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## ORIGINAL

### ORDER OF STRENGTH EXERCISES ON THE PERFORMANCE OF JUDO ATHLETES

### ORDEN EN LOS EJERCICIOS DE FUERZA SOBRE EL RENDIMIENTO DE LOS JUDOKAS

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## ABSTRACT

**OBJECTIVE:** To analyze the effect of strength exercises using different orders for upper and lower limbs on the specific performance of junior judo athletes. **METHODS:** 39 male athletes were divided into three groups: experimental-EG1, experimental-EG2 and control group. Experimental groups performed with intensities 80-90% of strength and power for 12 weeks. The exercise-order for EG1 followed an upper to lower limb sequence and EG2 performed the same exercises in reverse. The Special Judo Fitness Test (SJFT) was used in the assessment. **RESULTS:** Experimental intra and inter-groups showed differences ( $p < 0.05$ ) in the throws-falls and SJFT-index, but the EG2 showed best results. **CONCLUSIONS:** The SJFT-variables had better results to exercises order in EG2.

**KEYWORDS:** physical conditioning, resistance training, sports performance, judo.

## RESUMEN

**OBJETIVO:** El objetivo fue investigar el efecto del orden distintas de ejercicios de fuerza para extremidades superiores e inferiores en el rendimiento específico de judokas junior. **MÉTODO:** Se divide una muestra de 39 atletas masculinos en tres grupos: Experimental-EG1; EG2 y Control. Los Grupos realizaron ejercicios de fuerza máxima y potencia con intensidades del 80-90% para 12 semanas de intervención. El orden de los ejercicios para el EG1 fue del de extremidades superiores primero e inferiores después. El EG2 realiza los mismos ejercicios en secuencia inversa. Se utilizó la Prueba Especial Judo Fitness (SJFT) para evaluación. **RESULTADOS:** Los experimentos intra e inter grupos muestran diferencias ( $p < 0.05$ ) en los derribos-caídas y en el índice SJFT, con EG2 mostrando mejores resultados. **CONCLUSIONES:** Las variables de SJFT tuvieron mejores resultados en el orden de ejercicios seguidos por el EG2.

**PALABRAS CLAVE:** acondicionamiento físico, entrenamiento de resistencia, rendimiento deportivo, judo.

## INTRODUCTION

Competitive judo requires the development of various skills and physical abilities, such as muscle strength, speed and balance, due to the need for optimizing the specific performance of athletes in competition (2,3). Combat sports are characterized by a complex variety of motor actions affected by different exertion and intensity levels as well as fatigue (2,3).

The scientific literature shows that performance in competitive judo is negatively affected by a high percentage of body fat, significant accumulation of blood lactate and increase of injuries risk (24,13). Thus, high-level judo training requires specific planning, with special attention to variables that can improve the performance of athletes and their results in competition (16,18,23).

The need for information on the physical performance of elite athletes has prompted the scientific community to study the effects of various training techniques on athletic performance (3,18). Judo research has shown that the improvement of specific conditioning can determine the success or failure of these athletes in competition (7,16,29). For example, Resistance Training (RT) can be used to improve the performance of judo athletes (18).

Simão et al. (24,26) and Spinetti et al. (27) knowledge that RT programs must consider the order of strength exercises according to the final objective and specific movement patterns of the individual. The American College of Sports Medicine (5) recommends RT programs that initially focus on exercising the major muscle groups, followed by minor muscle groups and multi-joint exercises, before focusing on individual joints and muscles. However, exercise order is still a poorly studied variable in the literature (24). With regard to judo, there were no literature studies on strength exercise order using specific RT programs to enhance the performance of judo athletes.

Despite little evidence, the majority the literature recommends that strength exercise order should be based on the different body segments, exercising upper and lower limbs on alternate days. However, studies that support such recommendations are related to the acute effects of exercise (25,28), raising doubts about possible chronic effects. Indeed, the studies on the strength exercise order (19,24), have not examined the chronic effects of different orders of strength exercises for the upper and lower segments on the performance of judo athletes. This justifies the need for further studies to answer the following question: Can RT programs with different strength exercise orders enhance the performance of judo athletes?

