Acute Effects and Postactivation Potentiation in the Special Judo Fitness Test

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Abstract

Miarka, B, Del Vecchio, FB, and Franchini, E. Acute effects and postactivation potentiation in the special judo fitness test. *J Strength Cond Res* 25(2): 427–431, 2011—The purpose of this study was to compare the acute short-term effects of (1) plyometric exercise, (2) combined strength and plyometric exercise (contrast), and (3) maximum strength performance in the Special Judo Fitness Test (SJFT). Eight male judo athletes (mean ± *SD*, age, 19 ± 1 years; body mass, 60.4 ± 5 kg; height, 168.3 ± 5.4 cm) took part in this study. Four different sessions were completed; each session had 1 type of intervention: (*a*) SJFT control, (*b*) plyometric exercises + SJFT, (*c*) maximum strength + SJFT, and (*d*) contrast + SJFT. The following variables were quantified: throws performed during series A, B, and C; total number of throws; heart rate immediately and 1 minute after the test; and test index. Significant differences were found in the number of throws during series A: the plyometric exercise (6.4 ± 0.5 throws) was superior ($p < 0.05$) to the control condition (5.6 ± 0.5 throws). Heart rate 1 minute after the SJFT was higher ($p < 0.01$) during the plyometric exercise (192 ± 8 bpm) than during the contrast exercise (184 ± 9 bpm). The contrast exercise (13.58 ± 0.72) resulted in better index values than the control (14.67 ± 1.30) and plyometric exercises (14.51 ± 0.54). Thus, this study suggests that contrast and plyometric exercises performed before the SJFT can result in improvements in the test index and anaerobic power of judo athletes, respectively.

Key Words contrast method, judo, maximum strength, motor skills, plyometric exercises

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Introduction

During a judo match, through high intensity effort, athletes aim to wrestle their opponent to the ground or to obtain control during groundwork. Power for explosive attacks with integration of responses, intramuscular/intermuscular coordination, and correct timing are necessary for the effective application of techniques (12). Tests conducted to verify the performance of specific skills within a time structure similar to that of a judo match, such as the Special Judo Fitness Test (SJFT), can demonstrate the ability of athletes to meet the demands of specific tasks in matches and combat training (2,9,23). However, few studies have been conducted on training strategies that have short-term effects on the development of relevant motor units and increase the efficiency of different muscular movements in combat or during judo-specific training activities (20).

Some training exercises can result in acute short-term effects (AST). There is a close relationship between stimuli orientation and the ability of subjects to benefit from activation exercises with dynamic overload (10,19). If AST results in an increase in strength performance as a response to voluntary muscular activity, it is called postactivation potentiation (PAP) (19). Postactivation potentiation seems to result when excitation of the central nervous system produces an increase in contractile function due to a heavy conditioning stimulus (18). The methodological strategy used to explore PAP generally involves the execution of maximum or submaximum, dynamic, or static strength exercises (12,17). In addition, plyometric muscular movements seem to be equally capable of initiating fast muscular strength potentiation (8,11,14,16,17). Some researchers agree that plyometric training improves the power and dynamic performance of athletes, primarily when it involves the stretch-shortening cycle and increases movement speed. Implementation of such training has been shown to improve coordination and synchronization between muscle groups for simple motor tasks in sports such as volleyball, basketball, and speed running (8,16).

However, there is a considerable lack of information about PAP in combat sports such as judo, where power development is considered to be very important for competitive performance. Therefore, this study intends to compare the effects of different ASTs (maximum strength, plyometric, and contrast) on the execution of specific judo exercises using the SJFT as a performance test.

METHODS

Experimental Approach to the Problem

This was a randomized study where subjects participated in 2 control sessions and 3 experimental sessions. The control sessions were set up to determine the performance in the SJFT and to establish maximum dynamic strength (1RM) during squat exercise. Subjects then had to perform the SJFT after 3 different conditionings on different days (Figure 1). Tests were conducted between 2:00 PM and 4:00 PM at an average room temperature of 28°C. A minimum of 48 hours of rest was observed between tests to avoid interference between different interventions. All participants had previous experience with the tests and procedures used in this study.

Subjects

The sample was composed of 8 brown-belt adult male athletes who had competed at state-level competitions. The participants' characteristics were as follows (mean ± *SD*): age 19 ± 1 years; height 168.3 ± 5.4 cm; body mass 60.4 ± 5.0 kg; judo practice time 6 ± 1 years. The study was conducted at the end of the competitive period. This study was submitted to and approved by the Committee of Ethics in Research at the State University of Londrina under protocol number FR–112997, following the rules of resolution 196/96 of the Brazilian National Health Council. All study participants took part voluntarily after being informed about the risks and benefits of the procedures involved and signed an informed consent form that was previously approved by the Ethics Committee.

