Can Different Conditioning Activities and Rest Intervals Affect the Acute Performance of Taekwondo Turning Kick?

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Abstract

da Silva Santos, JF, Valenzuela, TH, and Franchini, E. Can different conditioning activities and rest intervals affect the acute performance of taekwondo turning kick? *J Strength Cond Res* 29(6): 1640–1647, 2015—This study compared the acute effect of strength, plyometric, and complex exercises (combined strength and plyometric exercise) in the countermovement jump (CMJ) and frequency speed of kick test (FSKT) and attempted to establish the best rest interval to maximize performance in the CMJ, number of kicks, and impact generated during FSKT. Eleven taekwondo athletes (mean ± *SD*; age: 20.3 ± 5.2 years; body mass: 71.8 ± 15.3 kg; height: 177 ± 7.2 cm) participated. One control and 9 experimental conditions were randomly applied. Each condition was composed of warm-up, conditioning activity (half-squat: 3 × 1 at 95% 1RM; jumps: 3 × 10 vertical jumps above 40-cm barrier; or complex exercise: half-squat 3 × 2 at 95% 1RM + 4 vertical jumps above 40-cm barrier), followed by different rest intervals (5-, 10-minute, and self-selected) before CMJ and FSKT. The conditions were compared using an analysis of variance with repeated measures, followed by Bonferroni's post hoc test. The alpha level was set at 5%. Significant difference was found in the number of kicks ($F_{9,90} = 1.32$; $p = 0.239$; and $\eta^2 = 0.116$ [small]). The complex method with a 10-minute rest interval (23 ± 5 repetitions) was superior ($p = 0.026$) to the control (19 ± 3 repetitions), maximum strength with a self-selected rest interval (328 ± 139 seconds; 18 ± 2 repetitions) ($p = 0.015$), and plyometric with a 5-minute rest interval (18 ± 3 repetitions) ($p < 0.001$). Our results indicate that taekwondo athletes increased the number of kicks in a specific test by using the complex method when 10-minute rest interval was used.

Key Words heavy strength exercise, plyometric exercise, complex exercise, rest interval, kick impact

Introduction

During taekwondo matches, 98% of scores are obtained through kick techniques, which are highly intense actions (15). Because of the introduction of the electronic trunk protector, the development of speed and power during the kick techniques execution is extremely necessary to achieve optimal performance in taekwondo. The electronic trunk protector activates when it detects minimal impact, variable according to weight category (2). The main technique used during taekwondo matches is the turning kick known as *bandal tchagui* (15). In this technique, speed is a key element for avoiding a proper reaction from the opponent, i.e., defense action or counterattack. Thus, if the *bandal tchagui*'s velocity or force improves, the probability of scoring increases. Recently, researchers have investigated how to improve performance of the turning kick (4–7,13,22). Tests such as speed of kick test (25) and frequency speed of kick test (FSKT) (25,26) are conducted to investigate speed during taekwondo-specific skills. To date, few studies have investigated taekwondo acute performance during training situations using specific skills (25,26).

Postactivation potentiation (PAP) is an acute short-term effect designed to improve athletic performance (23). Variables such as rest intervals before the main activity and the characteristics of exercises used in conditioning activities can influence performance (23,27). According to a recent meta-analysis (27), rest intervals from 0 to 24 minutes were used in previous investigations, and the optimal rest interval is considered to be 3–12 minutes.

However, few studies have investigated the effect of different rest intervals by using independent experimental sessions (11,23,27), i.e., likely an additive effect took place in many studies. The exercises most used during conditioning

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29(6)/1640–1647

Journal of Strength and Conditioning Research

activities are squats (moderate and heavy load), jumps, and the complex method (high-intensity exercise followed by plyometric exercises) (11,27).

Postactivation potentiation manifestation was investigated in combat sports, e.g., in judo (20) and taekwondo (25,26) athletes. Results showed that taekwondo athletes can improve the velocity in the turning kick between 8 and 17% after acute exposure to strength exercises (25,26). However, the lack of randomization between the conditioning activities investigated might have affected the results (25,26). Additionally, the effect of different conditioning activities and rest intervals afterward have not been studied, and no study attempted to determine whether athletes were able to choose an optimal interval between conditioning activity and performance activity. Therefore, this research proposes to investigate the effect of different conditioning activities on countermovement jump (CMJ) performance, number of kicks and impact generated during the FSKT, and to determine the optimal rest interval. The hypothesis is that a positive PAP effect would be observed after the conditioning activities with 10-minute rest interval and that athletes would choose proper rest intervals to maximize their performance.

