



Original article

Specificity of performance adaptations to a periodized judo training program



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ABSTRACT

Objective: Judo is a combat sport characterized by high-intensity intermittent efforts. To suit high competitive demand, the training periodization should be adopted to improve judo athletes performance. Thus, the objective of the present study was to monitor the changes in different variables during judo training periodization.

Method: Ten male adult judo athletes were evaluated 18 weeks apart, in the beginning of preparatory period and one week before the main competition of the competitive period. During this observational study, the variables considered were: body composition, upper and lower-body anaerobic power and capacity, lower-body muscle power, upper and lower-body aerobic power, maximal and strength endurance, and judo specific performance. Paired Student's *t* test was used to compare variables across periods.

Results: In the end of this period, athletes presented a significant increase in upper-body anaerobic power (pre = 535 ± 74 W; post = 617 ± 81 W; 15%) and capacity (pre = 344 ± 29 W; post = 402 ± 38 W; 17%), lower-body anaerobic power (pre = 778 ± 77 W; post = 882 ± 130 W; 13%), isometric (pre = 31 ± 17 s; post = 43 ± 15 s; 39%) and dynamic grip strength endurance (pre = 7 ± 5 rep; post = 11 ± 5 rep; 57%), upper-body aerobic power (pre = 113 ± 25 W; post = 122 ± 29 W; 8%), and row 1RM (pre = 85 ± 23 kg; post = 92 ± 26 kg; 8%). The body composition, judo specific performance, handgrip strength, bench-press 1RM, row and bench-press number of repetitions at 70% 1RM, and lower-body muscle power were maintained. Athletes presented a decrease in lower-body aerobic power (pre = 235 ± 62 W; post = 209 ± 43 W; 11%).

Conclusion: The results of the present study indicated that the changes during a periodized judo program were specific to the match demand, although not all variables improved across this period.

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Especificidad de las adaptaciones de un programa periodizado de judo

RESUMEN

Objetivo: El judo es un deporte de combate caracterizado por intervalos de esfuerzos de elevada intensidad. Para soportar la elevada demanda competitiva, la periodización del entrenamiento debe ser utilizada para mejorar el desempeño de los atletas de judo. Por tanto, el objetivo del presente estudio fue evaluar los cambios, en diferentes variables, durante la periodización del entrenamiento de judo.

Método: Diez atletas de judo varones fueron evaluados con 18 semanas de intervalo, en el inicio del período preparatorio y una semana después de la principal competición del período competitivo. Durante este estudio observacional, las variables consideradas fueron: composición corporal, potencia y capacidad anaeróbica de miembros superiores e inferiores, potencia muscular de miembros inferiores, potencia aeróbica de miembros superiores e inferiores, fuerza máxima, resistencia de fuerza y la performance en un test específico para el judo. El test *t* de Student para datos pareados fue utilizado para comparar las variables durante el período de entrenamiento.

Palabras clave:

Artes marciales

Ejercicio aeróbico

Ejercicio de fuerza

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Resultados: Al final de ese período, los atletas presentaron aumento significativo en la potencia (pre = 535 ± 74 W; post = 617 ± 81 W; 15%) y en la capacidad (pre = 344 ± 29 W; post = 402 ± 38 W; 17%) anaeróbicas de miembros superiores, potencia anaeróbica de miembros inferiores (pre = 778 ± 77 W; post = 882 ± 130 W; 13%), resistencia de fuerza isométrica (pre = 31 ± 17 s; post = 43 ± 15 s; 39%) y dinámica de golpeo (pre = 7 ± 5 rep; post = 11 ± 5 rep; 57%), potencia aeróbica de miembros superiores (pre = 113 ± 25 W; post = 122 ± 29 W; 8%), y fuerza máxima de 1 RM (pre = 85 ± 23 kg; post = 92 ± 26 kg; 8%). La composición corporal, el desempeño en el test específico, la fuerza de prensión manual, la fuerza máxima en el press de banca y de 1RM, el número de repeticiones en el press de banca a 70% 1RM y la potencia muscular de miembros inferiores no experimentaron cambios. Los atletas presentaron una disminución en la potencia aeróbica de miembros inferiores (pre = 235 ± 62 W; post = 209 ± 43 W; 11%).

