ABCS HEALTH SCIENCES

ORIGINAL ARTICLE

Isometric exercises have high responsiveness to lower limbs

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ABSTRACT

Introduction: For post-surgical rehabilitation of the anterior cruciate ligament, the medialis and the lateralis vastus need to be worked on for good recovery. There is the discussion about the isometric and isotonic exercises to be used in the rehabilitation phase, and their results diverge in the literature. **Objective**: This study aims to compare the activation of the medialis and the lateralis vastus in isometric and isotonic exercises. **Methods**: Eleven subjects (seven men and four women) physically active and experienced in resistance training participated in the study. Anamnesis, anthropometric assessment, 10 Repetition maximum (RM) load test, maximum voluntary isometric contraction test and squat test were performed. **Results**: For the vastus lateralis of the right leg, the electromyographic activity was significantly higher in the maximal isometric voluntary contraction compared to the dynamic squatting ($p<0.05$). The same was observed for the left leg ($p<0.05$). **Conclusion**: Recruitment of the medial and the lateral vastus in isometric exercises is higher in relation to isotonic exercises.

Keywords: anterior cruciate ligament injuries; electromyography; physical education and training; quadriceps muscle; rehabilitation.

How to cite this article: Mota *et al.* Isometric exercises have high responsiveness to lower limbs. ABCS Health Sci. 2020,45:1250. https://doi.org/10.7322/abcshs.45.2020.1250

Received: Feb 11, 2019
Revised: May 08, 2019
Approved: Jul 01, 2019

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Declaration of interests: nothing to declare

INTRODUCTION

Injury to the anterior cruciate ligament (ACL) occurs mainly in active and young individuals, making the knee joint unstable[1,2]. Such damage is more common in sports that require knee rotation movements, such as basketball, skiing and soccer, with an average of 250,000 cases per year in the United States[3,4].

The ACL is the main author that restricts ligament instability and internal rotation of the tibia[5,6], its injury occurs when the ligament is forced beyond its elastic ability, which can cause a total or partial rupture[7]. After ACL rupture, most individuals have a deficit in proprioception[8], inhibiting the motor action of the quadriceps, and consequently reduces strength, power and resistance, resulting in decreased performance[9].

The treatment for ACL rupture is through invasive surgery, and due to the degree of the procedure, there is weakness of the knee extensor and flexor muscles[10]. Such muscle weakness is aggravated by swelling of the joint, lack of physical exercise and pain, which can persist up to 6 months after surgery[11].

Among the set of muscles called the quadriceps femoris, the vastus medial (VM) and the vastus lateralis (VL), contribute to patellar dislocation during knee extension and flexion movements. In particular, the VL can obtain a biomechanical advantage over the VM, if the same atrophy, since the sum of the strength components of the VL is greater than the strength component of the VM, due to the cross-sectional area of the VL being greater[12]. Such an advantage can generate uneven biomechanical strength in the limb resulting in inadequate patellar traction[13].

It is suggested that the VL is the most representative of the quadriceps femoris, when quantifying neuromuscular changes produced by strength training, having as main reason to present less variability of the electromyography (EMG) signal[14,15]. Thus, it is suspected that the VL is the main responsible for accelerating the surgical recovery of the ACL, however most studies that deal with the relationship between EMG and strength use isometric protocols, that is, in ideal situations where there is no joint movement[16].

In order to accelerate the surgical recovery process, it is necessary to use dynamic movements, however when there are isotonic contractions, there is the problem of instability of the electrode position in relation to the active muscle fibers, where any movement of the electrode on the skin may affect the breadth of recorded action potentials[17,18].

Thus, the aim of the present study was to compare the activation of VM and VL in isometric and isotonic exercises.