Methods

Experimental Approach to the Problem

This study used a within-subject repeated-measures research design to investigate the effect of conditioning activities and rest intervals on CMJ and FSKT. Athletes were submitted to a control and 3 conditioning activities (strength condition, plyometric condition, and complex condition). After each experimental condition, athletes self-selected their rest interval or rested for 5 or 10 minutes. Thus, a total of 1 control and 9 experimental conditions (i.e., 3 conditioning activities × 3 rest intervals) were performed by each taekwondo athlete. For each condition, after a general warm-up, the taekwondo athletes performed a control condition or 1 experimental condition (strength condition, plyometric condition, complex condition), followed by the execution of CMJ and FSKT. Before the execution of the CMJ and FSKT, 5-, 10-minute, or self-selected rest intervals were applied. The study was conducted in 5 different days, with 2 conditions per day. A 90-minute rest interval was given between 2 experimental conditions conducted in the same day and 48 hours between days. All conditioning activities and rest intervals were randomly determined.

Subjects

Eleven black-belt taekwondo athletes (mean ± *SD*, age: 20.3 ± 5.2 years; height: 177 ± 7.2 cm; body mass: 71.8 ± 15.3 kg; maximum dynamic half squat (1RM): 136.4 ± 30.7 kg and practice time: 9.6 ± 7.2 years) volunteered to participate in this study and provided written consent after being informed about the procedures and risks associated. No subjects were under 18 years of age. The athletes were competing at a state or more prominent level (international: 73%; national: 9%; state: 18%) and resistance trained 1 to 3 times per week–depending on their periodization phase–for a minimum of 1 year, and taekwondo sessions 5 ± 1 times per week, with 2 hours of duration per session. They were free from any lower injury and neuromuscular disorder. The research was approved by the Institutional Ethics Committee.

Experimental Procedures

This was a single-group repeated-measurements study, where the athletes were submitted to 1 control and 9 experimental conditions (Figure 1).

After a familiarization session to all tests involved in the study and a test session to determine the half-squat 1-repetition maximum (1RM), athletes were submitted to the 10 experimental conditions. This study took 4 weeks. In the first week, the subjects visited the laboratory to be familiarized with the conditions, tests, and all procedures. In the second week, the subjects performed the 1RM test (1). During the third and fourth weeks, the subjects performed 1 control and 9 experimental conditions following the practice of CMJ and FSKT (Figure 1). The purpose of the control condition was to determine the performance in CMJ and in FSKT. After a general standardized 5-minute warm-up (i.e., running on a treadmill at 9 $km \cdot h^{-1}$), athletes were given a 2-minute rest interval. The subjects were then required to perform 1 conditioning activity as follows: (a) half-squat: 3 sets × 1 repetition at 95% 1RM/3-minute rest interval between sets; (b) jumps: 3 sets × 10 vertical jumps (40-cm)/30-second rest interval; and (c) complex exercise (half-squat + jumps): 3 sets × 2 repetitions at 95% 1RM + 4 vertical jumps/3-minute rest interval. Before the execution of the CMJ and FSKT, 5-, 10-minute, or self-selected rest intervals were applied.

All conditioning activities and rest intervals were randomly determined. Right before each experimental condition, the subjects reported their recovery using the rating of perceived recovery (RPR) scale (16). Thirty minutes after finishing each experimental condition, all subjects reported their session rating of perceived exertion (session-RPE) (9). The dependent variables were the maximal CMJ height, number of kicks, and maximal impact of kicks. These variables were chosen because they represent the athlete's muscular power performance and were used in other studies that investigated the PAP (11,14,27). A 90-minute rest interval was given between 2 experimental conditions conducted in same day and 48 hours between days (Figure 1). All participants had previous experience with the procedures used in this study and were tested in the competitive phase of their periodization.