Conclusión: Los resultados indican que los cambios durante el ciclo del programa de entrenamiento de judo fueron específicos a la demanda del combate competitivo, aunque algunas variables no cambiarán en ese período.

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Especificidade das adaptações de desempenho a programa periodizado de treinamento de judô

R E S U M O

Palavras-chave:
Artes marciais
Exercício aeróbio
Exercício de força

Objetivo: O judô é um esporte de combate caracterizado por esforços intermitentes de elevada intensidade. Para lidar com a demanda competitiva, a periodização do treinamento deve ser adotada para melhorar o desempenho de atletas de judô. Assim, o objetivo do presente estudo foi monitorar as mudanças em diferentes variáveis durante o treinamento periodizado de judô.

Método: Dez atletas de judo adultos foram avaliados com intervalo de 18 semanas, no começo do período preparatório e uma semana antes da principal competição do período competitivo. Durante esse estudo observacional, as variáveis consideradas foram: composição corporal, potência e capacidade anaeróbicas de membros superiores e inferiores, potência muscular de membros inferiores, potência aeróbia de membros superiores e inferiores, força máxima, resistência de força e desempenho específico do judô. O teste t de Student foi utilizado para comparar as variáveis entre os períodos.

Resultados: Ao final deste período os atletas apresentaram aumento significante na potência (pré = 535 ± 74 W; pós = 617 ± 81 W; 15%) e capacidade anaeróbicas de membros superiores (pré = 344 ± 29 W; pós = 402 ± 38 W; 17%), potência anaeróbia de membros inferiores (pré = 778 ± 77 W; pós = 882 ± 130 W; 13%), resistência de força isométrica de pegada (pré = 31 ± 17 s; pós = 43 ± 15 s; 39%), resistência de força dinâmica de pegada (pré = 7 ± 5 rep; pós = 11 ± 5 rep; 57%), potência aeróbia de membros superiores (pré = 113 ± 25 W; pós = 122 ± 29 W; 8%) e 1RM na remada (pré = 85 ± 23 kg; pós = 92 ± 26 kg; 8%). A composição corporal, o desempenho específico ao judô, a força máxima isométrica de prensão manual, o 1RM no supino, o número de repetições a 70% de 1RM na remada e no supino e a potência muscular de membros inferiores foram mantidas. Os atletas apresentaram decréscimo na potência aeróbia de membros inferiores (pré = 235 ± 62 W; pós = 209 ± 43 W; 11%).

Conclusão: Os resultados do presente estudo indicam que as mudanças durante um programa periodizado de treinamento de judô foram específicas à demanda da luta, embora nem todas as variáveis tenham melhorado ao longo do período analisado.

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Introduction

Judo is characterized by high-intensity intermittent efforts, resulting in high physiological demand.¹ Judo athletes typically take part in seven to eight competitions, either regionally or internationally.² Thus, the training periodization is important to provide judo athletes a better chance to qualify in these tournaments.³⁻⁵

Previous investigations have indicated that judo athletes with higher upper-body anaerobic power and capacity, specific endurance, and lower-body muscle power present more chance of success.^{1,6-8} When considering a typical judo match, most of the time is spent in grip disputes (*kumi-kata*), requiring high level of upper-body strength endurance, while powerful upper and lower-body actions are needed during technique application.⁸⁻¹² Furthermore, several authors¹³⁻¹⁵ have indicated that the aerobic profile of judo athletes may be important during several situations: (a) in the final moments of a combat;

