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Comparison of the Knee Extension Torque in the Maximum Voluntary Isometric Contraction and in the One Repetition Maximum Tests at Equivalent Angles

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SUMMARY

Objective. The purpose of this study was to compare the knee extension torque in the maximum voluntary isometric contraction (MVIC) and in the one repetition maximum (1RM) tests considering equivalent angles.

Methods. Twenty-seven untrained women performed the MVIC and 1RM tests on the knee extension machine on two different days in a crossover design. MVIC test was performed at angles of 30°, 40°, 50°, 60°, 70°, 80°, and 90° of knee flexion (0° = full knee extension). After a 10-minute rest break after the MVIC tests, the 1RM test was performed using up to 6 attempts (range of motion = 100° to 30° of knee extension). In the attempt that corresponded to the 1RM value, the average of the torque values was calculated using one degree below and above the angles in which the MVIC tests were performed (89° to 91°; 79° to 81°; 69° to 71°; 59° to 61°; 49° to 51°; 39° to 41°; 30° to 31°). Statistical analysis was performed with Two-way ANOVA (Angle × test) with repeated measures using the Scott-Knott *post-hoc.*

Results. The MVIC test presented higher torque values than the 1RM test ($p < 0.05$). Additionally, the central angles presented higher torque values than the extremes in the MVIC test, but the torque values were not significantly different between angles in the 1RM test.

Conclusions. We conclude the MVIC test presents higher maximum torque values than the 1RM test during the knee extension movement.

KEY WORDS

Equivalent-angle; force-angle; knee extension strength; Strength test; torque-angle.

INTRODUCTION

Strength training is integrated into physical exercise recommendations, both in the context of health (1) and sports performance (2), in which increasing the maximum strength is one of the targeted adaptations from its implementation (2). Different test procedures are used to measure the maximum strength, and the one repetition maximum test (1RM) and the maximum voluntary isometric contraction test (MVIC) are widely used for this purpose (3). However, considering that the force production capacity varies according to the muscular length and, consequently, by the range of motion (ROM) (4), it is necessary to verify if these tests present similar results. Van Den Tillaar *et al.* (5) observed in the bench press exercise that the force produced in the 1RM test is greater than in the MVIC test in the equivalent angles before the sticking region, and it has similar values during the sticking region and lower values in the subsequent angles of range of motion (ROM). However, the performance of maximum strength in different joint-angles is not the same considering different articular movement (6).

Athletes from different sports have different profiles of knee extension maximum strength along the ROM (7, 8), it would be relevant to determine whether different tests can provide similar information about this strength performance in this exercise. This comparison can support more assertive training prescriptions aligned with the proposed objectives.

Thus, the aim of the present study is to compare the knee extension torque at equivalent angles during the 1RM and MVIC tests in the knee extension machine. The hypothesis of the study is that greater torque values will be found in the initial angles of the concentric action for the 1RM test than in the MVIC test, and after these peak torque angles, the torque values will be greater for the MVIC.

METHODS

Experimental approach to the problem

The present study consisted in two sessions, in which the first one was used for recording of anthropometric measurements, standardization of participant positioning on the knee extension machine, and familiarization of the tests of MVIC and 1RM. The MVIC and 1RM tests were performed on a seated knee extension machine adapted with a load cell and potentiometer. Machines with similar adaptations have been reported in the literature and enable recording torque and knee angles (9, 10). The second session occurred 2 days after the first session and it was reserved for the strength tests, in which the results were used for statistical analysis.

Subjects

Twenty-seven untrained women, aged between 18 and 35 years (mean ± SD: age = 21.0 ± 2.6 yrs; body mass = 58.6 ± 8.2 kg; height = 161.4 ± 5.4 cm) participated of study. The sample size was calculated by the software G.Power* (version 3.1.7). Participants were informed about the study objectives, procedures, and risks and freely signed an informed consent form. The Ethics Committee of the Federal University of Minas Gerais (1758518.1.0000.5149) approved the study on November 07, 2018, and all the guidelines from the Declaration of Helsinki were followed.