Warm-up and Exercise Conditions

Warm-up. All experimental procedures were started by warming-up for 5 minutes on a treadmill at 9 $km \cdot h^{-1}$. After the warm-up, the athletes waited for 2 minutes and started the CMJ and FSKT.

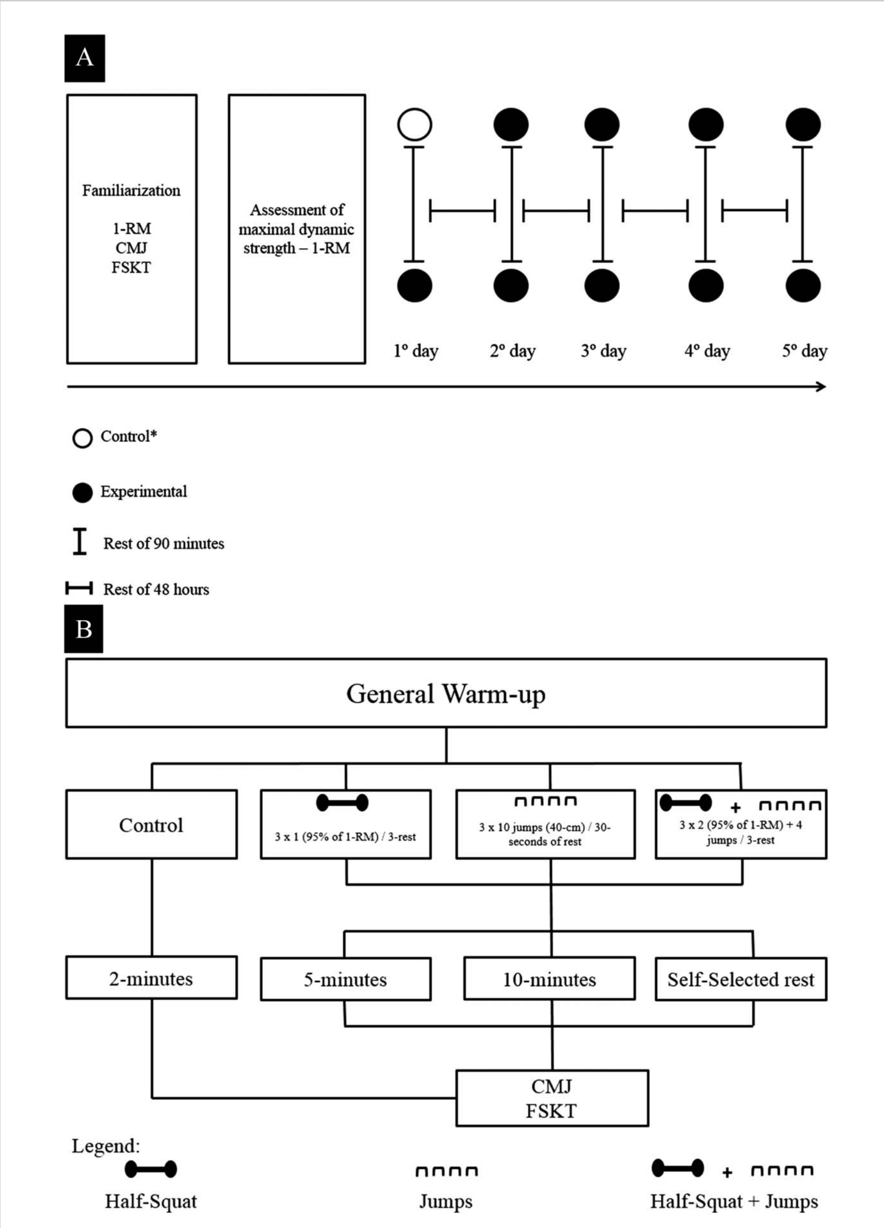

Figure 1. A) Experimental design. B) Conditions and procedures performed. *The order of the experimental and control conditions was randomly determined.

Strength Condition (Half-Squat Exercise). This condition involved the 1RM half-squat exercise to determine the load. The condition included 3 sets of 1 repetition at 95% 1RM. The rest interval between sets was 3 minutes. After subjects completed the exercise condition, they waited for 5-, 10-minute, or self-selected rest intervals. The order of rest intervals was randomly determined.