(b) when a high number of matches are performed in the same competition; and (c) during the recovery process between the matches. Therefore, variables related to upper-body anaerobic power and capacity, strength endurance, lower-body muscle power, and aerobic fitness should be specifically addressed during the training process. Additionally, as judo requires athletes to compete in different weight categories, these variables should be improved without relevant changes in body mass.¹⁶⁻¹⁸ However, few studies presented the physiological changes in judo athletes during periodization or training phases, and most of these studies considered short periods, i.e., three to eight weeks.^{3-5,19-23} Thus, the objective of the present study was to monitor the changes in different variables during judo training periodization. Our hypothesis was that athletes would present an increase in upper-body anaerobic power and capacity, lower-body muscle power, upper-body aerobic power, and strength endurance, while maintaining lower-body aerobic power and body composition.

Initial evaluation	General phase	Special phase		Final evaluation
	General strength muscle hypertrophy	Specific strength development	Complex training	
	3 sessions/week	8 weeks, 3 sessions/week	3 weeks, 3 sessions/week	
	8-12 strength exercises Focus on the main muscle groups 4 x 8-12 repetitions 70-80% of 1RM	Pulley machines, rowing, squat, Olympic type weightlifting movements, Wrist flexion exercise 4 x 3-5 repetitions at ~90% of 1RM at the highest speed possible	Olympic weightlifting, squat and bench press exercises followed by specific judo actions (mainly throwing judo techniques).	
	<i>Randori</i>	<i>Randori</i>		
4 times/week 60% of maximal perceived effort 6-8 combats of 5 minutes each 5 to 10 min of recovery	4 times/week 70-90% of maximal effort (7 to 9 in the 0-10 Borg scale) 4-6 combats (5 to 10 min of recovery)			
Aerobic conditioning	Aerobic conditioning			
2 sessions/week 60% of reserve heart rate	2 sessions/week 90-100% of reserve heart rate			
7 weeks	11 weeks			

Fig. 1. Schematic representation of the training phases and periods of evaluation.

Method

Subjects

Ten male adult judo athletes (23 ± 2 years-old) volunteered for this study after reading and signing an informed consent form. All athletes were brown or black belt, competed in state level for more than 5 years and had previous experience with the tests conducted. These athletes presented no injury during the period of the study that was serious enough to result in missing a training session. As the athletes were paid by the club to train and to compete, no absence was observed during this training period. Athletes were not using any supplementation and were oriented to keep their normal nutritional habits throughout the study. This observational descriptive study was approved by the local ethics committee. For most variables a sample size of 10 athletes is large enough to detect changes in the dependent variables, with 80% confidence and error smaller than the standard deviation reported in previous studies.^{1,6,8}

Procedures

Before the beginning of this study, athletes took part in a 20 days judo training period, composed by technical workouts (*uchi-komi*, technique application, for 10–15 min) and *randori* (match simulation, performed during 40–60 min continuously). The athletes were evaluated 18 weeks apart, in the beginning of preparatory period and one week before the main competition of the competitive period.

The current training periodization was composed by two phases (Fig. 1). The first one, named preparatory phase and lasting seven weeks, was designed: (a) to improve general strength and promote muscle hypertrophy (3 resistance training sessions/week); (b) to develop technical skills through *randori* (4 times per week at 60% of maximal perceived effort; i.e., 6 in the 0–10 Borg scale²⁴; (c) and to improve aerobic conditioning (2 running sessions/week at 60% of reserve heart rate; RHR). During this phase, strength training involved 8–12 strength exercises performed in 4 sets of 8–12 repetitions at 70–80% of one repetition maximum (1RM), with 1 min rest between sets.²⁵ *Randori* involved six to eight 5 min combat simulations, with short interval (1–3 min) between them.

Aerobic conditioning involved continuous running training during 40–60 min at the frequency presented above.

