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ORIGINAL ARTICLE

Use of 1-RM Test in the Measurement of Knee Flexors and Extensors Ratio in Young Adults

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ABSTRACT

Strength ratio between agonist and antagonist muscles provides significant information about muscular equilibrium, which helps to detect musculoskeletal changes and to guide preventive and rehabilitation programs. Isokinetic dynamometry provides reliable values for muscle torque and subsequently on the force ratio between knee flexors and extensors. However, this method is not clinically accessible. A possible alternative to evaluate this force is the One-Repetition Maximum test (One-Rep Max or just 1-RM), which is the most commonly used test for dynamic force assessment. However, there is no report in the literature of the use of 1-RM test for the quantification of knee flexors and extensors ratio. For this reason, the objective of this study was to use the 1-RM test to measure the ratio between knee extensors and flexors in young adults in order to find reference values. The studied sample was composed of 80 young adults (40 men and 40 women), mean age of 22.21 (±3.58) years with no musculoskeletal injuries. They were submitted to the following procedure: IPAQ-short version, weighing and prognostic of 1-RM, warm-up, and unilateral 1-RM test (at the flexor and extensor machine). After the test application, the data were analyzed and the mean values for the ratio between agonist/antagonist found were 52.34% (±9.72) for men and 43.19% (±5.82) for women (which were significantly different between groups). The values found in the present study may be used as reference for asymptomatic individuals with similar age.

Keywords: agonist/antagonist ratio, isokinetic dynamometry, torque, quadriceps, hamstrings.

INTRODUCTION

Strength ratio between agonist and antagonist muscles, which is usually calculated by maximum torque of the knee flexor muscles divided by the maximum torque of the knee extensor muscles and multiplied by 100[1], provides significant information about the muscular balance[2]. This ratio can be important in the detection of musculoskeletal alterations, in the guidance of prevention measurements as well as in the implementation of specific training programs, besides determining whether the individual is able to return to his/her sport or occupational activities[3,4].

It is known that imbalance of the forces which statically and dynamically act on the joints can appear due to the use pattern in daily and sports activities, resulting in the development of specific musculature according to the applied overload. These muscular specializations can trigger posture and articular mechanics alterations, besides overloading musculotendineous structures around the joint[5,6]. In individuals with imbalance between agonists and antagonists higher than 10%, the risk of injury is three to 20 times higher than in individuals with no imbalance [7], suggesting hence greater susceptibility to injury in the weaker group; for example, hypertrophy of knee extensors over the flexors is a probable cause of flexor injury[8].

Resistance tests have their main application in the scientific investigation in the cases where it is necessary to understand the capacity of the individuals in generating tension[9]. Isokinetic dynamometry, gold standard for muscular strength evaluation, provides reliable values on the generated torque and subsequently, the force ratio between flexors and extensors[5]. However, it is not very accessible and of high cost for the majority of the researchers and professionals of the physical exercise fields[10].

A possible alternative for strength evaluation is the one repetition maximum test (1-RM), which is the most used for assessment of dynamic strength, since it is a practical method, of low cost and apparently safe for most of the populations[11-13]. A maximum repetition refers to the maximum load lifted correctly one single time, during the performance of a standardized exercise of weight lifting[14,15]. However, there are no investigations in the literature which have used the 1-RM test for quantification of the knee flexors and extensors ratio.

OBJECTIVE

Considering the accessibility of the 1-RM test and all the intervention possibilities which the agonist/antagonist ratio offers, the aim of the present study was to use the 1-RM test in the measurement of the knee flexors and extensors ratio in young adults, in order to find reference values.

MATERIALS AND METHOD

Type of study

Observational transversal study.

Sample

80 young adults, 40 mean and 40 women, aged between 18 and 30 years were recruited by convenience. Individuals who presented history of muscle injury in lower limbs, current complaint of osteomioarticular pain or any nervous and/or cardiopulmonary systems disorder were not included in the study.