Plyometric Condition (Plyometric Exercise). The subjects performed 3 sets of 10 vertical consecutive jumps as fast as possible. The jump was performed above a 40-cm barrier. The rest interval between sets was 30 seconds. After subjects completed the exercise condition, they rested 5-, 10-minute, or self-selected rest interval. The order of rest intervals was randomly determined.

Complex Condition (Half-Squat and Plyometric Exercise). This condition involved the execution of 3 sets immediately followed by 4 vertical jumps above a 40-cm barrier. Resting interval between sets was 3 minutes. After subjects completed the exercise condition, they rested for a 5-, 10-minute, or self-selected rest interval. The order of rest intervals was randomly determined.

Performance Assessments

One-Repetition Maximum Test. The maximal dynamic strength was measured for lower body using half-squat exercise. All the subjects performed a familiarization session before the 1RM session using the Olympic barbell (20 kg) and free weights. The position of half-squat movement was performed according to standard procedures (21). General warm-up consisted of 5 minutes on a treadmill at 9 $km \cdot h^{-1}$ followed by a 3-minute rest interval. Then, the subjects performed 2 sets of the half-squat exercise. The first set consisted of 8 repetitions with 50% of the estimated 1RM followed by a second set of 3 repetitions at 70% of the estimated 1RM, with 3-minute rest interval between sets. The 1RM load was obtained after a maximal of 5 attempts (1).

Counter Movement Jump. The CMJ was performed on a contact platform (Axon Jump; Axon Sports Bioengineering, Buenos Aires, Argentina). Each subject performed 3 CMJ attempts. Both the maximal jump height and the mean jump height were considered for analysis.

Frequency Speed of Kick Test. The FSKT had the duration of 10 seconds. To perform the FSKT, each athlete was placed in front of the stand bag equipped with a taekwondo trunk protector (TK-Strike Protector, Daedo, Barcelona, Spain) (Figure 2A). After the sound signal, the subject performed the maximal number of kicks as possible, alternating right and left legs (Figure 2B). The body protector was activated when the sensors positioned in the socks touched the sensors positioned in the body protector. For each weight category and gender, there is a specific minimum impact value that should be achieved for the technique to be validated as a score (2). For the athletes from different weight categories who participated in the presented study, the minimum impact was 34 ± 3 arbitrary unit. The technique used during the test was the turning kick (*bandal tchagui*). The performance was determined by the total number of kicks and the maximal impact generated during the test. The reliability presented for this test was reported above as ranging from $r = 0.76$ to 1 (25) and from 0.82 to 0.86 (26).

Rating of Perceived Recovery. This approach has been used as a parallel approach to the RPR to assess the level of athlete's recovery. The RPR scale proposed by Laurent et al. (16) was applied before the beginning of either experimental or control conditions. The main purpose of this particular scale is to detect early signs of overtraining (16). However, in this study, it was used to detect whether the athletes had a different perception of their recovery before the different experimental conditions. The RPR scale is of 0 (very poorly recovered/extremely tired) to 10 (very recovered/highly energetic), similar to that of an RPE scale, representing varying levels of an individual's level of RPR. Based on the RPR scale, it is expected decreased performance for values between 0 and 2, maintained performance for values between 3 and 6, and enhanced performance for values between 7 and 10 (16).

Session Rating of Perceived Exertion. The session-RPE scale (CR-10) proposed by Foster et al. (9) was applied 30 minutes after finishing the experimental condition or control conditions. The instruction on the use of perceived exertion scale was read to the participants before the test. The subjects

Figure 2. Stand bag with a taekwondo trunk protector (A) and frequency speed of kick test execution (B).

