Prior to the evaluation, subjects were weighed and measured and carried out a prior global warming than 5 minutes on a cycle ergometer unloaded.

Participants then were placed on the dynamometer in accordance with the guide device technical standards,<sup>(20)</sup> in the particular trunk module for strength analysis and were kept in the same position throughout the test. The subjects were positioned standing, semi-flexed knee limited later in the line of the popliteal fossa and previously above and below the patella, the drive shaft of the dynamometer positioned at the time the line between L4/L5, a fastening belt at the hip, fixing also in the shoulder girdle region associated with a belt above the nipples with the palm rest, leaving only the free movement of flexion and extension of the trunk (figure 1). After adequate fixation of the individual equipment, the trunk has been weighed by the machine in the position of 45 degrees of flexion (Figure 2), and this amount was deducted from the weight of obtaining results. The positioning and fixing of all subjects were performed by the evaluator to avoid bias.

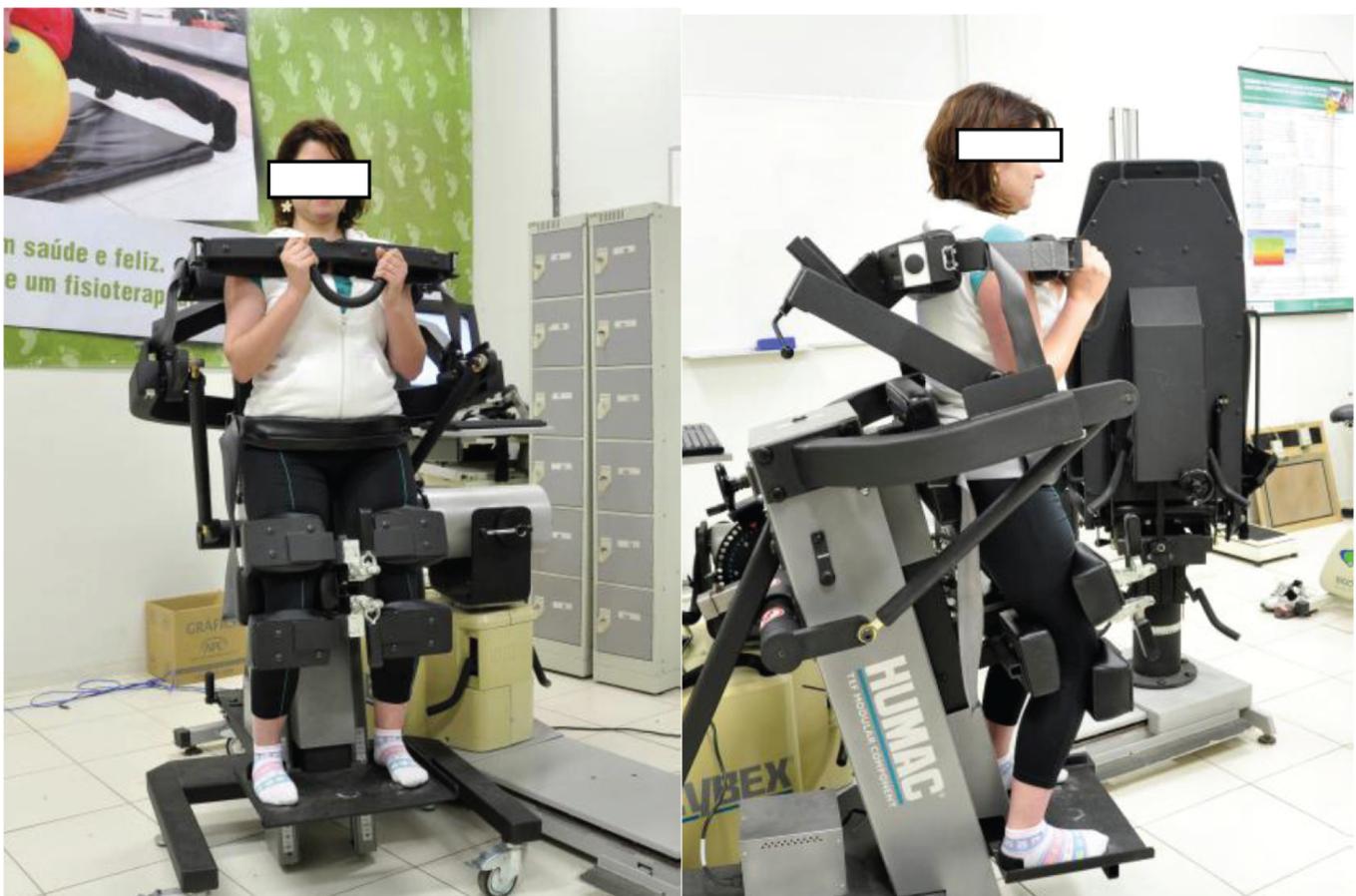


Figure 1. Initial positioning and fixing the trunk module (Front and Side).



Figure 2. Range of motion of 45 degrees of trunk flexion segment weighing (front and side).

The evaluation protocol comprised a sequence that was tested two forms of muscular contraction for the flexor muscles and extensor trunk with an interval of three minutes between each form contraction. During the break the guys held up at rest, positioned and attached to the equipment.

First it was performed concentric isokinetic evaluation (concentric / concentric mode). After the rest period, the eccentric isokinetic evaluation (eccentric / eccentric mode), both with the parameters described below was performed. For the trunk flexion and extension, starting with 10 degrees of extension up to 70 degrees of flexion, five replicates were performed at angular velocity of 60°/sec. It has previously been shown that the use of lower angular velocities (60 to 120 °/s) to assess the trunk corresponds to a smaller error of measurement and it is also recommended to use this angular velocity to be next in a series of daily activities. (5, 15,17) The range of motion that occurs during active flexion and extension stem is composed of the sum of motions of all levels of the lumbar spine joint with the hip movement.

The maximum amplitude of motion of the lumbar spine is 59 ° of flexion to 37° extension.<sup>(20)</sup> Since the hip motion has a maximum amplitude of 125 ° of flexion to 15° extension.<sup>(21)</sup> It adopted the range of motion of 70° trunk flexion range that ensures that the maximum amplitude of trunk flexion

