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Acute Effects on Maximal Isometric Force with and without Knee Wrap During Squat Exercise

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Abstract The aim of this study was to investigate the acute effects on maximal isometric force without and with two kinds of knee wraps (hard and soft) during squat exercise. Ten physical active participants were evaluated during this study. All subjects were familiarized with the isometric squat position in all conditions: without and with knee wrap (hard and soft stiffness). The squat exercise position was set up individually, guaranteeing their thigh parallel to the floor, the arms crossed on the chest, and the feet were kept always in the same position for all trials and conditions. All subjects performed three maximal isometric squat contractions in 3 different conditions: without knee wrap (WKW), with soft knee wrap (SKW) and with hard knee wrap (HKW). The peak of force was acquired at a 100Hz sampling frequency, during 3 seconds, 5 minutes of resting and all conditions were randomized. The results shows significant differences for peak force between conditions WKW and HKW (P=0.029, ES=1.27, Δ%=22%]) and WKW and SKW (P=0.038, ES=1.20, Δ%=21%]). The use of the knee wrap under the presented conditions seem to increase the maximal isometric force during the squat exercise, independent of the level of stiffness of the knee wrap.

Keywords Biomechanics, Exercise performance, Strength

1. Introduction

The knee wrap is an equipment commonly used by weightlifters and powerlifters aiming to stabilize the knee, to improve the strength performance (gain mechanical advantage) or to improve the confidence during squat exercises [1, 2]. The knee wrap is a long wrap of elastic material (tick canvas interwoven with rubber filaments) with approximately 2 meter long, which is wrapped around the knees as tight as possible [3, 4]. There are some studies that investigated both kinematics and kinetics of the squat exercise using the knee wrap in powerlifters [5, 6] and trained subjects [4], however little has been known about its effects of loading capacity. Eiter et al. [5] studied the use of knee wrap in powerlifters and analyzed the general characteristics of the squat exercise (execution time, percentage of the transition cycle (upward-downward displacement) of the center of mass and the bar vertical displacement) with and without knee wrap, with no differences between them. Lake et al. [4] studied the use of knee wrap in trained subjects with and without knee wrap. The authors analyzed the ground reaction force, output of the mechanical force applied to the center of mass, vertical impulse, horizontal displacement of the bar, mechanical work and peak power. They observed that the elastic properties of the knee wrap increased the production of mechanical force by changing the squat technique.

In general, when the knee is flexed against an external resistance during a squat exercise, the elastic material is stretched during the lowering phase, returning this energy during the lifting phase. This potencial energy accumulated is transferred to the lifter and added to the strength performance of the movement in the concentric phase [1], and this additional effect on the strength performance is also known as *carry-over*. Only two studies reported the amount of *carry-over* of 19.8% in elite powerlifters [6] and 25,1% in subjects trained [3], respectively, during squat exercise. However, little is known about the effects of different models (stiffness) of knee wrap in the peak force during the squat exercise and how much carry-over can actually be related to the knee wrap instead of the stretch-shortening cycle. Therefore, the purposes of the present study was to compare the acute effects on maximal isometric force without knee wrap and two kinds of knee wrap stiffness (hard and soft) during squat exercise.

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2. Methods

Subjects

Ten physical active participants were evaluated during this study (age 24±3 years, body mass 79.9±9kg, height 175.7±3cm). All subjects were engaged in regular resistance training routine (hypertrophy loads: 3-4 exercises for lower limbs, 8-12 maximum repetitions) including squat exercise (2 sessions per week) for not less than one year. The number of subjects was determined by using the same variable from our pilot study, and ten subjects were showed to be necessary based on alpha level of 0.05 and a power (1-β) of 0.80 [7]. All subjects who participated in this study had no previous trunk or lower limbs surgery/injury and they were evaluated with a minimum of 48 hours without training sessions. All the participants were instructed about the potential risks involved, read and signed an institution-approved informed-consent form before participating in the study. The study was approved by the ethics committee of Methodist University of Piracicaba (Protocol: 76/12).

Procedures

Initially, all subjects were familiarized with the isometric squat position in all conditions: without and with knee wrap (hard and soft stiffness). The squat exercise position was set up individually, guaranteeing their thigh parallel to the floor, the arms crossed on the chest, and the feet were always kept in the same position for all trials and conditions. A load cell (CEFISE biotecnologia esportiva, Nova Odessa, Brazil) was attached perpendicularly to the ground and in subject's hip by using a belt. Then, each subject performed three maximal isometric squat contractions in 3 different conditions: without knee wrap (WKW), with soft knee wrap (SKW) and with hard knee wrap (HKW). For the placement of the knee wrap we used a spiral technique as described by Coutinho [6], always by the same researcher. The peak of force was acquired by CEFISE software at a 100Hz sampling frequency, during 3 seconds and 5 minutes between contractions and conditions. All conditions were randomized and collected in one session. All the data were analyzed with a customized program written in Matlab (Mathworks Inc., EUA). The peak of force was filtered with a 4th-order 10 Hz low-pass zero-lag, Butterworth filter.