## OBJECTIVE

The aim of this study was to investigate the effect of different orders of strength exercises, for upper and lower limbs, on the specific performance of junior judo athletes.

## MATERIAL AND METHODS

For this experimental study, the sample consisted of 39 young male judo athletes randomly allocated to three groups: Experimental Group 1 (EG1, n = 13; age  $20.69 \pm 2.36$  years); Experimental Group 2 (EG2, n = 13; age  $20.23 \pm 2.45$  years) and a control group (CG, n = 13; age  $20.15 \pm 1.57$  years), as shown in Table 1.

Subjects were aged from 18 to 21 years, had practiced judo for more than three years and competed in official national events for more than one year. The judo experience was characterized by groups in Table I. All young athletes participated in competitions at state and national levels in the under-21 category, but not considered elite-athletes. Individuals using anabolic steroids, either for health reasons or to enhance their athletic performance, were excluded from the experiment.

The study was approved by the institutional ethics committee (protocol number CAEE: 0070.412.000-11). The procedures followed the rules of ethics in research with human beings according to National Board of Health Resolution number 251 of 07/08/1997, which are the guidelines and rules for research involving human subjects in accordance with the ethical principles contained in the World Medical Association Declaration of Helsinki (31).

A Filizola<sup>®</sup> mechanical scale (Brazil) with a capacity of 150kg and 100 g precision was used to measure body weight, while height was measured with a Sanny<sup>®</sup> stadiometer (Brazil). These measures were also used to calculate body mass index (BMI). All measurements were in accordance with International Standards for Anthropometric Assessment recommendations (21).

The 10 RM test was assessed for each individual in each exercise. Data were collected on three non-consecutive days. The 10RM test was conducted on the first day for all strength exercises. The two different sequences of exercises were performed on days 2 and 3. The 10 RM tests were carried out in the following order: bench press, lateral pulldown, military press, biceps curls, squats, leg press, leg extension and leg curl. All strength exercises were performed on Life Fitness<sup>®</sup> equipment (Franklin Park, IL, USA). The following strategies were adopted to reduce possible errors in the 10RM tests: (a) prior to testing, all participants received standardized instructions regarding the technical execution of the exercises, (b) the technical movements during the test sessions were monitored and adjusted as necessary, and (c) all subjects were verbally encouraged during the test (5).

During 10RM test, each subject had a maximum of five attempts at each exercise, with 2-5 minutes between them (5). After determining the 10RM load in a particular exercise, a rest break of at least 10 minutes was allowed to determine 10 RM load in the ensuing exercise (5). The standard exercise technique was explained to the subjects in each exercise. No pause was allowed between the eccentric and concentric phase of a repetition or between

repetitions. All athletes had experience in RT (Table I).

The Special Judo Fitness Test (SJFT) was validated in Brazil by Sterkowicz and Franchini (30). The SJFT is conducted with two judokas (Ukes) in the same weight category, positioned frontally and 6 feet (approximately two meters) apart, and a third judoka (Tori / performer) between the others (Ukes). The test is divided into three time periods: 15 seconds (A), 30 seconds (B) and 30 seconds (C) with a 10-second interval between them, for a total of 95 seconds (31). The tori is subject performing the test and while the ukes are thrown. The throwing technique chosen was Ipon-seoi-nage.

The test was conducted in a training hall (dojo) on a synthetic rubber tatami mat (2x1m, 40mm thick), which cushions the projections. The following instruments were used for the measurements: (a) a Polar<sup>®</sup> timer (Finland) for total test time, (b) heart rate monitor, also by Polar<sup>®</sup> (Finland), to determine heart rate after one minute and at test completion, (c) a tape to mark the location of the Ukes and Tori, (d) a 10m metric tape measure (Western<sup>®</sup>, Germany) to measure the distance between the Tori and Ukes, (e) a Fox<sup>®</sup> - 40 whistle (USA) to signal the beginning and end of each test period, (f) a Panasonic<sup>®</sup> Digital camcorder (United Kingdom) to record the test and (g) a Casio Ex-F1<sup>®</sup> camera (UK) to record some of the test movements. In addition, volunteers used Seishin<sup>®</sup> judogis (uniforms) (Brazil).

