

A PRIOR ISOMETRIC STRENGTH TRAINING INCREASES MUSCLE POWER PERFORMANCE OF JUDO ATHLETES

EXERCÍCIO PREPARATÓRIO DE FORÇA ISOMÉTRICO AUMENTA O DESEMPENHO DE POTÊNCIA MUSCULAR DE JUDOCAS

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RESUMO

A potência muscular, determinante nas lutas de judô, pode ser desenvolvida por exercícios de força de alta intensidade através de um mecanismo conhecido como potenciação pós-ativação. Sendo assim, o objetivo do presente estudo é verificar o efeito do agachamento em isometria no desempenho de judocas. A amostra foi composta por oito judocas ($22,3 \pm 3,5$ anos; $166,0 \pm 6,0$ cm; $65,4 \pm 7,0$ kg). Foi realizado quatro dias de testes, uma para sessão de familiarização, uma para a situação controle e duas para sessões experimentais. Nas sessões experimentais foi testado o efeito do exercício de agachamento guiado em contração voluntária isométrica máxima (CVIM) no desempenho do *Special Judo Fitness test* (SJFT) e do salto vertical com contra movimento (SCM). Na sessão controle foi realizado apenas o SJFT. O teste *T Student* pareado foi utilizado para comparar o desempenho entre as diferentes situações. Após a execução da CVIM foi observado um aumento significativo no número de arremessos no teste SJFT ($25,5 \pm 2,2$ vs. $26,8 \pm 2,2$ projeções) e na altura do SCM ($31,0 \pm 2,2$ vs. $33,3 \pm 2,2$ cm). O protocolo de exercício CVIM realizado como atividade preparatória aumentou o desempenho de atletas de judô em teste específicos do Judô / SJFT e de SCM.

Palavras-chave: Judô. Potenciação pós-ativação. Treinamento complexo.

ABSTRACT

Muscular power, a determinant in judo fights, can be developed by high intensity strength exercises through a mechanism known as post-activation potentiation. Thus, the objective of the present study is to verify the effect of isometric squat exercise on the performance of judo athletes. The sample was made up of eight judo athletes (22.3 ± 3.5 years old, 166.0 ± 6.0 cm; 65.4 ± 7.0 kg). The subjects went through four days of tests, one familiarization session, another as a control situation and two others as experimental sessions. In the experimental sessions, exercises in a Smith squat machine prior to the vertical countermovement jump (CMJ) test and a Special Judo Fitness Test (SJFT). In the control session, only SJFT was performed. Student's t test for paired samples was used to compare performances in the different situations. A significant increase was observed in the number of projections in the SJFT (25.5 ± 2.2 vs. 26.8 ± 2.2 projections) after MVIC and in the height in CMJ (31.0 ± 2.2 vs. 33.3 ± 2.2 cm). The MVIC exercise protocol performed as a preparatory activity increased the performance of judo athletes in judo-specific tests/SJFT and CMJ.

Keywords: Judo, post-activation potentiation, complex training.

Introduction

Judo is a combat sport characterized by throwing the adversary to the ground through unbalancing and projection. The performance of throws requires great strength and velocity from both the lower and upper limbs, with a predominance of the anaerobic energy pathway¹. Additionally, the number² and efficiency¹ of the throws seem to be related to the individual's muscular power^{1,2}. Detanico *et al.*² reported a significant positive correlation ($r=0.74$, $p \leq 0.05$) between countermovement jump performance and a specific test used to evaluate the performance of judo athletes in specific fight movements – the Special Judo Fitness Test (SJFT). This result indicates that the muscular power of the lower limbs in judo athletes is related to their capacity to perform this specific kind of movement and their performance in competitions.

Muscular power is determined from the product of strength and velocity, strength being that produced by a muscle group at maximum torque at a given velocity³. Power is determined by the optimal combination between strength and velocity produced by the muscles. Factors such as neural recruitment capacity, good use of the stretch-shortening cycle and the rate of release of energy through the anaerobic metabolic pathway may determine the power produced⁴. As a result, complex training has been investigated as an alternative to improve muscular power. The hypothesis here is that in this kind of training, performance improves due to an acute physiological mechanism called post-activation potentiation (PAP)⁵. Generally, complex training involves the performance of a high-intensity strength exercise (conditioning activity) (1 to 5 repetitions maximum – RM) followed by a plyometric exercise with similar characteristics^{6,7}.