METHODS

Eleven individuals (seven men and four women) participated in this study, physically active and with experience in weight training. To fit the sample, individuals should attend the gym at least five times a week, uninterrupted for the past six months. For the recruitment, the convenience technique was used, with public calls and calls in the Federal District, there was no sample calculation and neither sample loss. The study is classified as a non-randomized cross-sectional, descriptive and cross-sectional trial. It took three visits to the laboratory with an interval of 48 hours for data collection. The study was approved by the ethics committee of the Centro Universitário de Brasília - UniCEUB (Opinion No. 418,576) and the subjects signed the informed consent form for the research.

First day

Anamnesis, anthropometric evaluation and 10 RM load test were performed in the dynamic squat exercise (AGD). Each attempt had a 5-minute recovery interval. After reaching 10 or less repetitions, the estimate of 1 RM[19] was calculated. To characterize the sample, age, height and weight were used. The percentage of fat, as well as skeletal muscle mass and fat mass, were determined using the seven skinfold method of Jackson & Pollock[20], as well as the Siri formula[21].

Second day

The isometric strength was evaluated by means of a maximum voluntary isometric contraction (CVIM) in a load cell, where a window for capture was made in 120 seconds, using the program tcs_I-Metrics 8.21. Participants should perform maximum strength during knee extension at 60º, and the test was completed when the individual was unable to maintain 50% of the maximum torque achieved. There was a firing threshold of 1 kg, the test always started on the right leg and the recovery interval between legs was 3 minutes.

To capture the signals, ErgoSystem, from Globus Italia Codogné (Treviso), Italy, was used, and Tesys Suite 6.2.2, from the Globus Evaluation Concept was used to integrate the programs. To capture the EMG signals, 2 reading channels were used, one for the right thigh and one for the left thigh, in addition to a Globus channel sensor that was connected to the Globus Ergo System Tesys 1000 and used the tcs program EMG 8.21.

The EMG signs were normalized from the CVIM. For the electromyography collection procedure, trichotomy of the location of each electrode was performed and the skin was cleaned with cotton soaked in 70% alcohol to facilitate adherence of the electrode, minimizing the risk of interference in the conduction of EMG signals. For the VL, the electrodes were fixed according to the procedures used by Winter & Yack[22] and for the VM according to the recommendations of SENIAM[23].

Third day

On the third day, 30 seconds of AGD without load were performed for warming-up, 5 minutes after the end of the warm-up, the muscular region was cleaned and the electrodes were positioned equally on the second day of collection. A load relative to 40% of 1RM adjusted on the bar was used, which was supported on a squat cage.

The test ended when the individual performed 30 seconds of exercise. The subjects were instructed to perform the movement in a 2:2[17,24] cadence, and to measure the cadence, the Metronomo Beats app for Android was used.

Descriptive analysis was used to calculate the mean and standard deviation of all variables. The Shapiro-Wilk test was used to verify the normality of the data. The t test for independent samples was used to compare the electromyographic activity of the vastus in the two interventions, CVIM and AGD. $P \leq 0.05$ was adopted as the level of significance. All analyzes were performed using the Statistical Package for Social Sciences (IBM Corporation, Armonk, NY, USA, 25.0) for Windows.

RESULTS

The characterization of the sample is shown in Table 1. There was no statistically significant difference between knees for the variables of the isometric tests (Table 2). Electromyographic activity was significantly higher in both widths of both knees at CVIM when compared to AGD (Figure 1).

DISCUSSION

It can be seen that the electrical activation of VM and VL was significantly higher in CVIM than in AGD, in both knees. In addition, there was no difference between knees in CVIM at maximum strength, maximum strength time and contraction time. A fact that drew attention was the non-difference between knees in any variable, showing an excellent balance of strength between the lower limbs of the individuals. Certainly, such data bring greater confidence to the work.

Table 1: Sample characterization (n=11).

	Media ± Standard Deviation
Age (years)	21.5±3.53
Weight (kg)	73.45±10.21
Stature (m)	1.77±0.11
Skeletal muscle mass (kg)	34.80±6.88
Fat mass (kg)	11.92±4.90
Fat percentage (%)	16.23±7.10
1RM (kg)	94.53±29.71
40% 1RM (kg)	37.81±11.88

1RM: 1 maximum repetition.