is performed by individuals and 10 ° own extension by mechanical constraint imposed by the equipment. It is noted that this full range of motion is most often seen in the literature for isokinetic evaluation trunk.<sup>(15,16)</sup>

During the tests, all evaluated always receive the same verbal encouragement by the evaluator to develop maximum strength with each repetition.

Prior to each mode of assessment, the assessed underwent a familiarization with the equipment and the contraction mode. Held in the same angles of motion and angular velocities of the respective tests, but at a submaximal intensity.<sup>(22,23)</sup> The familiarization protocol consisted of three repetitions in concentric contraction 30 seconds before the test concentric and eccentric contraction in three repetitions 30 seconds before the eccentric test.

The parameter evaluated was the ratio of peak torque flexors /extensors trunk provided by the dynamometer own report, given in absolute value that has been transformed as a percentage.

### Statistical treatment

Data were analyzed with SPSS version 20.0 with statistical significance set at 5%. The results were described as mean, median, minimum, maximum and standard deviations.



For comparisons between groups regarding the quantitative variables was considered the Student t test for independent samples. For intra-group comparisons regarding the quantitative variables was considered the Student t test for paired samples.

## RESULTS

They evaluated 100 subjects who met the selection criteria. They had a mean age of  $22.2 \pm 3.3$  years and body mass index (BMI) of  $24.4 \pm 4.0$  kg/m<sup>2</sup>. It is half male and half female. The description of the age and BMI of groups defined by gender is presented in Table 1. Where there were no significant differences between the gender in relation to these variables.

It was found, by analyzing Table 1, there is no significant difference between the age of men and women in the sample ( $p = 0.116$ ) and BMI ( $p = 0.195$ ).

Table 2 shows that there were significant deficiency in muscle ratio flexors/extensors of trunk between the genders, both in concentric contraction as in eccentric contraction. Males presented a concentric contraction of the flexor muscle deficit in relation to the extensors of 18.58% while women showed a deficit of 7.26%. In eccentric contraction males showed a deficit of flexor muscle in relation to the extensors

of 17.74% while women showed a deficit of 3.46%. Showing that the male has a muscle strength deficit flexors over the extensors more than women.