Procedures

The study was conducted at the judo training facility (Dojo) at the Centre of Physical Education and Sports at the State University of Londrina (UEL). Therefore, interventions that took place before the test were conducted in the same building to avoid the need for excessive transport between the treatments and tests.

Protocols and Tests

Special Judo Fitness Test Protocol. This test was developed by Sterkowicz (23) and was previously described by Franchini et al (9) and Artioli et al (2). Three athletes of similar body mass are needed to perform the SJFT: 1 participant (tori) is evaluated, and 2 other individuals receive throws (ukes). The tori begins the test in a position between the 2 ukes who are standing 3 m away from each other. On a signal, the tori runs to one of the ukes and employs a throwing technique called ippon-seoi-nage. The tori then immediately runs to the other uke and completes another throw. The athlete must complete as many throws as possible within the test time. The SJFT is composed of 3 periods (15 seconds, 30 seconds, and 30 seconds) separated by 10 seconds recovery intervals. Performance is determined by the total number of throws completed during each of the 3 periods. Heart rate is measured immediately after and 1 minute after the test and the following index is calculated as follows:

$$\text{Index} = (\text{HR after} + \text{HR 1 minute after}) / \text{number of throws}$$

The index value decreases with better the test performance. To increase heart rate measurement accuracy, a Polar Vantage Night Vision (Polar Electro Oy, Finland) monitor was used. Reliability values for this test was reported as 0.97 (23), although we observed an intraclass correlation coefficient of 0.89 when evaluating athletes with similar performance levels as those who took part in this study.

One Repetition Maximum Protocol. Maximum dynamic strength for the squat exercise was assessed using free weights. The positioning of the subject's body and feet were recorded. The 1RM squat test was performed according to standard procedures (5). Briefly, subjects ran for 5 minutes on a treadmill at 9 km/h, followed by lower limb stretching

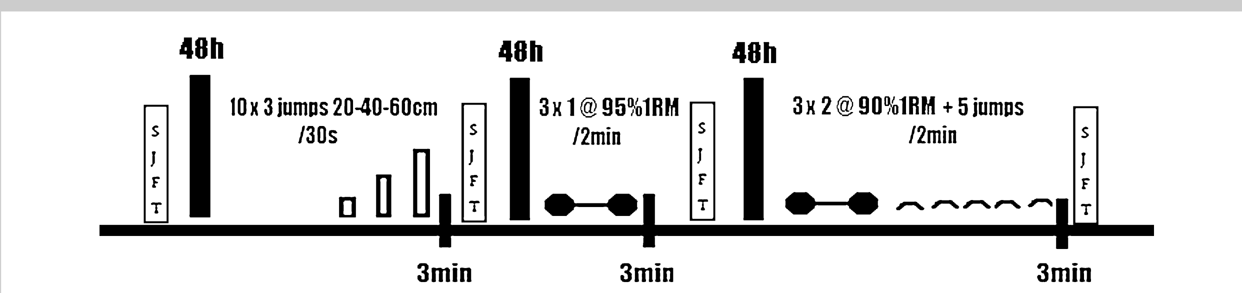

Figure 1. Intervention design protocol. Subjects performed the SJFT, symbolized by white bars all days of experiment, including a control section. The rest of interventions are presented after the black bars–first plyometric vertical jumps; second maximal loads, and; third contrast method. SJFT = Special Judo Fitness Test.

Table 1. Number of throws, heart rate and index in the SJFT during each procedure ($n = 8$).

Condition	Series A	Series B	Series C	Total	Index	HR After	HR 1 Minute
Control SJFT	5.7 ± 0.5	9.7 ± 0.5	8.4 ± 0.5	23.7 ± 1.4	14.49 ± 1.30	187 ± 11	154 ± 11
P + SJFT	6.4 ± 0.5*	9.6 ± 0.5	8.4 ± 0.5	24.3 ± 1.0	14.51 ± 0.54	192 ± 8†	159 ± 7
MS + SJFT	6.3 ± 0.5	9.7 ± 0.5	8.6 ± 0.8	24.3 ± 1.5	14.06 ± 0.77	188 ± 12	154 ± 5
CE + SJFT	5.7 ± 0.5	10.1 ± 0.9	8.4 ± 0.5	24.3 ± 1.7	13.58 ± 0.72‡	184 ± 9	144 ± 6§

Data are expressed as mean ± *SD*.
*Different from control condition ($p < 0.05$).
†Different from contrast exercise condition ($p < 0.05$).
‡Different from control and plyometric conditions.
§Different from all other conditions.
HR = heart rate; Control SJFT = Special Judo Fitness Test performed in a control condition; P + SJFT = Special Judo Fitness Test performed after a plyometric exercise procedure; MS + SJFT = Special Judo Fitness Test performed after a maximum strength procedure; CE + SJFT = Special Judo Fitness Test performed after contrast exercise procedure.