Some studies⁵⁻⁸ have looked into the effect of PAP using complex training through the performance of high-intensity strength and plyometric exercises and reported a sharp increase in muscular power performance in specific tasks in judo athletes. Miarka *et al.*⁹ observed an improvement in performance in judo-specific activities, in the SJFT test, right after the performance of plyometric exercises either combined or not with the dynamic squat exercise. Although some authors found no improvement in performance in SJFT with only squats, others reported on the effect of the squat exercise on the performance in the countermovement jump¹⁰, indicating that performing the squat exercise may result in PAP in jump exercises.

Therefore, since the maximal isometric squat exercise can stimulate mechanisms involved in PAP and improve jump performance^{11,12}, a positive effect (better performance) on SJFT could also be expected. However, to the best of our knowledge, no study has reported so far on the effects of the maximal isometric squat exercise on SJFT.

It is important to bear in mind that the intensity of this judo training strategy in the literature available refers to a percentage of one repetition maximum (95% 1RM, for example)⁹. As a result more equipment and time is required to perform 1RM tests before this strategy can be applied in practice, which makes its implementation difficult. In contrast, if this potentiating effect from the maximal isometric squat exercise is observed in specific judo exercises, trainers and physical coaches might create simpler organization strategies (less equipment and time requirements) to implement complex training in their physical preparation routines. Thus, the aim of this study is to verify the effect of maximal isometric squats on the performance of judo athletes.

Method

Subjects

The study sample was made up of eight male state-competition-level judo athletes with 8 ± 2 years of judo practice (22.3 ± 3.5 years old, 166.0 ± 6.0 cm, 65.4 ± 7.0 kg, $10.3 \pm 5.8\%$ of body fat). This study was approved by the Research Ethics Committee of the Federal University of Minas Gerais (Opinion No. 54067816.3.0000.5149) and complies with Resolution No. 466/2012 of the National Health Council on research with human subjects. All volunteers gave their written informed consent for the study.

Experimental Design

In order to test the effect of the isometric squat exercise on SJFT performance, the athletes underwent familiarization with all the study procedures first. Next, they participated in three experimental sessions either with or without a maximal voluntary isometric contraction protocol. Besides testing the effect of maximal voluntary isometric contractions on SJFT, a judo-specific performance test, its effect on the power performance of the lower

limbs was also tested with a countermovement jump protocol. All experimental sessions were conducted between 08:00 and 10:00 a.m. and with 48-72-h intervals between sessions in a random balance design. The study was conducted in the Judo Training Center (Dojo) of the School of Physical Education, Physiotherapy and Occupational Therapy of the Federal University of Minas Gerais.

Each athlete performed ten countermovement jumps with 15-s recovery intervals between jumps in the first visit to the laboratory for familiarization. After a 10-min rest, the athletes were submitted to the maximal voluntary isometric contraction protocol in the squat exercise followed by the SJFT. The control athletes rested for 10 min and then did the SJFT test. In one of the experimental sessions, the athletes underwent the maximal isometric squat exercise protocol, followed by a 4-min rest and then did the SJFT. In another experimental session, the athletes performed the countermovement jump protocol before and 4 min after the maximal isometric squat exercise (Figure 1).

Both in all the experimental and familiarization sessions, the athletes performed a standardized preparatory activity, which consisted in running for 5 min around the dojo. The volunteers were instructed to run at low velocity, as they were used to doing in their routine training. After that, the athletes sat and rested for 10 min to recover. This preparatory activity was based on previous studies that also investigated the effects of PAP^{11,12} and was repeated in all experimental sessions in this study.

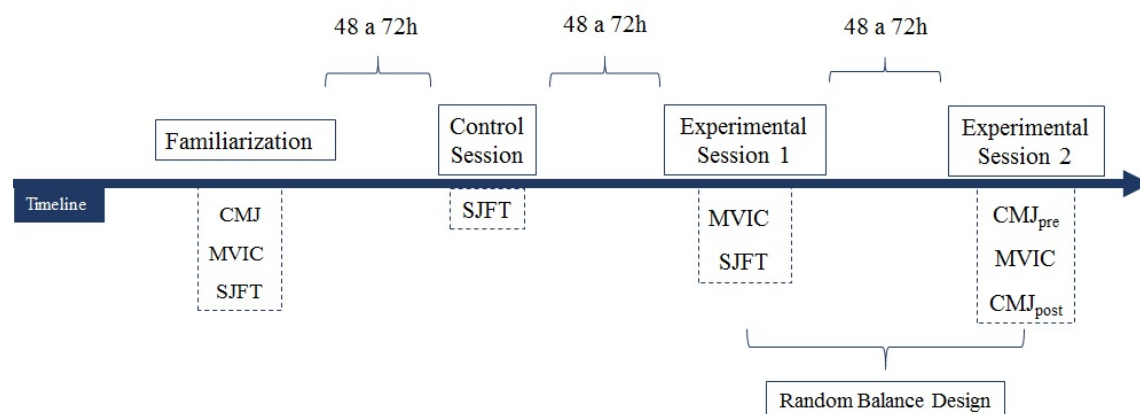


Figure 1. Chronologic sequence of the data collection sessions. Countermovement jump (CMJ), maximal voluntary isometric contraction (MVIC), Special Judo Fitness Test (SJFT)