The special phase, lasting 11 weeks, was designed to improve specific strength, the first 8 weeks with basic resistance training exercises and the last 3 weeks with complex training (3 sessions per week). Basic specific strength was developed by using wrist flexion exercises, triceps and back pulley machines exercises, rowing, squat, Olympic-type lifts (e.g., power clean, high pull, clean and jerk, snatch), performed at high-intensity (4 sets of 3–5 repetitions at ~90% of 1RM, and at the highest speed possible, with 3 min interval between sets), while complex training involved the use of Olympic weightlifting, squat and bench press exercises, with the same protocol, but followed by specific judo actions (mainly throwing judo techniques, applied 3–5 times with different partners, 3–5 min after the maximal strength exercise). *Randori* intensity was increased to 70–90% of maximal effort (7–9 in the 0–10 Borg scale,²⁴ performed in 4–6 combats with longer interval (5–10 min) between them, using the same number of sessions per week. Aerobic training also increased its intensity (90–100% of RHR, twice a week), performed intermittently (1:1 effort:pause ratio) and in a lower volume (30 min per session).

Measures

Anthropometrical measurements

After body mass and height assessment, skinfold thicknesses, bone diameter and circumference measurements were taken according to Drinkwater and Ross.²⁶ The research responsible for the assessment had a variation of less than 2% between skinfold thickness, bone diameter and circumference measurements, with high reliability (ICC = 0.98). Percent body fat was determined according to Drinkwater and Ross.²⁶

Upper and lower-body Wingate tests

These tests were performed on an EB4100 and a Biotec 2100® cycle ergometer (Cefise, Brazil). Load was set at 4.9 N kg^{-1} of body mass for the upper-body Wingate test and 8.8 N kg^{-1} of body mass for the lower-body Wingate test.²⁷ Power was measured every second by a software, and the following variables were determined: mean power (average power during 30 s) and peak power (highest power during the test). This test has been widely used and its reliability has been reported²⁸ as 0.98 via ICC.

Special judo fitness test

The Special Judo Fitness Test (SJFT) is a specific evaluation test divided in three effort periods (A = 15 s; B and C = 30 s each) with 10 s intervals between them.²⁹ Briefly, each partner was positioned 6 m apart and the participant was required to run to each partner and then throw them as many times as possible using the *ippon-seoinage* technique, and all involved athletes had a similar height and body mass. Just after and 1 min after the test heart rate (HR) was measured. The throws were summed and the following index was calculated (Eq. (1)):

$$\text{Index} = \frac{\text{final HR (bpm)} + \text{HR 1 min after the test (bpm)}}{\text{number of throws}} \quad (1)$$

It is important to emphasize that a higher index indicates a worse SJFT performance, and that this test has been shown to be highly reliable (ICC = 0.89 for the index).³⁰

Upper and lower-body aerobic power

These tests were employed to measure the participant's maximal mechanical aerobic power in upper and lower-body, conducted in a EB4100® (Cefise, Brazil) and in a Biotec 2100® (Cefise, Brazil) cycle ergometer, respectively. For the lower-body, the test started with 18 W, with subsequent increments of 30 W every minute until the participant's exhaustion. For the upper-body the test started with 18 W, with subsequent increments of 15 W every minute until the participant's exhaustion. In both conditions exhaustion was defined as the incapacity to maintain a 60 rpm cadence. In order to attain maximal values, a strong verbal encouragement was given to participants to continue as long as possible. The load achieved in each test was considered to be the athlete's maximal mechanical aerobic power.³¹

Maximal and endurance strength tests

Quantifications of 1RM for straight bench-press, and rowing at 45° were carried out. All athletes were familiar with the performance of these exercises, and each athlete carried out at least three and at most five trials, with 3–5 min intervals between them. The interval between exercises was of at least 30 min. The subjects began the test with a general warm-up of five minutes. Subsequently, they performed a set of eight repetitions with the intensity at 50% of estimated 1RM load, followed by another set of three repetitions at 70% of estimated 1RM load. The attempt to establish 1RM was a lifting with progressively heavier load to volitional fatigue. For this study, the load increase was 5% as recommended before.³²

Besides the absolute value, 1RM values relative to the athlete's weight were also calculated. Endurance strength tests involved the performance of the maximal number of repetitions with 70% of 1RM for each exercise.

