Original Article

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Impact of two different strength/conditioning training interventions on sport and strength performance of junior male judokas

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Abstract

Background. The influence of different strength training interventions on strength and competitive performance has been insufficiently examined in elite junior judokas. This study aimed to investigate the impact of different strength interventions in precompetitive training process of elite junior male judokas. *Material and Methods.* Fifty-three elite judokas (age: 17.22±1.37 yrs, height: 176.34±5.47 cm, body weight: 78.46±6.22 kg, judo training experience: 4.52±0.89 years) performed two different 8-week strength training interventions. Group 1 (n=27) were performed "strength" intervention, group 2 (n=26) were performed "CrossFit®" intervention about 5.3-6.0 hours per week. The base training exercises were as follows: bench press, barbell bench pull and lat pull-down, clean & jerk, snatch, squats and knee flexion curl, pull up. The handgrip strength test, the one-repetition maximum tests, pull up test and competitive performance evalution, were in this study. *Results.* In post-intervention period, were found that bench press and back squat findings were significantly ($p \leq 0.05$) higher in judokas (group 1) as compared to judokas (group 2). There were significantly ($p \leq 0.05$) higher pull up findings in judokas (group 2). No significant differences were observed among the groups with regard to competitive performance values within 3.5 months after post-intervention. *Conclusions*. This study demonstrated that 8-week of different strength training interventions are not equally effective to increase performance of junior male judokas in specific strength tests and not to change competitive performance of athletes within 3.5 months after strength intervention. The final decision for the particular strength training intervention ("strength" or "CrossFit®") can be decided according to an judoka's individual challenges during the competitive season.

Keywords: sport-specific performance, conditioning, strength training, muscle strength, judo training, elite athletes, CrossFit®.

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INTRODUCTION

It's known that muscle strength is a fundamental component of physical fitness in many sports that needs to be developed at an early age to achieve high competitive performance on the elite level [1]. In this regard, muscle strength and strength power were identified as decisive physical fitness attributes in combat sports: judo [2, 3], sambo [4] and combat sambo [5]. Judo became an official sport event in the Olympic Games of Munich in 1972 for men and in the 1992 Games (Barcelona) for women [6, 7]. Competitive judo is a dynamic high-intensity combat sport [8, 9] that requires physical and technical skills and tactical excellence for sporting success. Elite judokas have to perform a great number of physical and technical actions during each match, as such, the physical demand of a single judo match is high [10, 11]. The impact of strength conditioning on competitive success in combat sports, especially judo is accepted by everyone scientific experts and sport/strength professionals [12, 13]. To be successful in this combat sport, judokas need to develop several physical capacities, including anaerobic power and capacity, aerobic power and capacity, maximal isometric and dynamic strength [14], muscle power and strength-endurance [15]. Also, the extensor and flexor strength of thigh and shoulder muscles could discriminate between successful and less successful athletes in judo competition [16].

In competitive judo, rapid force production during pulling movements is an important component of athletic performance, which is why this strength capacity needs to be specifically exercised [17]. Sterkowicz et al, state that junior male judokas must demonstrate high strength in the muscles which are active when pulling (arms joint and flexors and extensors of elbow joint) or lifting the opponent (knee joint extensors and hip flexors and extensors) during performing throws [18]. Investigators state a insufficient development of velocity component of strength while maintaining stability in explosive dynamic situations in competitive confrontation with an opponent among most Russian junior judokas [19]. Çelik & Soyal, indicate that isometric strength is quite important in judo. The higher a judoka has isometric strength (handgrip power), the higher becomes one's technique capacity, thus, the higher one's probability to win the competition [20]. Ullrich, et al, indicate that competitive judo requires whole-body maximal strength and power, judo coaches and strength/conditioning professionals are encouraged to include muscular power training during short-term preparatory periods [21]. In this vein, full scientific knowledge the effect of a short-term specific strength and conditioning training programs on strength and competitive performance in elite judo athletes will be needed.