Statistical Analyses

Normality and homogeneity of variances within the data were confirmed by the Shapiro-Wilk and Levene tests, respectively. To compare the effects of using knee wrap (WKW, SKW and HKW) a repeated measures ANOVA were employed. Post-hoc comparisons were performed by using the *Bonferroni* test. Cohen's formula for effect size (ES) was used and the results were based in the following criteria: <0.35 trivial effect; 0.35-0.80 small effect; 0.80-1.50 moderate effect; and >1.5 large effect, for recreational trained according to Rhea [8]. An alpha of 5% was used for all statistical tests. The ICC was test for all trials for each conditions (WKW= 0.96; HKW= 0.96; SKW= 0.98).

3. Results

There were significant differences between peak force and conditions: WKW and HKW (*P*=0.029, ES=1.27, Δ%=22%]) and WKW and SKW (*P*=0.038, ES=1.20, Δ%=21%]). However, it was not observed significant differences between kinds of knee wraps (*P*=0.98). Figure 1 shows the mean and standard deviations of the peck force values for the three testing conditions.

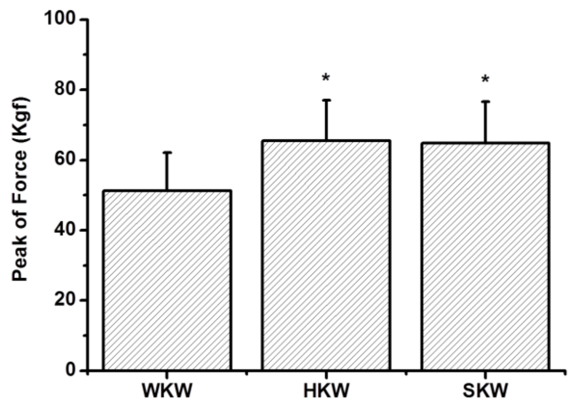

Figure 1. Mean ± standard deviation of the peak of force during isometric squat for different conditions (without knee wrap, high knee wrap and soft knee wrap, respectively). **P*<0.05

4. Discussion

The aim of this study was to compare the effect by using different models of knee wrap (hard and soft) in peak force of trained subjects while performing a maximum voluntary isometric contraction (MVIC) in the squat exercise. There were differences between the conditions HKW and WKW (P <0.029) and between conditions WKW x SKW (P <0.038), resulting in a *carry-over* of 22% (ES = 1.27) and 21% (ES = 1.20) respectively, corroborating the findings of Harman and Frykman [3].

Related to *carry-over* effect observed during our study, we could verify an increase in the external load, that was due to the elastic energy stored in the knee wrap material under mechanical deformation [6]. The knee wrap is composed of elastomeric material and polyester, and it has the ability to suffer large deformations and return elastically to its original shape, as springs. This elastic effect is due to the crosslink of the polymer, which, when stretched, results in a force capable of returning the material strands to their original conformations without any permanent deformation (plastic deformation) [9]. So, this elastic energy can be transferred into kinetic energy and added to the lifter [6].

Curiously, we did not observe any difference on the force of peak between the models of knee wrap (hard x soft). This similarity can be related to the number of laps to involve the knees. The soft knee wrap allowed a higher number of laps when compared to hard knee wrap (approximately, two laps). Probably, the higher number of laps, in the soft knee wrap, can result in a higher number of elastic fibers in parallel, adding elastic energy and compensating the greater resistance of the hard knee wrap [10]. This hypothesis is based on the principle of laminated composites cited by

Callister [9], which states that the sum of composite layers stacked one on top of the other, resulting in a relatively high resistance. According to specifications of the manufacturer both wraps are composed of 70% polyester and 30% elastodiene. However, factors such as the arrangement or orientation of the fibers have a significant influence on the strength and other properties of fiber reinforced composites [9]. It is important to emphasize that, for both models (SKW and HKW), we used the same placing technique by the same investigator. The present study analyzed the maximal isometric squat exercise aiming to verify the *carry-over* effect without elastic components of the muscle (stretch-shortening cycle, SSC). Previous studies analyzed the squat exercise with and without knee wrap in a dynamic condition. However, the *carry-over* effect can be influenced by the combination of both, SSC and elastic energy of the knee wrap [11], in addition to that the velocity of motion execution can affect the SSC response [12].

5. Conclusions

The acute effect on maximal isometric force during squat exercise was to present an effective carry-over during the squat exercise by using the knee wrap. For coaches, athletes and sport science practitioners the use of knee wrap under the presented conditions seem to increase the maximal isometric force during the squat exercise, independent of level from stiffness of knee wrap.

Conflict of Interest

There were no conflicts of interest for conducting this study.

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