Instruments

Flexion and extension benches

In order to apply the 1-RM test, the flexion and extension benches were brand name *Gervasport* were used. The individuals performed the movement at sitting position, at angulation from 0º to 90º on the flexion bench and 90ºto 0º on the extension bench. In order to standardize the test performance, the participants were instructed about the ideal positioning on the flexion and extension benches, and were correctly seated with lumbar back rested on the back, holding on the side grips of the apparatus with both hands. The apparatus was placed on the tibia five centimeters proximal of the lateral malleolus, and was to the tibia on the flexion bench and anterior to the tibia on the extension bench. The flexion bench was used to measure the strength of the knee flexor musculature ands the extension bench to measure the strength of the knee extension musculature.

International Physical activity Questionnaire – short version

The short IPAQ was proposed by the International Group for Consensus on Measurements of Physical Activity, constituted under the World Health Organization, with members of 25 countries, including Brazil. It is a validated instrument adapted to the Brazilian Portuguese language, developed with the aim to estimate the level of habitual physical activity of populations of different countries, providing information about the frequency and duration of gaits and daily activities which require physical exertion of moderate and vigorous intensities on weekdays (between Monday and Friday) and on weekends (Saturday and Sunday), having the last week as reference period[16,17].

Procedures

After approval by the Committee on Ethics in Research from the Pontificial Catholic University of Minas Gerais (#° 0114.0.213.000-09), data collections were conducted in the *Personal Impact* Health Center, in Itabira, MG. Initially, an interview was held to obtain information about age, history of injury on lower limbs and disorders in the osteomyoarticular, nervous and/or cardiopulmonary systems. Subsequently, the individuals selected to participate in the study received information on aims of the investigation as well as procedures through which they would be submitted to and signed the Free and Clarified Consent Form agreeing on the participation in the study and answered the short IPAQ in order to characterize the level of physical activity.

Bileteral measurement of the tibial length was performed, having as anatomical reference the tibial plateau and the medial malleolus as the particiaptns' weighting (the 1-RM was predicted from 50% of body mass)[11]. Subsequently, the individuals performed warm-up composed of five minutes of bicycle keeping velocity between 24 and 28km/h, self-stretching of knee extensors and flexors, using three sets kept for 30 seconds, intervalled by 10 seconds of rest [18]. Six to 10 repetitions of the knee extension and flexion movements ere performed, with approximately 50% of load to be used on the first trial of the 1-RM test, in order to promote correction of the performance technique, familiarization with the equipment used and local muscular warm-up [14].

After three to Five minutes of recovery, the participants were told to try to complete two repetitions with load equivalent tone 1-RM already predicted. In case these two repetitions were completed on the first trial, new load was added so that a second trial was performed. In case not even one repetition was completed, a second trial with lower load was performed. Such procedure was repeated in following trials in case the load referring to one maximal repetition had not been determined yet. Additionally, it is worth mentioning that this procedure was bilaterally performed, and the dominant limb was tested first and test order on the flexion and extension benches was random, that is to say, while one individual performed the flexion bench another one performed the extension bench and switched afterwards; recovery interval of three to five minutes was performed between the trials to reach 1-RM[14]. Performance technique and manner of each exercise was continuously monitored in a trial to guarantee quality of information.

Calculation of flexor, extensor torque and agonist/antagonist ratio

Torque was established from the following sequence of activities: firstly, leg mass, which, according to Winter[19], equals to 6.1% of the total body mass, was calculated. Gravity was corrected by subtracting the value of the leg weight from the flexion bench and added to the extension bench. Subsequently, the values found were multiplied by 9.8m/s^2 (value corresponding to the gravity acceleration), transforming hence the exercise load in weight. This weight was then multiplied by the tibia length, providing the torque information. The found torque was divided by the individual's weight in order to find comparable values among the participants. The agonist/antagonist ratio was calculated by dividing the flexor torque by the extensor torque and the result was multiplied by 100.

Data analysis

Descriptive analysis of the central tendency and of the data variance through mean and standard deviation of the torque measurements normalized by the body weight of the knee flexors and extensors as well as agonist/antagonist ratio. Moreover, the *Student's t* test was used to investigate the differences in the torque means and of the ratio between men and women. The entire statistical analysis was performed through the SPSS software for *Windows* (Version 13.0, SPSS Inc.©, Chicago, Illinois).