Judo coaches and strength/conditioning professionals should have a solid knowledge about physiological responses to judo competitions and physical and physiological adaptations to training in order to design an adequate training program during competitive season [6]. Turkish investigators showed that the application of preconditioning strategies in a systematic manner provides performance improvements of professional martial artists, specifically in strength [22]. Hartmann et al, indicate that owing to differences in mesocycle length, conditioning programs, and program variables, competitive athletes either maintained or improved strength and/or speed-strength performance during off-season, pre-season and in-season conditioning. The extent of strength training in in-season conditioning depend on the duration of the contest period, the frequency of the contests, and the proportion of the conditioning program. These strength/conditioning professionals recommended high-repetition strength training (>15) should be avoided because it does not provide an adequate training for strength performance in high-performance sports. Also, confirmed the necessity of the habitual use of ≥80% 1 RM to improve maximal strength during the off-season and in-season to reach peak performance in maximal strength and strength improvements in top-athletes. [23]. Asian investigators state that low-load resistance exercise (20-50% of 1RM), in combination with venous occlusion, has been proposed as an alternative to high-load resistance exercise, because low-load resistance training under hypoxic conditions may be responsible for the increased force, endurance and size of the muscle in professional athletes [24]. Russian scientists, also, provided information benefits of the CrossFit® training program (high intensive strength exercises with low-load – 25-50% of 1RM) to athletic and competitive performance of junior elite judokas [25, 26]. Sivokhin et al, provided information practical benefits of the strength training techniques with variable weights customizable to individual characteristics of the athletes. These investigators state a significant

training benefits of the special strength training tools including squatting practices with variable weights [27]. This scientific review indicates that different strength/conditioning professionals offer different methods and strength training programs for athletes.

Some lack and differences in scientific knowledge that investigated the effect of different strength training program on sport-specific performance and strength performance in elite junior judokas were found in this literature review. *Franchini et al,* indicate that different strength training program (e.g., weightlifting-type exercises, complex training connecting strength exercises to specific judo actions, etc.), longer periods of training, and different judo-performance variables (e.g., judo technique speed and force measurements) should be investigated to establish the best combination required to improve performance of elite junior male judokas [10]. Correct defining safe and effective training programs can be beneficial for professional athletes not only for sporting success, but also for the prevention of different diseases and injuries [28]. Also, In many martial arts it is crucial to be able to make a contact with objects on optimal force [29, 30].

The authors suggested that particular strength (strength or CrossFit®) interventions will have a different impact of judokas' strength rates and competitive performance. We are hypothized that strength intervention will have a more significant impact of judokas' strength rates (one-repetition maximum tests and Pull Up test) and CrossFit® intervention will have a more significant impact of judokas' competitive performance. Therefore, the aim of this study to investigate the impact of different strength interventions in precompetitive training process of elite junior male judokas.

MATERIALS AND METHODS

Participants

The athlets from 16-18 years old men (n=53), participated in this study (age: 17.22±1.37 yrs; height: 176.34±5.47 cm; body mass: 78.46±6.22 kg). The inclusion main criteria of the subjects in this study were follows: those junior men, who had experience in competitive judo, who are can training every day during the study, have no side effects (such as diseases or sport injuries), living in independent daily living activities and no significant differences with regard to age, height, weight and testing indicators (special physical tests). All judokas were brown (n=43) or black (n=10) belt, competed in regional and national level for more than 4.52±0.89 years. All athletes had previous experience with the special physical tests conducted.

All ethical norms and principles have been met in full. All subjects were fully informed of the study protocol and provided signed informed consent. The study was approved by the local ethics expert committee (№32/9.2020) of the Institute of Physical Culture, Sports and Tourism (Siberian Federal University). Full study data were collected between September, 2020 and February, 2021.

The Research Design

All subjects were randomly assigned to two groups: group 1 (n=27) and group 2 (n=26). The overall period of this strength intervention was 8 weeks. All subjects had a total training time amount of 18-20 hours per week. All subjects had two training sessions during the each day (rest between training sessions was at least 4-5 hours). The total amount of strength training sessions had about 5.3-6.0 hours per week. Strength training was executed on Monday, Wednesday, Thursday and Saturday. On the intermediate two days in this training intervention (Tuesday and Friday), all study subjects followed the same judo training program, focused on technical skills, Uchikomi, Randori and grappling. All subjects rested for one day per week (Sunday).

Power (strength and CrossFit®) exercises were selected taking into the recommendations for resistance, strength and CrossFit® training in health adolescents and young adults [31], professional athletes [23, 24, 27, 32, 33] and elite judokas [10, 21, 25, 26, 34]. Each strength training session in study subjects took approximately 80-90 minutes, including warm-up and cool-down periods. Warm-up consisted of 10-minute running (125-145 bpm) followed by a 10-minute dynamic full-body stretching routine. Cool-down included 5-minute running (100-120 bpm) followed by a 10-minute full-body isometric hold-and-relax stretching routine. The overall training regimen in both subject's group consisted of free weights exercises and showed an emphasis on upper-body, lower-body, and

Table 1. The training program of studied judokas during the intervention – group 1 and group 2.