During each test, the Tori throw the Ukes as many times as possible, using the ippon-seoi-nage technique. The athlete's (Tori) heart rate is recorded immediately after and 1 minute after the end of the test. The pitches are added and the index is calculated as follows:

$$Index = \frac{HR \text{ final (bpm)} + HR \text{ 1 minute after the end of the test (bpm)}}{\text{Total number of pitches}}$$

All volunteers completed the training protocol, which consisted of 36 sessions held three times a week. The subjects underwent a specific warm-up involving 20 repetitions with a load of 50% of the weight used in the first training exercise.

Experimental groups 1 and 2 performed three sets of 8-12 repetitions of every exercise with an intensity of 80%-90% of 10RM for development of maximum strength and power. The order for EG1 obeyed the following sequence for upper limbs: bench press, lateral pull-down, military press and biceps curls; and legs: squats, leg press, leg extension and leg curl. The EG2 volunteers were submitted to the reverse sequence at the same intensity as the previous group. Every time the upper limit of 12 repetitions was exceeded, an adjustment was made to ensure a similar intensity. During the training sessions, participants received verbal support for the exercises performed until concentric failure. In addition, during the experimental intervention, all volunteers were paired-up to perform the exercises and sessions with time intervals, which included a two-minute rest between them.

## Statistical analysis

IBM® SPSS® 19.0 for Windows was used. Shapiro-Wilk and Levene's normality tests were applied to assess homoscedasticity and normal distribution of all variables. A two-way ANOVA test was also used followed by Tukey's post-hoc test for multiple comparisons. The level of significance for hypotheses was  $p < 0.05$  with  $\alpha = 5\%$ . Additionally, effect size (22) (the difference between pre-test and post-test scores divided by the standard deviation of the pre-test) was calculated to determine the magnitude of the effects of inter-test differences. The formula  $[\Delta\% = (\text{post-test} - \text{test}) * 100/\text{Test}]$  was used to calculate the percentage difference.

## RESULTS

Table I presents descriptive data with mean and standard deviation.

**Table I.** Descriptive data variables in the studied groups

Variables	EG1, n=13	EG2, n=13	CG, n=13
	Mean± SD	Mean ± SD	Mean ± SD
Age (years)	20.69±2.36	20.23±2.45	20.15±1.57
Body Mass (kg)	71.70±12.39	70.86±12.39	78.36±11.28
Height (m)	1.67±0.07	1.69±0.05	1.72±0.06
BMI (kg/m <sup>2</sup> )	25.35±3.47	24.51±3.25	26.46±3.04
Judo experience (years)	6.40±2.60	5.90±2.20	6.10±2.50
RT experience (years)	5.40±2.10	5.20±1.70	5.30±1.90
Throws-Fall/SJFT(number)	24.58±1.78	24.83±1.80	24.58±1.77
Index SJFT (score)	14.47±1.14	14.36±1.46	14.28±1.24
Horizontal bench press(kg)	45.0±18.57	48.92±15.02	55.23±5.92
Shoulder adduction (kg)	36.53±11.07	37.62±8.20	44.23±9.09
Shoulder elevation (kg)	29.84±10.50	31.38±9.71	30.46±9.32
Biceps elbow flexion (kg)	20.69±6.47	20.77±3.44	22.69±4.15
Squats (kg)	47.0±10.02	49.62±13.15	50.3±13.41
Leg press machine (kg)	62.69±19.96	61.54±10.08	66.53±18.86
Knee extension (kg)	42.30±15.36	41.92±13.0	47.30±12.52
Knee flexion (kg)	25.38±7.49	25.38±7.48	30.0±7.07

BMI: Body mass index; SJFT: Special Judo Fitness Test; SD: Standard deviation; EG=Experimental group; CG: Control group; RT: Resistance training.