Table 2: Analysis of maximum isometric voluntary contraction (CVIM).

	RK	LK	p
Maximum CVIM (N)	561.33±62.04	565.17±77.47	0.899
CVIM Average (N)	414.60±108.98	421.28±107.84	0.887
Maximum contraction time (s)	30.81±13.49	29.43±10.20	0.790
Maximum force contraction time (s)	13.38±6.04	19.39±12.29	0.161

Values presented in mean and standard deviation. RK: right knee; LK: left knee; N: newtons.

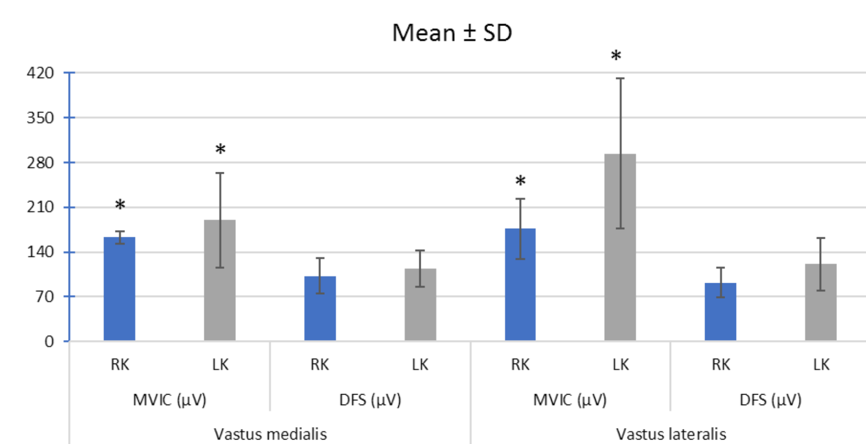
It is believed that CVIM was more expressive due to the execution of the exercise, because during the knee extension at 60º, the individuals were seated with a better support to generate strength, whereas in the AGD, at 90º of knee flexion, there was the load factor and instability of the bar, causing a greater imbalance.

In CVIM there is a greater activation and similarity of signals between the vastus, when compared to AGD, this is due to the knee extension being a monoarticular movement and not suffering interference from the hip during the movement[15]. In addition, the lateral force vector of the VL is greater than that of the VM, and the cross-sectional area of the VL is greater than that of the VM[12].

The anatomical position of the femur related to the movement of the tibia during knee extension causes lateralization of the patella and this requires greater activation of the vastus medialis to compensate. In addition, MV has greater activation in the last 30 degrees of knee extension[24-26], which explains the greater activation of VM in CVIM, for maintaining the isometry at an angle where there is greater activation compared to AGD.

It is suspected that the VL is the main responsible for accelerating the surgical recovery of the ACL, and most studies dealing with the relationship between EMG and strength use isometric protocols[16]. This corroborates with our results, proving that isometric exercises are essential for post-surgical recovery.

The study has some limitations, first, the small sample size that may have generated a type two error in the study. Second, the use of women in the sample without controlling the menstrual cycle, depending on the phase of the menstrual cycle, there are hormonal changes, such as cortisol and testosterone, that can influence the results. For future studies, it is suggested to standardize the sex



SD: standard deviation; RK: right knee; LK: left knee; µV: microvolts; *Significant difference between groups (p <0.05).

Figure 1: Comparison between maximum isometric voluntary contraction (CVIM) and dynamic squat (AGD) of electromyographic activity.

of individuals, increase the sample size and use a larger number of maximum repetitions.

Thus, it is concluded that the recruitment of VM and VL in isometric exercises is greater in relation to isotonic exercises.

ACKNOWLEDGMENTS

The authors would like to thank CEUB for all the support in this study.

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