Day	Training program
Monday	Uchikomi and grappling – morning training (90-100 min) "Strength" program – evening training (80-90 min) – "CrossFit®" program
Tuesday	Uchikomi and grappling – morning training (90-100 min) Randori – evening training (55-60 min)
Wednesday	Uchikomi and grappling – morning training (90-100 min) "Strength" program – evening training (80-90 min) – "CrossFit®" program
Thursday	Uchikomi and grappling – morning training (90-100 min) "Strength" program – evening training (80-90 min) – "CrossFit®" program
Friday	Uchikomi and grappling – morning training (90-100 min) Randori – evening training (55-60 min)
Saturday	Uchikomi and grappling – morning training (90-100 min) "Strength" program – evening training (80-90 min) – "CrossFit®" program
Sunday	Rest

total body strength enhancement. The base training exercises were as follows: bench press, barbell bench pull and lat pull-down, clean & jerk, snatch, squats and knee flexion curl, pull up. The study subjects (group 1) were performed "strength" program (7-12 repetitions in each set, 4-5 sets and 65-85% of 1RM in each exercise). Rest periods of approximately 2.5-3.0 minutes were given between the sets. The study subjects (group 2) were performed "CrossFit®" or "strength velocity" program (maximum repetitions in each set, 6-8 sets and 25-50% of 1RM in each exercise). Each set in this program lasted 4.0 minute (overall time in competitive judo match). Rest periods of approximately 4.0 minutes were given between the sets. All training sessions were supervised by gym instructors, who have a large experience in strength/conditioning training. The general information in strength training interventions outlined in Table 1.

In post-intervention period (November, 2020 – February, 2021) all studied athletes continued training (18-20 hours per week) during two week. The base of each training session consisted Uchikomi & Randori. Then each judoka participated in competitive cycle (five judo tournaments during twelve week). The recovery period and training for the next competition was about two weeks.

Procedures

The robust and simply measurement tools: isometric handgrip strength test, the one-repetition maximum bench press and back squat tests, pull up test and competitive performance evalution, to assess the strength and competitive performance of study subjects were in this study.

Isometric Handgrip Strength Test (IHST). The maximal isometric handgrip strength in study subjects was measured three times on each side, alternately, with a 30-sec interval between attempts, and, in each one, the subject was instructed to generate the greatest possible force during 3-5 sec, in a standing position, with fully extended elbow and self-selected wrist positions. All measurements were conducted using a MEGEON 34090 dynamometer (MEGEON, Moscow, Russia), with a 100 gram-force (gf) accuracy. The higher value for each side was used in the study analysis. All study subjects underwent measurements twice (pre- and post-strength intervention). Those procedures were conducted taking into the information by E. Franchini for IHST measurements in elite judo athletes [14].

The one-repetition maximum test (1RM) is defined as the maximal weight an individual can lift for only one repetition with correct technique. 1RM test is often considered as the "gold standard" for assessing the strength capacity of individuals in non-laboratory environments. The basic steps in 1RM test procedure: each subject should warm up, completing a number of submaximal repetitions. Than study subjects determined the 1-RM within four trials with rest periods of 3 to 5 minutes between trials (initial weight is must within the subject's perceived capacity – 50-70%). Weight resistance is progressively increased by 2.5-5 kg in each repetition until the subject cannot complete the selected repetition. All repetitions should be performed at the same speed of movement and range of motion

[35]. An Olympic bar of 20 kg and Olympic barbells of 2.5-25 kg (ProfiGym, Tula, Russia) was used in this study.

The one-repetition maximum (1RM) bench press test. The each subject should a rest (two to four minutes), then perform the 1RM attempt with proper technique. If the lift is successful, rest for another two to four minutes and increase the load 2.5-5 kg, and attempt another lift. The subject keep increasing the weight until a maximum lift is performed for the four attempts after the warm-up sets. The absolute weight is recorded in the study analysis.

The one-repetition maximum (1RM) back squat test. The subject stand under the bar, with feet shoulder-width apart (the knees should be in line with the toes). The subject take the weight on shoulders, then bend at the knees and hips to lower the body, then push back up to a standing position. Weight lifting was successful if, in the lowest point of the squat, the thigh was parallel to the ground before lifting (determined visually) and if the load was lifted without assistance. If the repetition is successful, subject had a rest for two minutes and increase the load 2.5-5 kg, for new attempt (maximum – four attempts). The absolute weight is recorded in the study analysis.