Procedures

Session 1. Initially, height and body mass measurements were performed. Next, the participants were positioned on the machine to maintain the hip flexed at an angle of 110°. The lateral epicondyle of the femur was aligned with the machine rotation axis, and the distal support of the machine was placed approximately 3 cm above the medial malleolus (11). These positions were recorded for future replication during the subsequent tests and the next session. All sessions were performed at the same day time for each participant.

After positioning the participant on the machine, the MVIC and 1RM tests familiarization were performed on a seated knee extension machine adapted with a load cell and potentiometer. The MVIC test familiarization consisted of two trials at each angle of 30°, 40°, 50°, 60°, 70°, 80°, and 90° of knee flexion (0° = full knee extension), 3 s duration with two-minute rest between angles and trials (11). The two MVIC values at each angle were used for reliability calculation, in which the intraclass correlation coefficient values ranging from 0.95 to 0.96, relative standard error of measurement values ranging from 6.6% to 5.6%, and the mean coefficient of variation values at pre- and post-test sessions were 3.6 ± 3.3% and 3.1 ± 2.8%, respectively. Testing order at each angle was randomized between the participants. The highest peak torque value registered between two trials at each angle was used for analysis. During the MVIC test familiarization, participants received verbal encouragement from the evaluators and were instructed to apply maximum force against the fixed lever of the knee extensor machine.

Ten minutes after the last MVIC test familiarization was given for resting. In sequence, the 1RM test familiarization was performed. The 1RM test familiarization was performed within a maximum of 6 trials, with 3-minute rest periods provided between trials (11). The weight was gradually increased, and when the participant could not achieve 30° of knee extension during the concentric muscle action, the prior successful load lifted was recorded, representing the 1RM test result. In the attempt that corresponded to the 1RM value, the average of the torque values between the angles correspondent of one below and above the angles in which the MVIC tests were performed, except for the first and last angles combination, in which we performed the average of torque values of the two closer angles (89° to 91°; 79° to 81°; 69° to 71°; 59° to 61°; 49° to 51st; 39° to 41°; 30° to 31°). All signals (potentiometer and load cell Type S, TEDEA supports up to 500 kg) were synchronized and converted into digital signals by an A/D board (BIOVISION, Germany) with 14 bits and input range of -5 to +5 volts. Dasylab program (DASYLAB 11.0, Ireland) was used, for acquisition and treatment of all signals, with sampling frequency of 2,000 Hz.

Session 2. All strength tests procedures of familiarization were replied on the second session. Data from the second session was used for inferential statistic.

Statistical analyses

The normality of the distribution and the homogeneity of the variances of all measurements were confirmed using the Shapiro-Wilk and Levene tests, respectively. The inferential analysis was performed with the values of peak torque in the MVIC and mean torque in the 1RM for each angle/angular interval through a Two-way ANOVA (angle × test) with repeated measures with *post-hoc* of Scott Knott. Within the ANOVA, the eta square (η^2) was determined. All statistical procedures were performed using the SISVAR 5.7 and SPSS 20.0 statistical packages. The significance level adopted was 0.05.

RESULTS

The ANOVA analysis found a significant interaction effect between factors ($F_{1.6}$ = 3,697; $p < 0.05$; and $\eta^2 = 0.03$). **Figure 1** presents the descriptive values of the torque values in the 1RM and MVIC tests across the angles, with the inferential analysis verified by the *post-hoc*.

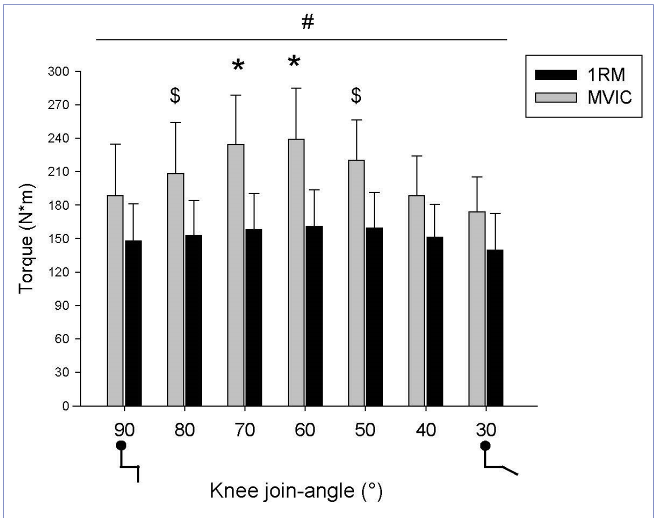

Figure 1. Inferential and descriptive analysis of torque in the 1RM and MVIC tests at different knee joint angles.