Source: Authors

Special Judo Fitness Test (SJFT)

The SJFT was performed in the dojo. The athletes were instructed to perform the greatest number of throws possible in the time available in each series. The SJFT consists of two Ukes (the individual who will be projected) 6 m apart and a Tori (the individual who will perform the throw), 3 m away from each Uke. At a buzz, the Tori must run towards the Uke, perform the *Ippon-seoi-nague* projection technique and immediately run towards another Uke and perform the projection again¹³. The test is divided into one 15-s (A) and two 30-s (B and C) sessions with 10-s recovery intervals in between.

Heart rate (HR) was recorded immediately after the end of the test (HR_{final}) and after a 1-min interval (HR_{1min}) with a cardiofrequencimeter (Polar RS810i, Finland). The SJFT performance index was calculated using the test performance index given by equation:

$$\text{Index} = \text{HR}_{\text{Final}} + \text{HR}_{\text{1min}}/\text{Throws}$$

The lower the index, the better the performance, following the classification system proposed by Franchini *et al.*¹⁴: (≤ 11.7 – Excellent, 11.74 - 13.03 – Good, 13.04 - 13.94 – Average, 13.95 - 14.84 – Poor, >14.84 – Very Poor). Previous studies demonstrated that the SJFT has good reproducibility, an interclass correlation coefficient (ICC) of 0.88 for the total number of projections and of 0.84 for the test index¹³.

Isometric Squat

Maximal voluntary isometric contraction was performed in a Smith squat machine (Vitality[®], Brazil). The machine bar was locked for due retention and fixation in order to prevent movement. Each athlete stood under the bar with feet parallel and knee articulation angle fixed at 120° with a manual goniometer following a procedure previously used in this type of protocol¹². After the athlete's positioning and fixation of the bar, the athlete was instructed to exert the greatest strength possible to raise the bar by plantar flexion and knee, hip and column extension. The athletes performed three series with one repetition with contraction duration of 3 s and a 2-min interval between series.

Countermovement Jump

Countermovement jumps were performed on a smooth flat surface lined with a 0.1-cm accuracy contact mat (Hidrofit[®] Ltda; Brazil) connected to *Multisprint* (Hidrofit[®] Ltda, Brazil) software, as published elsewhere¹⁵. During the test, the athletes stepped onto the mat with feet in parallel and hands resting on the iliac crest, head up and looking straight ahead. The athletes were instructed not to change the position of the hands at any moment during the jump and to keep knees extended during the combat phase. When prompted to jump, the athlete should flex his/her knees to a comfortable amplitude and immediately jump vertically as high as possible. Only jumps performed following the test instructions were considered for analysis. Five jump attempts were performed and the average of the three values closest to the upper limit was considered in the jump performance analysis.

Statistical Analysis

The Shapiro Wilk and Levene tests were applied to verify the normality and homogeneity of variances. Student's t test for paired samples was used to compare: 1) the SJFT performance results (number of throws and test index) from the control and experimental sessions, 2) the jump performances before and after the maximum squat protocol. A significance level of $p < 0.05$ was used. Additionally, the size of the effect (ES - Cohen's D effect size) was calculated to verify the magnitude of the differences of jump performance, number of projections and SJFT index. In the effect size classification, we considered $ES = 0.20-0.49$ small, $ES = 0.50- 0.79$ moderate and $ES \geq 0.80$ great magnitude¹⁷. The results are given as mean $\pm$ standard deviation. All the analyses were performed with Windows software SPSS 13.0.

Results

The number of SJFT throws (25.5 ± 2 vs. 26.8 ± 2.2 throws, $p < 0.01$, $ES = 0.60$) (Figure 2A) and the performance evaluated by the test indexes – lowest indexes achieved (13.9 ± 1.4 vs. 13.0 ± 1.3 , $p < 0.01$, $ES = 0.61$) (Figure 2B) were checked after the maximal voluntary isometric contraction protocol in relation to the control. No significant difference was found

for HR_{final} and HR_{1min} between the control and the maximal voluntary isometric contractions (191 ± 9 vs. 190 ± 8 bpm; $p=0.61$ and 160 ± 16 vs. 158 ± 19 , $p=0.44$, respectively).