Static grip strength was assessed for right and left hand using a Jamar™ dynamometer. For this test a low variation (less than 2%) and a high reliability (ICC = 0.97) has been observed in our laboratory.

Two *judogi* strength endurance tests were performed³³: (1) isometric – while holding on *judogi* (judo uniform) rolled around the bar, with the elbow joint in maximal flexion, athletes were required to sustain this position (*judogi* isometric pulling) during the maximal possible time, measured in seconds; (2) dynamic – during this test the same grip position was applied, but athletes performed the maximal number of repetitions from a fully flexed to a fully extended elbow position. In both cases, athletes performed the exercises until voluntary failure and a minimum of 15 min rest was allowed between each test. The reliability for both tests was assessed in a previous study, which reported an intraclass correlation coefficient of 0.98 for the dynamic test³⁴ and 0.99 for the isometric version,³⁵ with limits of agreement of –0.9 to 0.3 rep in the dynamic version and –3.3 to –1.2 s for the time of suspension in the isometric test.³⁵

Counter movement jump performance

The counter movement jump performance was accessed through a contact mat (Jump Test, Belo Horizonte, Brazil). Athletes performed three non-consecutive jumps, with 2 min interval between trials. During each trial the athletes kept their arms crossed in front of their thorax and tried to jump as high as possible. The best result was considered in our analysis.

Testing assessment order

The athletes performed the tests on three nonconsecutive days. In the first day athletes were measured (height, body mass, skin-fold thickness, circumferences and bone diameters) and performed handgrip test, vertical jump test, pull-up bar test in *judogi* and lower-body maximal aerobic test. The interval between handgrip, pull-up bar with *judogi* and the maximal lower-body aerobic test was 15 min. In the second day the athletes were submitted to 1RM tests, separated by 5 min intervals. After a 15 min rest they performed one lower or upper-body Wingate test and after a 30 min rest were submitted to the other Wingate test (upper or lower-body, depending on which test was performed before).²⁷ In the third day, athletes performed strength-endurance tests in the bench press and rowing, and the SJFT. In the third day a 15 min interval was given between strength-endurance tests and 30 min between them and the SJFT. All tests were performed in the afternoon, between 3 p.m. and 4 p.m. During all testing days athletes were instructed to maintain their habitual diet and not to perform any vigorous physical effort 24 h before the beginning of test assessment sessions.

Statistical analysis

Data are presented as mean and standard deviation. Paired Student's *t* test was used to compare variables across periods. Effect sizes (Cohen's *d*) were calculated and the following scale was used for the interpretation: [trivial]: <0.2, [trivial]; 0.2–0.6, [small]; 0.6–1.2, [moderate]; 1.2–2.0, [large]; and > 2.0 [very large].³⁶ The significance level was set at 5%.

Results

All athletes completed the training periodization as proposed. From the ending of one season to the first peak of the other season, athletes presented an increase ($P < 0.05$; $d = 0.12$, trivial) in body mass (pre = 82.6 ± 17.6 kg; post = 84.8 ± 18.0 kg), but no change in body fat composition (pre = 16.0 ± 4.3%; post = 16.9 ± 4.5%).

There was an improvement ($P < 0.05$) in row 1RM ($d = 0.29$, small), isometric chin up ($d = 0.75$, moderate) and in dynamic *judogi* chin up ($d = 0.80$, moderate) during the training cycle (Table 1).

There was no significant difference in the CMJ comparing pre (35.4 ± 4.2 cm) and post (34.8 ± 4.1 cm) measurements.

Table 1

Maximal isometric handgrip (kgf), one repetition maximum (1RM) in row and bench press (kg), *judogi* chin up repetitions and time of suspension (s), and number of repetitions at 70% 1RM in row and bench press exercises before and after periodization training cycle of state level male judo athletes ($n = 10$).