Table 1. Countermovement jump (CMJ), frequency speed of kick test (FSKT) repetitions, and impact generated after different experimental procedures ($n = 11$).*†

Experimental condition	RPR	CMJ_{max} (cm)	CMJ_{mean} (cm)	FSKT (reps)	Impact (au)	Session-RPE
Control	9.7 ± 0.5	37.5 ± 4.0	36.1 ± 4.1	19 ± 3	57.4 ± 6.4	7.1 ± 1.8
Half-squat						
5-min	8.8 ± 1.0	37.2 ± 5.6	36.2 ± 5.7	20 ± 3	60.9 ± 4.3	7.7 ± 1.9
10-min	9.2 ± 1.1	37.5 ± 5.7	36.1 ± 5.6	19 ± 4	57.5 ± 6.2	7.6 ± 2.1
Self-selected rest interval	8.7 ± 1.4	37.0 ± 4.4	35.7 ± 4.7	18 ± 2	58.5 ± 5.0	7.3 ± 2.4
Plyometric exercise						
5-min	7.4 ± 2.5‡	36.7 ± 5.1	35.8 ± 5.3	18 ± 3	58.6 ± 5.5	7.3 ± 1.4
10-min	8.4 ± 1.2	36.7 ± 5.4	35.9 ± 5.6	19 ± 3	57.1 ± 4.8	6.9 ± 1.5
Self-selected rest interval	8.0 ± 1.5	38.4 ± 5.0	37.2 ± 4.9	19 ± 3	58.0 ± 6.6	7.0 ± 1.0
Half-squat + plyometric						
5-min	8.6 ± 1.2	37.7 ± 5.0	36.8 ± 4.5	19 ± 3	57.5 ± 5.7	6.7 ± 1.1
10-min	9.0 ± 1.3	38.3 ± 4.8	37.0 ± 4.6	23 ± 5§	61.9 ± 6.0	7.1 ± 1.1
Self-selected rest interval	8.6 ± 1.0	38.4 ± 5.1	37.2 ± 5.0	20 ± 3	60.9 ± 5.8	6.6 ± 1.2

*RPR = rating of perceived recovery; CMJ_{max} = better jump of each subject; CMJ_{mean} = mean of tree jumps of each subject; au = arbitrary unit; Session-RPE = rating of perceived exertion of the training session.
†Data are presented as mean ± *SD*.
‡Different from the control conditioning.
§Different from the control conditioning, squat with self-selected rest and jump with 5-minute rest.

were asked how much they perceived the exertion. The session-RPE is a 0 (rest)–10 (maximal) scale.

Statistical Analyses

Data are presented as mean ± *SD*. The Greenhouse-Geisser test was used to verify the sphericity. Mauchly's test was used when necessary. Experimental conditioning comparisons were conducted using analysis of variance 1-way with repeated measure. When differences were detected, Bonferroni's test was used as a post hoc. All analyses were conducted using the alpha = 5%. The effect size were calculated using the eta squared (η^2) and classified using the following scale (10): <0.2 (trivial); 0.2 to <0.6 (small); 0.6 to <1.2 (moderate); 1.2 to <2.0 (large); 2.0 to <4.0 (very large); and ≥4.0 (nearly perfect) (12).

Results

Table 1 presents the results for each experimental procedure.

There was no difference between conditions on the maximal CMJ height ($F_{9,90} = 1.32$; $p = 0.239$; $\eta^2 = 0.116$ [small]) or mean jump height ($F_{9,90} = 1.21$; $p = 0.2986$; $\eta^2 = 0.11$ [small]). Self-selected rest intervals did not vary ($F_{2,20} = 0.71$; $p = 0.504$; $\eta^2 = 0.07$ [trivial]) between conditions: strength condition: 328 ± 139 seconds; plyometric condition: 319 ± 167 seconds; complex condition: 270 ± 165 seconds. However, a difference in the number of kicks performed during the FSKT was found ($F_{9,90} = 2.90$; $p = 0.005$; $\eta^2 = 0.225$ [small]). The complex condition with 10-minute rest interval was better than control condition ($p = 0.026$), strength with self-selected rest interval ($p = 0.015$), and plyometric with 5-minute rest interval ($p < 0.001$). No condition effects were reported concerning the maximal impact generated during the FSKT ($F_{3.5,34.8} = 1.32$; $p = 0.238$; $\eta^2 = 0.117$ [small]), which varied from 69 ± 14% to 83 ± 18% above the minimum limit of impact of athletes' weight category. The RPR differed between conditions ($F_{9,90} = 2.12$; $p = 0.039$; $\eta^2 = 0.209$ [small]). The taekwondo athletes reported lower RPR before the plyometric condition with 5-minute rest interval compared with the control condition ($p = 0.019$). Session-RPE did not differ between conditions ($F_{9,90} = 0.92$; $p = 0.215$; $\eta^2 = 0.184$ [small]).