The pull up test. This test (also called the chin-up test) is widely used as a measure of upper body strength. An pull up stand bar DFC POWER TOWER G002 (DFC, China) used in this study. All subjects should adequate warm up and had a rest for 2-3 min. The subject must grasp an overhead bar and pull up the body so the chin raises above the bar, then return to the position with the arms fully extended. The pull-ups should be done in a smooth motion. Jerky motions, swinging the body, and kicking or bending the legs are not permitted. The absolute result in pull ups is recorded in the study analysis.

Competitive performance (CP). To determine competitive success, each study subject was evaluated with regards to their performance during the five judo tournaments which were scheduled within 3.5 months after post-intervention (November, 2020 – February, 2021). The subjects' individual rank during the tournaments was evaluated in accordance with guidelines of the German potential analysis system (PotAS) for elite sports [36]. With respect to competitive success, the individual rank position (RP) of each study subject was evaluated using a graded point scale (RP-1 (gold medal) = 50 points, RP-2 (silver medal) = 40 points, RP-3 (bronze medal) = 30 points, RP-4 (fifth-sixth place) = 20 points, RP-5 (seventh-eighth place) = 10 points, RP-6 (ninth place and below places) = 5 points, missing attendance = 0 points). Those procedures were conducted taking into the information by O. Prieske for determine sporting success point scale in sub-elite judo athletes [3]. The subjects' mean final scores achieved were used in the study analysis.

Statistical analysis.

The overall results of this study were analyzed using the IBM SPSS Statistics for Windows, Version 21.0 (Armonk, NY: IBM Corp.). All values were expressed as means and standard deviations (SD). Distribution of data (normally or non-normally) was confirmed using the Shapiro–Wilk test. In order to compare the means of normally distributed variables between groups unpaired t-test was used. Fisher's F-test was to test for equality of variances from two normal populations. For non-normally distributed variables Mann–Whitney U-test was used. A p value of ≤ 0.05 was considered statistically significant for this study.

RESULTS

There were no significant differences in specific physical test results for all study subjects' group in pre- intervention. All subjects showed a similar strength performance in this period (September, 2020). The mean CP values of subjects in this period were not evaluated.

There were significant ($p \leq 0.05$) differences among the groups with regard to pull up, bench press and back squat test findings in post-intervention (November, 2020). In post-intervention period, were found that bench press and back squat findings were significantly ($p \leq 0.05$) higher in subjects (group 1) as compared to subjects (group 2). However, there were significantly ($p \leq 0.05$) higher pull up findings in study subjects (group 2). No significant differences were observed among the groups with regard to CP values within 3.5 months after post-intervention (November, 2020 – February,

2021). All subjects' group demonstrated similar mean CP values during the five judo tournaments. The general information in overall study period outlined in Table 2.

Table 2. The overall findings of studied judokas in pre- and post-intervention.

Period	Tests	Group 1 (n=27)	Group 2 (n=26)	p≤
Pre-intervention (September, 2020)	IHST (kg)	51.64±4.09	50.86±3.54	0.203
	Pull Up (rep)	22.32±3.69	21.79±3.18	0.254
	Bench Press (kg)	102.58±4.99	101.78±4.60	0.373
	Back Squat (kg)	116.25±8.26	115.36±8.40	0.298
	CP (mean score)	–	–	–
Post-intervention (November, 2020)	IHST (kg)	52.27±3.67	51.50±3.19	0.163
	Pull Up (rep)	22.98±3.20	24.03±2.92*	0.040
	Bench Press (1RM)	104.39±5.16*	102.65±4.61	0.044
	Back Squat (1RM)	119.67±6.25*	117.17±5.67	0.032
	CP (mean score)	64.70±25.15	61.56±26.19	0.312

* - statistical significance (p≤0.05), IHST - isometric handgrip strength test, CP - Competitive performance of athletes.

DISCUSSION

In this study, we have particularly support our hypothesis about different impact of particular strength interventions on the strength rates (1RM) of studied judokas. However, we doesn't evidences, which support our other hypothesis about different impact of particular strength interventions (strength and CrossFit®) on the CP values of studied athletes. It's known that identifying the most effective strength periodization model for eliciting maximal alterations during short-term training interventions is important for many combat sports, such as judo, requiring short duration off-season and preseason training programs. Today, judo and strength/conditioning professionals haven't yet determined the final model of strength training of elite judokas in pre-season and in-season. Different strength training protocols should be investigated to establish the best combination required to improve performance of elite judokas [10]. We are investigated the impact of two different (strength and CrossFit®) 8-week training program on strength performance and sport success of elite junior male judokas. This study suggested that different strength training intervention have a multidirectional effect on the strength performance of athletes in specific strength tests. However, no significant impact of any strength intervention on CP values in study subjects was found.