RESULTS

Characteristics of the participants

The study was composed of 80 individuals; 40 women with age mean of 22.23 years (±3.58), mean body mass of 58.50kg (±8.69), mean height of 1.63cm (±0.05); and 40 men with age mean of 22.20 years (±3.18); mean body mass of 74.05kg (±10.17); mean height of 1.76cm (±0.05). The two groups were paired concerning age (p = 0.18). The short IPAQ showed that 8.75% (seven) participants were classified as sedentary, 25% (20) as insufficiently active; 47.5% (38) as active and 18.75% (15) as very active. The level of physical activity by sex is presented in table 1.

Table 1. Level of physical activity per sex.

Level of physical activity (IPAQ – short)	Men (40)	Women (40)
Sedentary	5 individuals (12.5%)	2 individuals (5.0%)
Insufficiently active	6 individuals (15%)	14 individuals (35%)
Active	18 individuals (45%)	20 individuals (50%)
Very active	11 individuals (27.5%)	4 individuals (10%)

Torque and ratio

The values of torque normalized by the body weight and the agonist/antagonist ratio of men and women are presented in table 2. Significant difference has been observed between groups for all assessed variables ($p < 0.05$).

Table 2. Descriptive data of the flexor, extensor torque and agonist/antagonist ratio.

		Mean	Standard deviation	P value
Extensor torque dominant side	Men	434.08	82.66	< 0.01
	Women	289.55	47.76	
Extensor torque non-dominant side	Men	432.87	73.5	< 0.01
	Women	280.89	50.05	
Mean extensor torque	Men	433.48	76.05	< 0.01
	Women	285.22	47.37	
Felxor torque dominant side	Men	231.29	53	< 0.01
	Women	123.90	23.69	
Flexor torque non-dominant side	Men	217.83	46.47	< 0.01
	Women	121.29	25.51	
Mean flexor torque	Men	224.56	48.84	< 0.01
	Women	122.60	23.69	
Agonist/antagonist ratio dominant side	Men	54	11.66	< 0.01
	Women	42.98	6.06	
Agonist/antagonist ratio non-dominant side	Men	50.67	8.65	< 0.01
	Women	43.41	6.64	
Mean agonist/antagonist ratio	Men	52.34	9.72	< 0.01
	Women	43.19	5.82	

DISCUSSION

In order to have stable joints it is necessary not only strength, but also suitable muscular balance. A parameter which expresses this balance in the knee joint is the strength of the flexor/extensor musculature ratio, which has been studied and provides important data for prevention of injuries and guiding in the rehabilitation measures.

Traditionally (as in the present study), the agonist/antagonist ratio has been calculated through the division between concentric torque peak values of the knee flexor and extensor muscles. Some authors consider that this method is not representative of the muscular function, since the antagonist musculature (knee flexor muscles) would eccentrically act during the concentric action of the agonist muscles. However, Baratta *et al.*[20] demonstrated that the hamstring action as antagonist is directly proportional to its capacity to concentrically generate strength, giving hence support so that the ratio can be calculated based on concentric torque values.

It is described in the literature that the agonist/antagonist ratio at constant angular velocity of 60º/s tends to be approximately 60% in healthy adults [22,23]. Siqueira *et al.*[5], in their study composed of healthy men between 18 and 30 years of age, using the isokinetic dynamometer, found mean ratios of 60.35% for jumping athletes; 56.45% for running athletes and 57% for non-athletes and did not find significant differences among these groups. The values mentioned above are slightly higher than the ones found in the present study. A possible explanation is that the performance velocity of the exercises on the flexion/extension benches is probably lower than 60º/s. The lower the angular velocity of the movement, the lower the reference value for the ratio. Exemplifying this ratio (ratio x velocity), Ergun *et al.*[24], in their study composed of 88 men presenting mean age of 23 years, found out agonist/antagonist ratio of 59.0% at the 60º/s velocity and of 76.0% at the 180º/s velocity.