Discussion

This study's objective was to investigate the effect of different conditioning activities and rest intervals on CMJ and FSKT performances. Our hypothesis that a PAP would occur after all the exercise conditions was partially confirmed, but only for the FSKT performance: only the complex with 10-minute rest interval condition increased the number of kicks in this test as compared with the control, strength with self-selected rest interval, and plyometric with 5-minute rest interval conditions. Importantly, however, the effect was small. When the plyometric and half-squat exercises were conducted separately, no improvement was observed for any test or rest interval investigated. Other variables analyzed (i.e., maximal CMJ, mean CMJ, and kick impact on the body protector) were not affected by strength, plyometric, and complex conditions. The athletes' self-selected rest interval, close to 5 minutes, did not maximize their performance.

Few studies (20,25,26) have investigated PAP in combat sports, and only 2 were conducted with taekwondo athletes (25,26). In 1 study investigating taekwondo athletes, Villani et al. (26) found increased speed (11–17%) during the execution of the kick technique after 2 × 4 repetition at 80% 1RM squat exercise with a 3-minute rest interval between sets and 4-minute rest interval between the conditioning activity and kick technique execution. In another study (25), squat exercises were performed using 1 × 8 (40% 1RM), 1 × 6 (60% 1RM), and 2 × 4 (80% 1RM) with a 3-minute rest interval between the conditioning activity and the kick technique speed test, and additional 3-minute rest interval before the FSKT. The authors reported increased performance in both kick speed (8–15%) and in the FSKT (4%). Thus, these results differ from our findings because we did not find any improvement for the condition using only the squat exercise. The combination of lower percentage of 1RM, lower number of sets, and shorter rest interval used by Villani et al. (25,26) could explain the differences between their findings and ours. Maybe the number of repetitions and the percentage of 1RM intensity used in previous studies (25,26) activated different portions of the force-velocity curve improving the performance during the FSKT. Additionally, it is possible that the intensity used in our study affected the elastic energy that was dissipated as heat because of the lower velocity executed during the transition between eccentric-concentric phase and concentric phase. Our study also provided lower tension time (3 sets × 1 repetitions at 95% 1RM) compared with previous studies (2 sets × 4 repetitions at 80% 1RM, 1 set × 8 repetitions at 40% 1RM, 1 set × 6 repetitions at 60% 1RM, and 2 sets × 4 reps at 80% 1RM) (25,26).

In combat sports, there is only 1 study conducted with judo athletes that investigated the PAP effects using a complex condition (20). In that study, Miarka et al. (20) reported an increased number of throws (6.4 ± 0.5 throws in set A of the Special Judo Fitness Test) in a judo-specific test when athletes were submitted to 10 × 3 consecutive jumps with 30-second rest interval between sets, with 3-minute rest interval between this condition and the judo-specific test, compared with the control condition (5.7 ± 0.5 throws in set A of the Special Judo Fitness Test). These results are similar to our findings despite the difference between rest intervals (3-minute for Miarka et al. (20) vs. 10-minute in this study). Thus, it seems that complex conditions are effective for improving performance in specific actions of combat sports.