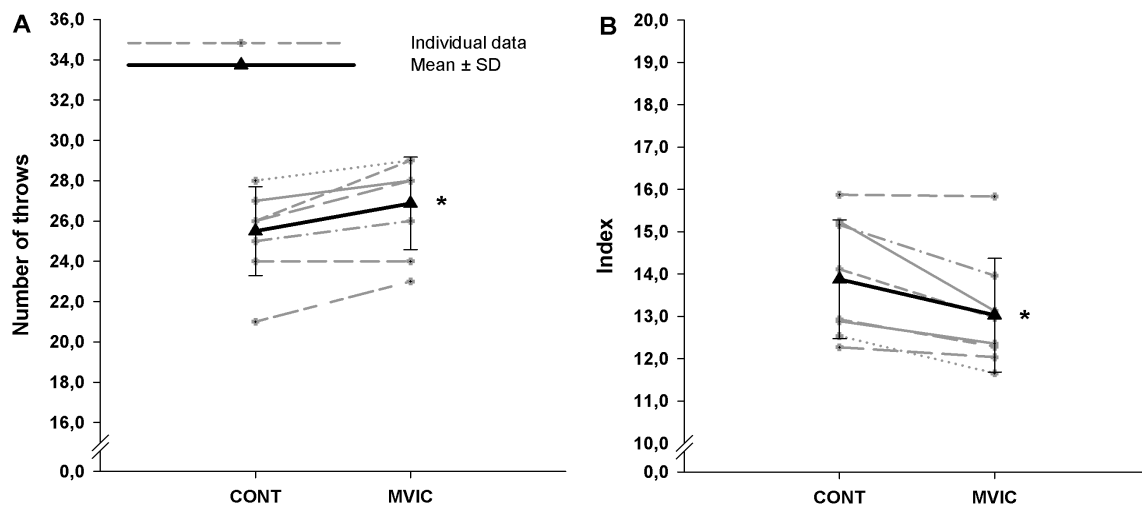


Figure 2. Number of throws in the Special Judo Fitness Test (SJFT) (A) and test index (B) of control (CONT) maximal voluntary isometric contractions (MVIC). #Significant difference in relation to CONT ($p < 0.05$)

Source: Authors

An improvement was also observed in countermovement jump performance after the maximal voluntary isometric contractions in the squat exercise (31.04 ± 2.24 vs. 33.34 ± 2.20 cm, $p < 0.05$, $ES = 0.13$) (Figure 3).

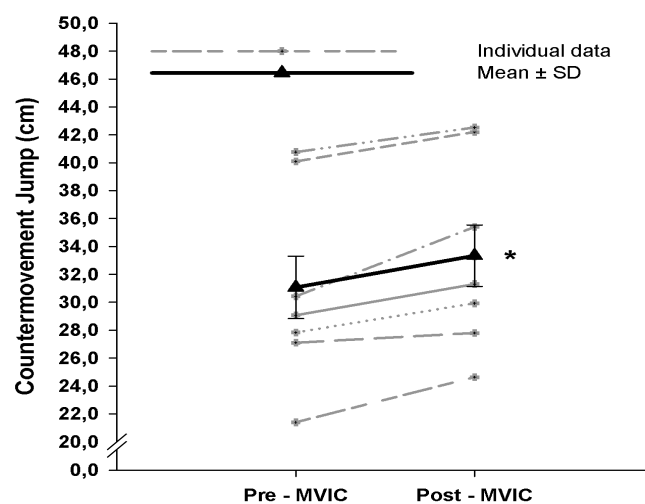


Figure 3. Jump height in the countermovement jump test before (PRE - MVIC) and after (POST - MVIC) the maximal voluntary isometric contraction (MVIC) protocol.

Note: * Significant difference in relation to PRE-MVIC ($p < 0.05$)

Source: Authors

Discussion

The results presented in this study demonstrate that the squat exercise with maximal voluntary isometric contraction improved the performance of judo athletes in a judo-specific test/SJFT and countermovement jump, thus confirming the initial hypothesis that a lower limb

maximal isometric contraction exercise may improve the physical performance of judo athletes in jump and judo-specific tests. The number of throws performed in SJFT was greater after the protocol performance, which resulted in a significant reduction on the SJFT index and indicates a potentiation effect on the test performance.