Significant difference has been found in the flexor torque and extensor and agonist/antagonist ratio values when men and women were compared. The flexor e extensor torque values found reinforce the information available in the literature, which indicates lower muscular strength in the great majority of women when compared to men, both in upper and lower limbs [25]. The magnitude of the differences found between sexes can be explained by some factors, such as: differences in plasma concentrations of the testosterone, GH and IGF-1 anabolic hormones; differences in the muscular areas of transversal section and in lean mass; type of exercise performed; body segment assessed; levels of physical fitness; equipment used; type of maximum voluntary contraction applied, besides, as a rule, the level of physical activity of the majority of women is lower than of the men [26-28]. In the present study, through the data generated by the IPAQ, it was observed that the men of the sample are physically more active than the women, a fact which can have interfered on the flexor, extensor torque values and agonist/antagonist ratio.

The significant difference found in the agonist/antagonist ratio between sexes can be associated with musculoskeletal alterations which follow female maturation. Alterations in height, weight and bone length in women are not followed by neuromuscular adaptation and can lead them to dynamic knee instability. Differently, men have a more efficient muscular strategy to absorb strength through greater muscular contraction. Results obtained by the isokinetic dynamometer demonstrate men present higher peak of knee flexor torque with age, while in women this remains stable due to poor female neuromuscular control. Higher flexor torques increase the agonist/antagonist ratio, which explains the higher male ratio compared to women's in this study [29,30].

Low agonist/antagonist ratio indicates predominance of extensor musculature or deficit of flexor musculature, suggesting hence that the women in the present study can present prevalence of extensor musculature compared to the flexor one. High agonist/antagonist ratio indicates predominance of flexor musculature or deficit of the knee extensor musculature. Melo *et al*.[31] corroborate this fact in a study with individuals with knee osteoarthrosis, presenting deficit of knee extensor musculature, where ratio values between 98 and 115% were found. Such imbalance has been reported as a possible cause for the increase of overload in this joint, making it prone to injuries in the musculotendinous intersections.

The methods used for obtaining this ratio are broadly discussed in the literature, and the isokinetic dynamometry is considered gold standard in its measurement. However, it is not very accessible and presents high cost, which makes important to search for new alternatives to find this ratio. The present study performed the 1-RM test using the flexion and extension benches of gyms to measure the ratio and demonstrated the viability of this procedure, since it is a method of easy application and understanding for who is performing it and is low cost. Moreover, it brought results close to those found in studies which use the isokinetic dynamometer as a measuring device. These findings make it possible to establish parameters of muscular function of the knee joint in healthy Young adults, which will serve as reference for future comparisons and will be able to be used to guide rehabilitation and prevention programs, as well as aid in the detection of the causes of injuries of the musculoskeletal system.

It should be mentioned that the flexion and extension benches do not provide the great amount of information that the isokinetic dynamometer does, such as velocity control, fatigue index, generated work, among others. Nevertheless, they provide very useful information about the capacity to generate strength of the flexor and extensor musculature, allowing hence determining the agonist/antagonist balance.

Finally, some important care should be taken so that there is higher reliability in the use of the 1-RM test, such as the positioning of the individuals. They should keep the lumbar back rested accordingly, trunk at 90º in relation to the thigh and hands holding the respective lateral grips to isolate the muscle group to be assessed and avoid compensations. Range of motion should also be standardized, which in this study, was of 90º both in knee flexion and extension as well as the tibial attachment adjustment, since the distance of this support until the knee corresponds to the resistance arm. Moreover, it is necessary to use equipment of good quality and of the same brand so that exceptional factors d not interfere on the final result of the applied test.

CONCLUSION

Reference values concerning knee flexor and extensor ratio using the 1-RM test in asymptomatic young adults were found. These data can be used by professionals of sport and health fields such as physiotherapists, physical trainers and educators, to help identify strength and muscular balance alterations as well as implement prevention and rehabilitation work.

All authors have declared there is not any potential conflict of interests concerning this article.

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