All measures of pre and post-test for muscle strength exercises demonstrated excellent reproducibility between different test days, exhibiting coefficients between 0.93 and 0.99, which are the intergroup strength measures (Table II).

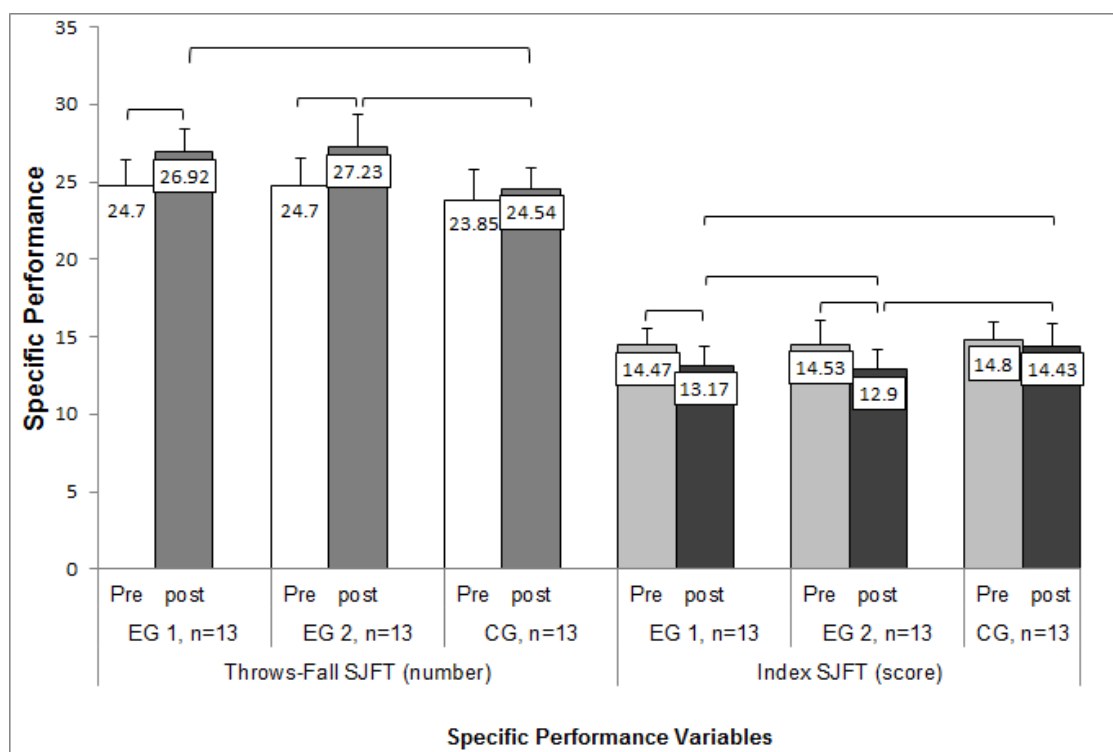
**Table II.** Intra - Class Correlation Coefficient of 10RM test

Exercises	Pre - Experiment			Post – Experiment		
	EG1	EG2	CG	EG1	EG2	CG
Horizontal bench press (kg)	0.995	0.995	0.967	0.968	0.932	0.966
Shoulder adduction (kg)	0.985	0.978	0.982	0.965	0.955	0.955
Shoulder elevation (kg)	0.994	0.989	0.996	0.923	0.998	0.964
Biceps elbow flexion (kg)	0.996	0.959	0.973	0.987	0.946	0.967
Squats (kg)	0.991	0.995	0.998	0.987	0.944	0.932
Leg press machine (kg)	0.993	0.977	0.988	0.932	0.987	0.940
Knee extension (kg)	0.996	0.995	0.992	0.968	0.945	0.953
Knee flexion (kg)	0.976	0.967	0.963	0.976	0.956	0.987