In contrast, Miarka *et al.*⁹ reported no similar effect with the dynamic squat exercise at 95% of repetition maximum, while in the present study, isometric squat was sufficient to produce a PAP effect in judo athletes with similar characteristics. This difference may be related to the characteristics of the protocol used, as well as to the interval between the preparatory activity and the tests. In a meta-analysis, Wilson *et al.*¹⁸ observed that the nature of the exercise (isometric or dynamic) did not affect the magnitude of PAP significantly, but that both exercise intensity and interval between stimulus and the main activity may influence the occurrence of PAP. Therefore, exercise intensity and the rest interval after the preparatory activity used in the present study may have influenced the occurrence of PAP and the improvement in the performance of the physical activity.

Other studies have also reported an improvement in jump physical performance after dynamic squat exercise^{6,8,19,20} and maximal isometric squat^{12,21}. Therefore, an increase in muscular strength and muscular power due to PAP may have increased the number of projections in SJFT as a function of the strength demand during the performance of the movement of projection of an opponent. In this technique (*ippon-seoi-nague*), the athlete needs to perform a hip and knee flexion in the preparatory phase of the technique and the projection. This movement is necessary so that the Uke can move his/her mass center to a position lower than the opponent's mass center²², since it is the knee extension that will raise the opponent. Therefore, we point out the importance of the lower limb power in the technique used in the test and the kinesiology similarity with the activity performed before the specific test. As a result, potentiating the production of strength in the knee and hip extension movement may directly influence the performance of the throw.

This increase in muscular strength and power may also explain the greater jump heights achieved after the maximum squat exercises in the present study. These results corroborate those from Rixon *et al.*¹², who compared the effects of dynamic and isometric squat on jump height and demonstrated that both squat protocols can induce PAP. However, despite the effect of the preparatory maximal isometric squat on physical performance attributed to a PAP effect, no specific instrument was used in this study to assess changes in neuromuscular variables.

Although not fully elucidated, PAP seems to result from a combination of mechanisms triggered at central and peripheral levels. Among the possible muscular mechanisms involved, the main one seems to be the phosphorylation of the regulatory myosin light chain, which alters the conformation of the cross bridges and places the globular heads in a position closer to the thin filaments of actin, thus increasing the possibility of interaction between the contractile proteins²³. Other possible mechanisms are an increase in the concentration of Ca^{2+} in the sarcoplasm²⁴, which may lead to an increase in the capacity to generate tension and alterations in the neural activation pattern, such as a greater excitability of the motoneuron pool²⁵, increasing the recruitment of motor units and the production of muscular strength.

The improvement in the test index after the maximal isometric squat protocol may have resulted from a change in various isolated or combined factors, such as an increase in the number of throws during the series (A, B and C), which may result in greater velocity, anaerobic capacity and/or efficiency in the throw performance, a lower HR at the end of the test, which represents a better cardiovascular efficiency for the same effort, a lower $\text{HR}_{1\text{min}}$ after the test, that is, a better recovery, which may represent an improvement in aerobic

capacity¹⁹. However, in the present study, the variable responsible for the improvement in the test index was the increase in the number of throws. The cardiac frequency values were not different after SJFT with or without the maximum contraction protocol.

Another factor that may influence the number of throws and the test index may be related to an increase in the running speed and movement after the experimental protocol, which may reduce the displacement time and increase the number of throws. The literature reports the potentiation of 10-m sprint performance after squat exercise²⁰. Thus, PAP may both contribute to improve SJFT performance as a result of an increase in muscular strength/power to perform the judo specific movement of throws and reduce the displacement time between throws. Nevertheless, one limitation of the current study is that these variables have not been measured. Further studies should be carried out to investigate the displacement and throw performance times and neuromuscular responses after the maximum isometric exercises so that the effect of the preparatory activity on the improvement of power in judo athletes could be better understood and the inclusion of this type of task in judo athlete training be emphasized to maximize training effects.

By demonstrating that the isometric squat exercise as a preparatory activity contributes to improve muscular power performance, as shown by the improvement in jump height and SJFT performance, this study may contribute to the daily practice of judo athletes, both in their training routine and in competition. As the muscular power performance influences the execution and efficacy of throws^{1,2}, performing a preparatory exercise with a smaller organization demand (smaller equipment and time requirements), but that effectively improves muscular power, may be an effective strategy in preparatory routine on competition days and contribute to improve the performance of competing judo athletes.

Conclusions

The present study has demonstrated that the squat exercise protocol with maximal voluntary isometric contractions can potentiate the performance of judo athletes in a judo-specific test and in countermovement jump. Therefore, the preparatory activity may have significant effects when the objective is to develop lower limb power in judo athletes and may be used to make up complex training of athletes and as a preparatory activity in competitions.

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