Ullrich, et al, state that independent of the periodization model, 4 weeks of muscular power training induced moderate gains in maximal lower-body, upper-body, and total body strength in previously trained young judoka [21]. At the same time, Greece investigators indicate that the 4-week strength training program, including mainly using circuit training, did not improve upper and lower body strength and power of combat athletes [37]. Franchini et al, state that 8-week of linear and undulating strength training interventions are equally effective to increase judo performance of judokas in a judo-specific test, isometric and dynamic maximal strength, and strength endurance, but not to change technical actions during judo match simulations [10]. Our findings demonstrated significant differences in specific strength tests (1RM) between subject's group after 8-week different strength training interventions, but not to significant changes in CP values among the subject's group within 3.5 months after post-intervention. We are suggested that strength training interventions using strength and CrossFit® exercises in junior male judokas are not able to significant change the physiological responses and successful of technical actions performed during the judo match if training strength intervention are not longed.

Çelik & Soyal, determined that the 6-week strength trainings junior elite judokas caused significant changes in their hand grip power [20]. No significant differences were observed among the study subjects with regard to maximal isometric handgrip strength values (IHST) in pre- and post-intervention in our study. Trivic et al, provided knowledge of handgrip strength in elite junior sambo

athletes. Mean handgrip strength performance values of these sambo athletes are follows – 52.0±2.8 kg [4]. It can be noted that all study subjects, who used different strength interventions, showed similar indicators in post-intervention. So we can assume that the possibility of the handgrip strength increasing does not depend on the specific of strength training intervention, a depend on longer period of strength training. Besides, body weight and age of the combat athletes (especially in judo) have a significant influence on the results obtained in the dynamometer measurement of hand strength [38]. Additionally, Spanish investigators state that judo bouts produced acute improvements in the arm pushing isometric strength and handgrip strength in elite male judokas. Effective training strategies should focus primarily on achieving high levels of arm isometric and handgrip strength and maximum strength in judokas at the expense the skillful using judo bouts [15].

Prieske et al, indicate that young sub-elite judokas with larger seasonal gains in maximal strength are not necessarily those combat athletes with more successful performance in judo competition [3]. Russian investigators state that young sub-elite and elite judokas, who practiced regular CrossFit® workouts, demonstrated a higher physical conditioning and more successful performance in judo tournaments [26]. Our findings revealed that differences in physical fitness (strength performance) between study subjects' group were not associated with sporting success in judo competition. There were no significant differences in CP values among the study subjects, who used different strength training interventions in this study. Further robust studies comparing strength intervention models with young elite male judokas during longer muscular power training regimens are needed to extend scientific knowledge.

All involves made in this study have some limitations. These limitations associated with the low number of study subjects and short strength intervention period. Also, in spite of being homogeneous in terms of chronological age, investigated 16-18 years old study subjects were still in the process of growth and maturation and that could have interfered with their perceived exertion, well-being, and recovery measures after intensive strength workouts. Also, the general findings of this study could be influenced by rapid weight loss procedures in junior judokas for competition success. Most of study subjects performed strategies for rapid weight loss (which is an acute loss of body mass) in the 3-6 days prior to the competition. It is known, that the rapid weight loss procedures can be harmful, especially during adolescence and junior. Also, the lack of a passive control group (junior male judokas, who not practiced a special strength intervention in precompetitive training) should be acknowledged as a methodological limitation of this study.

CONCLUSIONS

This study demonstrated that 8-week of different strength training interventions (strength training and CrossFit® training) are not equally effective to increase performance of junior male judokas in specific strength tests and not to change competitive performance of athletes within 3.5 months after strength intervention. This knowledge could be of interest for judo coaches with junior elite athletes competing. Strength/conditioning professionals and judo coaches can be used particular strength intervention to improve judokas' maximum strength and anaerobic power or CrossFit® training intervention to improve judokas' dynamic strength and aerobic power during the 8-week in precompetitive period. The final decision for the particular strength training ("strength" or "CrossFit®") intervention can be decided according to an judoka's medal challenges during the competitive season. We are expected that this knowledge to contribute to the development of optimal strength training interventions aiming to achieve maximum athletic performance and to maintain the health of elite junior judokas.

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CONFLICTS OF INTEREST

The authors declare that there are no conflicts of interest.

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