GE: Experimental group; CG: Control group

Figure 1 shows the SJFT test results. Intra-group comparisons showed significant differences ( $p < 0.05$ ) in pitches (throws) within the two experimental groups: EG 1 ( $\Delta\% = +9.03\%$ ; with medium Effect Size (ES) = 1.27)) and EG 2 ( $\Delta\% = +10.29\%$ ; with medium ES=1.41), except for the CG ( $\Delta\% = +2.89\%$ ; with small ES=0.35). There were also significant differences ( $p < 0.05$ ) between EG 1 and EG 2 vs. CG, with the experimental groups achieving better results, as shown in Figure 1.

Figure 1 also shows statistical improvements ( $p < 0.05$ ) in the SJFT test of experimental groups EG 1 ( $\Delta\% = -8.98\%$ ; with medium ES=1.20) and EG 2 ( $\Delta\% = -11.15\%$ ; with medium ES=1.06) compared to the CG (with very small ES=0.31). In addition, EG2 performed better than EG1 ( $p < 0.05$ ) (Figure 1).



**Fig 1.** Results of specific performance in SJFT. The symbol (  $\frown$  ) indicates intra and inter-groups differences ( $p < 0.05$ ).

The results show no significant intra or inter-group differences ( $p < 0.05$ ) in post-test HR for EG 1 (pre:  $187.5 \pm 5.4$  and post:  $191.3 \pm 6.4$ ;  $\Delta\% = +2.01\%$ ) with small ES = 0.69; EG 2 (pre:  $189.7 \pm 8.7$  and post:  $189.8 \pm 7.2$ ;  $\Delta\% = +0.04\%$ ) with very small ES = 0.01 and CG (pre:  $186.1 \pm 10.1$  and post:  $189.1 \pm 11.4$ ;  $\Delta\% = +1.57\%$ ) with small ES = 0.29. In addition, HR 1min post-test was the following: GE 1 (pre:  $168 \pm 9.8$  and post:  $162.5 \pm 10.6$ ;  $\Delta\% = -3.26\%$ ) with small ES = 0.56; GE 2 (pre:  $167.1 \pm 14.2$  and post:  $160.5 \pm 11.3$ ;  $\Delta\% = -3.91\%$ ) with small ES = 0.46 and GC (pre:  $165.3 \pm 11.8$  and post:  $163.7 \pm 12.4$ ;  $\Delta\% = -0.93\%$ ) with very small ES = 0.13.

## DISCUSSION

The aim of this study was to investigate the effect of 12 weeks of different orders of strength exercises for upper and lower limbs on the specific performance of judo athletes. Intergroup comparisons of muscle strength values show excellent reproducibility between different test days for all pre and post-tests of muscle strength, with coefficients between 0.93 and 0.99. In addition, there was no significant intra or inter-group difference ( $p < 0.05$ ) in post-test HR for EG 1, EG 2 and CG, and no change was observed in the HR 1min post-test in GE 1 and GE 2.

It is important to note that the SJFT has higher movement specificity, but smaller measures of physical performance in relation to other less specific but more accurate tests (11). Nevertheless, the SJFT study (11) showed that the test index presented good correlation with aerobic and anaerobic fitness indices.



Recent studies (2,8,12,20) have also shown substantial recruitment of lactic anaerobic metabolism during simulated fighting due to high blood lactate concentrations found after the bout (between 8:14 mmol.L<sup>-1</sup>), contradicting the results of our study. On the other hand, aerobic capacity and aerobic power are considered important because they correlate with higher post-bout blood lactate removal (9,14) and an increase in the number of pitches (projections) in a specific test.

The SJFT has become one of the most widely used tests in judo. With respect to the energy cost involved in testing, Franchini et al. (12) observed greater anaerobic alactic participation (42.3%), followed by anaerobic lactic (29.5%) and oxidative contribution (28.2%), with the last anaerobic sources displaying no significant statistical difference. High anaerobic alactic participation seems to be the result of greater intensity during the test and its intermittent nature, with these same characteristics also reported in other studies involving intermittent exercise (5,16). This also implies a cardiac adaptation to aerobic and anaerobic actions (1).