exercises and 2 squat warm-up sets. In the first set, individuals performed 5 repetitions with 50% of the estimated 1RM, and for the second set, they performed 3 repetitions with 70% of the estimated 1RM, with 3-minute intervals between them. After the second warm-up set, subjects rested for 3 minutes and then had up to 5 trials to achieve the 1RM load (ie, maximum weight that could be lifted once with proper technique), with a 3–5 minutes interval between trials. The 1RM value was used to calculate the loads on sets 2 and 3.

Control SJFT. Participants were separated into groups of 3, with similar body masses and heights. After 30 minutes of rest, the SJFT was performed.

Plyometric Intervention (P + SJFT)

Subjects went through 10 series of 3 consecutive jumps stepping off an elevated surface and landing as quickly as possible. Then, they performed a maximal vertical jump onto the next platform, with an interval of 30 seconds between series. Increasing heights were used, with benches starting from 20 cm to 40 cm and to 60 cm. Athletes executed 3 consecutive jumps with legs together. Three minutes later, athletes executed the SJFT.

Maximum Strength Intervention (MS + SJFT). Before the exercises, training loads for each subject were determined through the maximum squat repetition test (1RM) during the same week as the experimental tests were conducted but on nonconsecutive days. The applied stimulus consisted of 5 series of lifts with 1 repetition at 95% of 1RM and 2-minute interval between series. The intervals between the squat exercises and the SJFTs were 3 minutes (1).

Contrast Exercises (CE + SJFT)

For this exercise, alternating and consecutive stimuli were used on a series of maximum strength squat exercises together with reactive strength (plyometric) exercises. Combined exercises consisted of 3 squat series with 2 repetitions (with 90% maximum load) followed by 5 horizontal jumps with legs together with 2-minute rest intervals.

Statistical Analysis

Measures of centrality and dispersion are shown as mean ± *SD*. ANOVA with repeated measures was conducted to compare measured variables. A Mauchly's test of sphericity was used to check the repeated measurement analysis of variance. When differences were detected, the Tukey test was used as a posthoc test to identify specific differences between the intervention protocols, with a significance level of $p \leq 0.05$. Power was calculated for all the differences observed. All analyses were conducted using SPSS 13.0 for Windows.

Results

Table 1 presents the main results of the SJFT for each procedure:

A significant difference was found in the number of throws performed during series A ($F(3,21) = 5.75$; $p < 0.01$; observed power = 0.90). The posthoc test indicated a significant ($p < 0.05$) difference between the plyometric procedure compared with control conditions. No other significant differences were found in the number of throws among different procedures. Heart rate after the SJFT varied among exercises ($F(3,21) = 4.01$; $p < 0.01$; observed power = 0.77), with a higher ($p < 0.05$) value after the plyometric procedure than after the contrast exercise. Heart rate 1 minute after the SJFT varied among exercises ($F(3,21) = 11.6$; $p < 0.001$; observed power = 1.0), with a lower value ($p < 0.01$) after the contrast exercise than after all other exercises. The index also varied among exercises ($F(3,21) = 4.9$; $p < 0.01$; observed power = 0.84). The contrast exercise resulted in lower (better) values than the control conditions and plyometric exercises ($p < 0.05$).

Discussion

The results of this study suggest that plyometric exercises performed before the SJFT test, a closed but complex task exercise, may have a significant influence on performance improvement in male judo athletes during the first 15 seconds of the test. A series of consecutive jumps with increasing heights (20 cm, then 40 cm, and 60 cm) indicate the optimal state to maximize the PAP effect on the first phase when compared with the control condition. The volume of plyometric exercises used in this research was kept high, with high intensity and short durations. This can increase both fatigue and a potentiated muscular state, consequently leading to future optimal muscle performance (10).

Plyometric exercises with jumps tend to raise motor efficiency in the execution of maximum repetition during exercises (8). Some authors suggest that this can result in an increase in neural stimulation of the muscle and subsequently improve the production of power (15). These findings suggest that plyometric exercises can enhance neural stimulation to a level that will significantly increase in the first phase of SJFT because higher threshold motor units are recruited only when high power outputs are demanded (13). However, this procedure did not show significant differences from the other exercises used in this investigation even though it was the only 1 that presented an improved performance when compared with control conditions.