	Before	After
Right handgrip isometric strength (kgf)	61 ± 13	60 ± 13
Left handgrip isometric strength (kgf)	54 ± 12	55 ± 10
Bench press 1RM (kg)	88 ± 24	91 ± 23
Row 1RM (kg)	85 ± 23	92 ± 26*
Bench press at 70% 1RM (rep)	10 ± 7	13 ± 5
Row at 70% 1RM (rep)	17 ± 4	13 ± 3
Isometric chin up <i>judogi</i> (s)	31 ± 17	43 ± 15*
Chin up <i>judogi</i> (rep)	7 ± 5	11 ± 5*

* Significant difference between moments ($p < 0.05$); values are mean ± standard deviation.

Table 2

Number of throws (during sets A, B, C, and total), heart rate after and 1 min after the Special Judo Fitness Test, and index before and after periodization training cycle of state level male judo athletes (n = 10).

	Before	After
Throws set A (15 s)	6 ± 0	6 ± 1
Throws set B (30 s)	11 ± 0	11 ± 1
Throws set C (30 s)	10 ± 1	9 ± 1
Total throws	28 ± 1	26 ± 1
Heart rate after (bpm)	197 ± 6	190 ± 8
Heart rate 1 min after (bpm)	178 ± 9	171 ± 9
Index	13.66 ± 1.04	14.03 ± 1.15

Values are mean ± standard deviation.

While lower-body maximal mechanical aerobic power decreased (pre = 235 ± 62 W; post = 209 ± 43 W; $P < 0.05$; $d = 0.50$, moderate), maximal upper-body mechanical aerobic power increased (pre = 113 ± 25 W; post = 122 ± 29 W; $P < 0.05$; $d = 0.33$, small) during the training cycle.

For lower-body Wingate test, only peak power increased (pre = 778 ± 77 W; post = 882 ± 130 W; $P < 0.05$; $d = 0.75$, moderate) during the training cycle, but for upper-body Wingate test both peak (pre = 535 ± 74 W; post = 617 ± 81 W; $P < 0.05$; $d = 0.85$, moderate) and mean power (pre = 344 ± 29 W; post = 402 ± 38 W; $P < 0.05$; $d = 1.43$, large) increased during the training cycle.

No difference was found in any variable of the SJFT (Table 2).

Discussion

Our initial hypothesis was confirmed concerning improvements in upper-body anaerobic power and capacity (mean and peak power increase), lower-body muscle power (peak power increase) and strength endurance (isometric and dynamic grip strength endurance improvements) and body composition maintenance, but it was not confirmed concerning lower-body mechanical aerobic power maintenance.

Concerning strength variables, the adaptation seems to be specific to the judo actions, as only row 1RM increased and it is known that judo involves many pulling actions during the combat.¹ Additionally, both isometric and dynamic strength endurance were improved by these athletes in a task involving the grip on the judogi, but not in non-specific strength endurance exercises (bench press and row repetitions at 70% 1RM). Recently, Marcon et al.¹¹ and Miarka et al.¹² reported that approximately half of the combat time is spent in gripping fighting activities and Calmet et al.⁹ demonstrated that the grip fighting is one of the most important factors during judo matches, as the grip dominance is essential to increase the opportunities of throwing techniques execution. Thus, the specificity of adaptations was confirmed, especially because the effect size for strength endurance adaptations in these exercises were higher than for maximal strength in the only exercise involving pulling action. Additionally, an increase in the upper-body Wingate test mean power was also detected in this study. As mean power has been associated to the anaerobic capacity and the repetition of high-intensity grip disputes may be supported by this physical capacity, the improvement in mean power seems to be important to judo athletes performance enhancement,¹ and this was one of the few variables with large effect size, confirming the adaptation specificity.