#MVIC greater than 1RM; *greater than other angles; $greater than 30°, 40° and, 90°; p < 0.05.

DISCUSSION

The objective of the present study was to compare the torque values produced in the 1RM and MVIC tests across angles. The MVIC test showed higher torque values in all angles analyzed compared to 1RM test. Additionally, in the MVIC tests, higher torque values were verified in the central angles. For the 1RM test, similar torque values were found among all tested angles.

In the study by Van Den Tillaar *et al*. (5) there was a comparison of force production between the 1RM and MVIC tests during the bench press exercise. At the beginning of the concentric action, higher values were found for 1RM compared to MVIC. Unlike our results, in which 1RM test did not show any greater torque values than MVIC test across angles. Such differences can be explained, in part, by the muscular action in which the 1RM test started. In the present study, only the concentric action was used, whereas in the study by Van Den Tillaar *et al*. (5), the 1RM test, performed in the horizontal bench press with a barbell, started with the eccentric action and finished with the concentric action, thus, using the stretching and shortening cycle. Thus, due to the fact that the stretching and shortening cycle increases the force at the beginning of the concentric muscle action (12), this may have caused this superiority in the 1RM test in relation to the MVIC test in the initial angles in the study by Van den Tillar *et al*. (5).

The second factor for the divergence of results was the participation of untrained volunteers in the present study. In the study by Newton *et al*. (12), it was found that the greater the weight used, the greater the time required for force production. The average duration of the entire concentric action during the 1RM test in the present study was 2.24 (± 1.03) s, while each MVIC had a duration of 3 s for each attempt at each angle. Therefore, the maximum rate of torque production in 1RM test and the time available to reach the maximum torque may have influence on the results of the present study. Reinforcing this perspective, Orssatto *et al*. (13) found that individuals without strength training showed the lower levels of peak strength, explosive strength and neural impulses to the muscle compared to strength trained individuals. Still in this same perspective, Narici *et al.* (14) showed that strength training shortens the time required to reach maximum strength. Thus, differences in the sample would help to explain the differences between the present study and that of Van den Tillar *et al*. (5). As the volunteers in the present study were untrained individuals, they probably not be able to form a similar number of cross-bridges for the 1RM and MVIC test.

In the present study, the torque values produced during the MVIC tests across angle are in line with previous investigation (14, 15). This response pattern can be explained by the relationship between muscle length and torque production capacity, in which the greater torque peaks over the join-angle occur due to an optimal length to produced tension, where a greater number of cross-bridges are formed within the sarcomere (16, 17). However, the similarity of the torque along the angles in the 1RM test may be due to the characteristics of the equipment used, which has a Camus system that is homogeneous throughout the range of motion.

CONCLUSIONS

Considering the results found, it is clear that the maximum torque production capacity along the angles is influenced by the type of strength test used. In this sense, for a better understanding of strength performance in acute or chronic studies, it would be interesting to apply different strength tests. The present study found the MVIC test presented greater torque values than the 1RM test across all angles measured. In addition, the torque values produced across the angles were similar during the 1RM test. For the MVIC, greater torque values were found at the central angles.

FUNDINGS

None.

DATA AVAILABILITY

Data are available under reasonable request to the corresponding author.

CONTRIBUTIONS

RCRD: funding, conceptualization, data analysis, writing – original draft. MCNF, GFP, MDMS, BTRS, MOCF: study execution. MCNF, FVL, MHC, RCRD: writing – review & editing.

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CONFLICT OF INTERESTS

The authors declare that they have no conflict of interests.

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