Several studies on AST examined the effectiveness of PAP on subsequent power output in both the upper and lower body with conflicting results (3,4,21). For example, research done on football players showed that performance gain after high intensity squats (3 repetitions at 90% of maximum load) registered a decrease in time for a 40-m run (14). Young et al. (25) demonstrated that a loaded countermovement jump improved by 2.8% when it was preceded by 1 set of half squats with a 5RM load, and these findings have been verified by numerous studies (3,4,6). These investigators reported that lifting heavier loads, a common strategy in the postactivation theory, could be used for neuromotor recruiting (3,8). However, some studies have found no effect or even a slight decrease in power outputs after the preload stimulus (4,6,11).

In this study, a nonsignificant effect was found for maximum load exercises alone. This could probably be due to the limited rest time of 3 minutes between the series and the SJFT. However, this methodological limitation has also been encountered in other studies, specifically the training status of subjects. Additionally, previous reports have used recovery periods ranging from 0 to 18.5 minutes (3,4,25). Ebben et al. (6), in the only study that examined this variable directly, used various recovery periods (10 seconds and 1, 2, 3 and 4 minutes) and reported no significant difference between the power output at any point after the preload stimulus and the power output before the preload. Furthermore, the authors suggest that training status, strength, and skill level might be key determining factors for the positive benefits of PAP during performance (22,24).

According to some authors, the coexistence of fatigue and PAP is relative, and plausible reasons for unclear results might be the differences in the training status of subjects (4,8,25). Although increases in recruiting, potentiation and exhaustion have opposing effects, some studies have explained that the interaction between them does influence the manifestations of strength in different ways without altering their performance (6).

Previous studies showed that inducing PAP before competition can help athletes more than traditional warm-up (only little running and some stretching exercises) and enhance their performance in explosive activities, such as jumping, throwing, and sprinting (24). Athletes who are used to weight training may have improved intramuscular coordination for higher loads (13) and, therefore, may be more likely to benefit from the ASTs used in this study. Despite the fact that changes in the pennation angle warrant further investigation, the decrease in this angle and the increase in connective tissue/tendon compliance act to increase force transmission (13), which may explain the improvement in SJFT test performance after plyometric AST.

From a judo training perspective, it is important to determine the PAP that could facilitate peak performance. Achieving maximal power production is the goal of athletes who participate in judo competitions. This research, by using a contrast method, observed the positive influence of the exercises on SJFT performance, namely an increase in the number of throws.

A series of physiological responses that occurred with the exercises can influence organic adjustments in the cardiovascular system. In this study, heart rate measured 1 minute after the SJFT during the plyometric exercise was higher than in the contrast exercise. This can be explained by the higher number of repetitions used in the former exercise as compared with the latter. The data from this study suggest the need for more investigations into the application of PAP in aiding athletic performance in judo because the relationship between the level and method of potentiation necessary to improve judo performance is variable and not entirely clear at this time.

The effectiveness of acute plyometric training in improving explosive performance has been supported by different studies (10,19,21). Furthermore, when traditional strength training is combined with plyometric exercises, better adaptations in power related measurements are reported (8,13). To the best of our knowledge, no other studies compared the cardiovascular measurements and the time to recover during intermittent tasks, as is the case in a judo players' performance. This research showed significant improvement in the index proposed by Sterkowicz (23) when comparing the effects of contrast exercise with the effects of plyometric exercises or control conditions. This result can be interpreted as an effect of the better recovery. It has been suggested that contrast effects would induce an advantage in combat, where the athlete must perform many high intensity tasks with little time to recover (2,9,23).

Practical Applications

Identifying the occurrence of PAP and the effects of different ASTs can lead to improvements in coordination and synchronization between muscular groups. However, the specificity of judo has not been considered so far. Therefore, this research aimed to compare the effects of different ASTs (maximum strength, plyometric and contrast) on the execution of specific judo exercises using the SJFT as an evaluation instrument.

Significant differences were observed during the first phase (15 seconds) of the test. This suggests that different training methods may develop postactivation potentiation effects in the short term. This makes the execution of ASTs before exercises similar to SJFT, such as nage komi, a very interesting method of obtaining improvement in power in a short period of time. No acute negative effects were found on the ASTs, nevertheless, it remains unknown whether the same results would be found in open task situations, such as during combat.

Improving muscle function and athletic performance is of the utmost importance for judo players. Furthermore, plyometric exercises were observed to have positive influences on performance. This study found better results in the index test when judo players conducted the contrast exercise. It has been suggested that contrast effects would induce an advantage in combat where the athlete must perform many high intensity tasks with little time to recover.

The results of this study suggest the need for more studies with different training methods before combat situations. In addition, based on the specific plyometric procedures observed in this investigation, this study concluded that the level of cardiovascular stress elicited by continuous plyometric training is high enough to stimulate cardiovascular training response after SJFT when compared with contrast training.

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