As the match duration increases, it is supposed to increase the aerobic contribution needed to sustain the efforts made by the athletes.^{15,37,38} Considering that the upper-body has a higher solicitation during the match due to the time spent in the grip dispute,^{11,12} the improvement observed in upper-body aerobic power is important to provide athletes the condition to perform these repetitive muscle actions needed during the match and across the matches in a given competition.^{3,14,15}

Judo athletes' lower-body performs powerful and short actions during the execution of the throwing techniques,³⁹ but no change was observed in the CMJ. Callister et al.⁴⁰ did not find any difference in the CMJ performance in judo athletes submitted to intensified training to generate overreaching and suggested that maybe the CMJ performance is not sensitive enough to changes in judo athletes lower-body muscle power. Busko and Nowak²⁰ also reported no change in the CMJ performance across different phases of training periodization in Polish national level athletes. Conversely, Fukuda et al.⁴ observed improved jump performance in adolescent judo athletes preparing for competition. It is also important to consider that the judo techniques have longer duration (1.14 s to 1.4–1.7 s)^{11,39} than the CMJ. Lower-body Wingate test peak power increased after this training period, which would help judo athletes to perform their high-intensity lower-body actions needed in technique application.⁴¹ Kim et al.²² found a significant higher lower-body Wingate test peak power in high-level judo athletes compared to university level athletes, suggesting that higher peak power values are relevant to judo performance. Furthermore, Kim et al.⁴² also reported improvement in lower-body Wingate test peak power in athletes submitted to 8 weeks of judo training and high-intensity intermittent exercise.

In the interval among throwing technique execution (approximately 20 s)^{11,12} the judo athlete lower-body is involved in low to moderate intensity displacements, which do not impose a high metabolic stress compared to that imposed to the upper-body.¹ Thus, it is probable that the decrease in lower-body aerobic power observed in our athletes does not seem to result in a concomitant decrease in performance during the matches.

Furthermore, for judo throwing techniques execution it is also necessary a powerful pulling or pushing action performed by the upper-body during the imbalance phase (*kuzushi*)⁴³ and the improvement (moderate effect size) in the upper-body Wingate test peak power is an important adaptation to achieve this action successfully.

Although the athletes presented an increase in body mass, no change was observed in body composition, probably because the absolute increase in fat tissue was countered by the increase in muscle mass.

Surprisingly, no difference was found in the SJFT performance. Although the athletes improved the lower-body Wingate peak power (associated to the anaerobic power) and upper-body Wingate mean power (associated to the anaerobic capacity), the metabolic profile of the SJFT has an important aerobic contribution (32.9 ± 3.3%)⁴⁴ and the lower-body aerobic power has been positively associated ($r = 0.73$) to the SJFT index⁴⁵ and correlated ($r = 0.79$) to the number of throws in the SJFT.⁴⁶ Thus, the combination of anaerobic profile improvement and lower-body aerobic power decrement for this group may have interacted and the performance in the SJFT did not change during this period. An improvement in the number of throws during the SJFT would be important for the judo athletes because this variable has been correlated to the number of attacks during the match ($r = 0.68$).⁴⁷ In fact, in a shorter training period (i.e., six weeks), increase in the number of throws in the SJFT was observed.²³

Two main limitations can be identified in our study: the absence of a control group submitted to a non-periodized judo training and the lack of control concerning athletes' nutritional intake. The use of control group in periodization studies is difficult, because athletes are normally submitted to some type of periodization process. Additionally, some authors consider that there would be "ethical problems with restricting a particular treatment to elite athletes" (p. 814).⁴⁸ Although diet was not controlled in this study, athletes were not using any supplementation and were oriented to keep their normal nutritional habits throughout the study.

In conclusion, the results of the present study indicated that the changes during a periodized judo program were specific to the match demand, although not all variables improved across this period. Body mass increased, but body composition did not change. Variables important to sustain high-intensity actions across the match (upper-body peak and mean power, isometric and dynamic grip strength endurance) increased. Additionally, row 1RM and lower-body peak power, which are relevant to power actions during throwing technique application, increased. Additionally, upper-body mechanical aerobic power, which maybe connected to endurance during the match and to recovery process of this muscle group between successive matches, also increased.

Conflict of interest

The authors declare they have no conflict of interest.

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