In the table 3, it is observed that there was no significant difference between the average ratio flexor/extensor concentric and eccentric both men and women with their values ( $p = 0.684$ ) and for men ( $p = 0.137$ ) for women.

## DISCUSSION

Currently we can see an increase of studies related to the isokinetic evaluation and use the results as a parameter to the treatment program and intervention musculoskeletal disorders.<sup>(24)</sup> In general studies related muscle strength with musculoskeletal disorders.<sup>(3)</sup> It is common knowledge, the fundamental importance of muscle balance and preventing diseases. The musculature has a fundamental role against taxes imbalances for the spine.<sup>(4,5)</sup>

The ratio flexors/extensors is the ratio of the peak torque of the flexor muscles and the extensor muscles and serves as a parameter to assess the muscular balance of a joint.<sup>(25)</sup> Although there are many studies related to the isokinetic evaluation, we can see a shortage in the literature of directors studies on the flexor/extensor ratio in the trunk of the eccentric contraction mode. This has led to difficulty in discussing this study directly with the literature.<sup>(8,10)</sup>

The study sample showed homogeneous in age and BMI as shown in Table 1. Regarding the number of participants was statistically significant, since the average found in the literature on the subject was 30-40 participants.<sup>(6,8,12)</sup>

A study in 1991 evaluated the trunk isokinetically force of 29 men and 32 women with asymptomatic average ages of 40 years in angular velocity of 60°/sec concentric contraction.

**Table 1.** Comparison of Age and BMI between genders.

Variables	Gender	Mean $\pm$ Standard Deviation	P value
Age	Male	22.74 $\pm$ 3.70	0.116
	Female	21.68 $\pm$ 2.93	
BMI	Male	24.95 $\pm$ 4.12	0.196
	Female	23.90 $\pm$ 3.93	

Student's t test for independent samples,  $p < 0.05$ .

**Table 2.** Descriptive statistics and comparison of muscle ratio flexors/extensors trunk between the sexes in concentric and eccentric contraction at 60°/sec.

Variable	N	Gender	Mean $\pm$ Standard Deviation	Median (Minimum - maximum)	Pvalue
Ratio Flex/Ext CON	50	Male	81.42 $\pm$ 12.14	81 (54 - 114)	0.003
	50	Female	92.74 $\pm$ 23.31	84.5 (66 - 172)	
Ratio Flex/Ext ECC	50	Male	82.26 $\pm$ 12.98	82 (58 - 121)	<0.001
	50	Female	96.54 $\pm$ 18.78	92 (65 - 142)	

Student's t test for independent samples,  $p < 0.05$ .

**Table 3.** Comparing relative flexors/extensors concentric stem and eccentric stratified by gender.

Variable	N	Gender	Mean $\pm$ Standard Deviation	Pvalue
Ratio Flex/Ext CON X Ratio Flex/Ext ECC	50	Male	81.42 $\pm$ 12.14 82.26 $\pm$ 12.98	0.684
Ratio Flex/Ext CON X Ratio Flex/Ext ECC	50	Female	92.74 $\pm$ 23.31 96.54 $\pm$ 18.78	0.137

Significance of Student's t test for paired samples,  $p < 0,05$ .



And it averaged values ratio flexors/extensors of trunk 73% for men and 71% for women.<sup>(8)</sup>

In a study conducted in Mexico, researchers evaluated isokinetically 73 individuals, 38 females and 35 males. Aged between 20 and 39, the angular velocity test 60°/ without concentrically mode and range of motion of 70 degrees of flexion and degrees of extension 10, the same parameters used in the current test. Their findings showed average muscle ratio flexors/extensors of the trunk peak torque of 0.79 for men and 0.87 for women.<sup>(16)</sup>

In 2010, researchers conducted a study comparing strength of individuals with and without low back pain. They evaluated 68 individuals of both sexes. Of these, 40 did not have back pain while the other 28 had symptoms of chronic sciatic pain. A concentric test, angular speed of 60°/s in range of motion was 70 degrees of flexion and zero grade for extension was made. Asymptomatic individuals had a mean value of the relative muscle flexor/extensor 92% peak torque stem.<sup>(6)</sup>

Based on the studies cited above, then one can say that the ratio muscle flexor/extensor trunk peak torque remains between 71% and 92% for healthy individuals. The literature shows that it is expected that the ratio flexors/extensors trunk keep being 85 and 90%.<sup>(26)</sup> However, there are no normative data in the literature.