In this study, higher performance after the complex condition with a 10-minute rest interval can be explained by the following aspects: (a) high-intensity strength exercises could possibly increase the neural drive to the muscle groups activated (24). However, studies using EMG measurements did not find increased muscle activation after strength exercises (3,14). Plyometric exercise has been reported to increase motor efficiency when performing maximum repetition during exercises (8), and this can result in increased neural stimulation of the muscle and, consequently, improve power production (18); (b) Possibly, the specific combination of strength and plyometric exercises increased the phosphorylation of the regulatory light chain of myosin, which increases calcium sensitivity of myofilaments (actin and myosin), resulting in improved levels of myosin cross-bridge activity (18); and (c) Decreases in the pennation angle and an increase in connective tissue/tendon compliance would increase force transmission. Experimental data from Mahlfeld et al. (17) demonstrated that the pennation angle during the rest interval from 3 to 6 minutes after maximal isometric voluntary knee extension contraction was lower (~1.8°) than during the precontraction state (i.e., before the exercise). According to these authors, this postcontraction pennation angle decrease implies that muscle-fiber forces may be transmitted more directly to the tendon as compared with the state observed before exercise. Furthermore, in this study, the complex condition's intensity and duration were higher than the separate squat or plyometric conditions; this would be another aspect explaining improvement under this condition, when compared with the others. Thus, this exercise combination could have maximized one or more of the potential mechanisms described above, although experimental work should be conducted to confirm this suggestion.

Performance after conditioning activity is considered to be the result of the combination of the PAP and fatigue effects, factors that are affected by the duration of the rest interval between the conditioning activity and the performance activity. For such short-duration all-out tasks as the FSKT (10-second duration), the energy supply is maintained mainly by the phosphagen system (10). Thus, a full resynthesis of creatine phosphate (PCr) would be important for avoiding performance decrement in this task. Rest intervals longer than 5 minutes are expected to result in full PCr resynthesis (19); thus, the rest intervals in the study were adequate. Indeed, recent meta-analyses on PAP reported that short rest intervals (<2 minutes) normally result in a deleterious effect, whereas long rest intervals (>15 minutes) seem to dissipate the PAP effects (11,27). The positive effects were normally observed when rest intervals from 3 to 12 minutes were used (23,27). For this study's athletes, only complex conditioning with the upper-limit rest interval (i.e., 10 minutes) resulted in improved performance.

Another important aspect of the rest interval between conditioning activity and performance tasks is that the athletes were not able to choose a rest interval that optimized performance, thus disproving our hypothesis. Importantly therefore, coaches intending to use PAP during training sessions should determine each athlete's optimal rest interval, using 10 minutes as an initial reference.

This investigation's conditions did not change the impact generated during kicks, neither the mean nor the maximal CMJ height. Because taekwondo athletes need to achieve a minimum impact according to gender and weight category (2), it is likely that they learn how to control the kick application to stay higher than the minimum value and focus on the task goal, i.e., performing the maximum number of kicks in the time allowed.

To control the athletes' physical condition in the different conditions, both RPR and RPE were registered before and after each intervention, respectively. For the RPE, there were no variations between conditions, indicating that all experimental conditions resulted in the same fatigue sensation perceived by the athletes. The RPR was lower in the jump condition with a 5-minute rest interval as compared with the control condition. Because the conditions were randomly assigned in each session, it is impossible to explain this result. However, even with this difference, the values that the athletes reported were still in the expected range of performance enhancement, according to the scale created by Laurent et al. (16). Additionally, no significant performance difference was found between this condition and the control condition.

This was the first study to verify the effects of different conditioning activities on both taekwondo-specific (FSKT) and general power performance (CMJ). Although the FSKT performance increased after complex exercise with a 10-minute rest interval, no difference was observed in CMJ performance. These results can be attributed to the CMJ's lack of specificity or to its brevity, suggesting that taekwondo athletes submitted to PAP conditions would improve only in specific actions or actions of approximately 10 seconds.

Practical Applications

These findings suggest that complex exercises should be used to improve short-duration, all-out, taekwondo-specific performance. Heavy loads followed by plyometric exercises are effective to improve taekwondo athletes' kick performance when 10-minute rest intervals are used between the conditioning activity and the performance task. It is likely that athletes who are constantly submitted to training sessions, where specific conditions result in improved performance outcomes, would present better long-term training adaptations. Coaches should individualize the rest interval used or follow the condition used in our study because the athletes seemed unable to self-select optimum rest intervals to maximize performance. Additionally, in the most important taekwondo competitions (i.e., Olympic Games and World Championships), the moment the athlete will compete can be precisely determined; this allows use of these procedures as warm-up techniques during competition. However, because the athletes may need to perform as many as 7 matches during the same competition, studies investigating the effects of repeated PAP procedures in subsequent moments should be conducted.

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