Studies have shown the effects on variables related to the performance of judo athletes (8,13). Thus, we sought literature studies that show the effects of resistance exercise order on muscle strength in different individuals, in addition to those exhibiting effects on the performance-related variables of judo athletes (26,27). Simão et al. (26) found that exercise order influenced 10RM test performance and muscle hypertrophy in male athletes after 12 weeks of RT with linear periodization, resulting in increased strength and hypertrophy ( $p < 0.05$ ) in most experimental groups and no improvement in the control group.

In a similar study, Spinetti et al. (27) also examined the influence of 12 weeks of different exercise orders focused on the performance of 10RM and muscle hypertrophy, but with non-linear periodization. G1 exercised from the major to the small muscle groups, G2 performed the reverse order, as did the control group. The results of this study indicated no intergroup difference ( $p < 0.05$ ) in increased muscle strength or hypertrophy among the different exercise orders.

By contrast, the study conducted by Simão et al. (26), like ours, assessed the Effect Size (22), clearly demonstrating that differences in strength and hypertrophy were based on the exercise sequence (enhanced performance in exercises carried out at the start of the session). Thus, the results of this study (26) reinforce the hypothesis that the order and sequence of exercises should progress not only as a function of muscle size or body region, but also based on individual needs and movement patterns (19).

In relation to the specific performance of judokas, Blais and Trilles (7) claim that strength training should not be separate from technical training, since their study showed an improvement ( $p < 0.05$ ) in the running time of two classic projection judo techniques (Osoto Morote-gari and seoi nage), after a training period using specific resistance equipment developed for these techniques. It is important to underscore that, although the study by Blais and Trilles (7) was

conducted with resistance equipment, it was developed for technical movements, focusing on the set of muscles involved in the action.

The results of the present study showed a statistical improvement in the number of pitches and SJFT index (Figure 1). However, the resistance exercises that were used in the current study develop muscle groups separately, in contrast to the investigation conducted by Blais and Trilles (7). According to our results (Figure 1), the method based on exercise order may be a new tool for improving the performance of judo athletes. In addition, the fact that they are not elite athletes may have increased the sensitivity to chronic responses after the training program.

It is important to highlight that the SJFT has a number of neuromuscular limitations. During a bout, judokas tend to use their upper limbs more (12) because they rely on the "footprint" in judogi to apply any projection technique. In turn, neuromuscular SJFT predominance in the lower limbs occurs so that judokas can move as quickly as possible towards their opponent. Thus, in some cases, athletes may experience marked peripheral lower limb fatigue, unlike what occurs during fighting, where the upper limb muscles are most fatigued.

The experiment that evaluated the fight actions of 14 finalists at the 2005 European Championship may shed light on this discussion. The study found that champions demonstrated high performance in effective defense, counterattacks and effective global index of judo dynamics compared to their opponents (8). Moreover, there was no statistical difference between the actions of men and women (8).

The present study demonstrated that exercise order in RT can influence performance in elite judo athletes, through higher performance gains in SJFT. Despite the different methodological approaches, Dias et al. (10) observed that sessions starting with lower limb exercises generated larger increases than those beginning with the upper limbs. Therefore, in addition to the influence of training level and individual characteristics on the results of RT, it seems that athletes should begin their RT sessions with lower limb exercises.

Finally, this study supported the hypothesis that exercise order increases the performance of judo athletes, and that the sequence of exercises influences the magnitude of the gain. Based on our results, the sequence consisting of lower limb exercises early in the session generates larger gains than upper limb exercises. It is also interesting that the order of RT exercises that develop the muscle groups requires greater emphasis at the beginning of training sessions.

## **CONCLUSION**

The present study concludes that there were significant improvements in the performance of junior judo athletes. Furthermore, the group that started the sessions with leg exercises showed better results when compared with the group that started with arm exercises. However, further studies are recommended with a big sample and judokas with an international experience.

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