Our results agree with the findings of previous studies. Showing average muscle ratio flexors/extensors concentric peak torque of 81% trunk for men and 92% for women.

It can be understood that among these values indicate muscular balance. Therefore relationships below or above represent evidence of muscle imbalance.<sup>(27)</sup>

The present study also evaluated the relationship flexor/extensor trunk in eccentric contraction. Which showed an average ratio of 82% for men and 96% for women. It is observed that are very similar values, with no significant difference from those in concentric contraction. It is expected that muscle strength relationship agonist/antagonist of a joint, in this case the ratio flexors/extensors of the trunk segment must not change regardless of contraction so that is tested.<sup>(26)</sup>

It is noted so that the results of this study for comparison of the relationship flexor/extensor in relation to the contraction mode is consistent with expected. This is confirmed to realize that in eccentric contraction, as in concentric contraction, there was a significant difference when comparing the genders and that males had higher average relationship flexors/extenders when compared to women. I.e., men showed less muscle strength deficit of trunk flexors in relation to trunk extensors.

There are no available studies assessing one directive flexor/extensor trunk in an eccentric way relationship so that they can be directly compared with the results of the current study.

The eccentric work, the muscles can act as shock absorbers, dissipating energy by slowing the body segments, or as springs, storing energy for it to be used in a subsequent muscle contraction.<sup>(27,28)</sup> The eccentric muscle contraction compared

to concentric muscle contraction produces greater muscle torque in the same joint angle. This is of the highest mechanical efficiency that characterizes this contraction where the muscle contractile components store elastic energy and convert it into mechanical energy for muscle contraction, helping generate voltage. Another mechanism associated with a differentiated recruitment of motor units during the eccentric muscle contraction.<sup>(29)</sup> This shows that the eccentric evaluation and use of this form of contraction during physiotherapy treatments is as important as the concentric contraction.

However, more studies are needed with other populations to obtain a comparison to justify this statement. Also identifies the need for studies related to the eccentric contraction trunk, as its important role in the clinical conduct for their unusual properties to other contractions and potentially be able to produce unique adaptations in skeletal muscle.<sup>(30,31)</sup>

## CONCLUSION

This study reveals significant differences between the mean values of respect flexors/extensors peak torque trunk between both genders in concentric contraction as in eccentric contraction. Males presented a concentric contraction deficit of the flexor muscle in relation to the extensors of 18.58% while women showed a deficit of 7.26%. In eccentric contraction, males showed a deficit of flexor muscle in relation to the extensors of 17.74% while women showed a deficit of 3.46%. As expected, when comparing the values of the ratio flexors/extensors stem obtained in concentric contraction with those obtained in eccentric contraction showed no difference nor for females or for males. Confirming that the ratio flexors/extensors muscle strength of a joint should not change regardless of the contraction mode is tested.

With this study it was possible to obtain values that will serve as benchmarks for future research using isokinetic evaluation trunk. This study may contribute to the provision of isokinetic trunk ratings reports. In addition to these values serve as benchmarks for evaluation of symptomatic patients and as facings for building treatment protocols for low back pain.

This study highlights the importance of isokinetic evaluation to secure progress and successful treatment of syndromes and/or musculoskeletal injuries.

## AUTHORS CONTRIBUTION

MS and CKC: Data collection and scientific writing. MFCE: Update of references and standards. ADLM: Supervision of data collection and final correction. RSB: Research project development, data collection and statistical analysis.

## COMPETING INTERESTS

The authors declare no conflicts of interest.

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