ORIGINAL ARTICLE

The impact of various strength training protocols on the strength and sporting performance of junior male judokas

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Abstract

Background and Study Aim: Judo coaches offer various strength training protocols to improve performance of judo athletes. The purpose of the study was knowledge about the impact of a 12-week various strength training protocols on the strength and sporting performance of junior male judo athletes.

Material and Methods: The participants 17 years old elite male judokas (n = 36). The overall study period was 12 week. Various strength training protocols were used. The group 1 used resistance workouts (four workouts per week). Other participants used different protocols of mixed strength workouts: two resistance + two circuit workouts per week (group 2) and three CrossFit + one resistance workout per week (group 3). The general (IHST, Bench Press, Back Squat, Squat Jump) and specific (SJFT and Sporting Performance) tests to assess for strength performance of athletes were used.

Results: A higher ($p \leq 0.05$) positive impact of various strength training protocols for studied athletes on back squat test (group 1) and on the pull-up test (group 3) was found. A more significantly ($p \leq 0.05$) positive impact of resistance workouts and strength mixed (CrossFit + resistance) workouts on a sporting performance (won competitive judo matches) of studied judo athletes (group 1 and group 3) was found.

Conclusions: The study demonstrated that 12 weeks of various strength training protocols: resistance workouts and mixed (CrossFit + resistance) workouts, are more effective to increase some strength and sporting performance of junior male judokas.

Keywords: combat sports • CrossFit • circuit training • judo • resistance training • sporting success

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INTRODUCTION

Judo is an acyclic and high-intensity intermittent Olympic and Paralympic sport, which requires complex technical and tactical skills and puts high physiological and neuromuscular demands [1, 2]. Judo is a sport in which physical fitness of athletes is most important [3, 4]. This is a combat sport characterized by high-intensity intermittent efforts, that creates great muscle-strength and power demands on both the upper and lower body [5, 6]. These high physical and technical demands stress the necessity for specialized strength and conditioning training programs for these athletes [7]. Experts suggesting that strength and conditioning are related to modality specificity [8]. Since the introduction of the international ranking system in 2009 by the International Judo Federation (IJF), judo athletes compete regularly in seven to ten international competitions per year. To be successful in international competitions, judo athletes must achieve an excellent level of physical fitness and condition during training, where the muscular strength plays one of the most important indicators [9].

The block periodization has been proposed as an approach to be used in the contemporary high-level sports context [10]. Training periodization resulted in advantageous body composition changes and improved physical fitness of the athletes [11]. To suit high competitive demand, the training periodization should be adopted to improve judo athletes performance [12]. The methodology of the judo sport training (planning and appropriate periodization of the sporting training) was always guided for the performance [13]. Judo coaches, must have a detailed specific classification for judo-specific aerobic and anaerobic fitness [14-16], as well as judo-specific strength-endurance performance [17]. Tracking fitness profiles on a regular basis over the course of a training season in judo athletes appears to be critical since these characteristics drive performance during competition. This becomes even more important in young judoka given that the main long-term goal of training with young athletes is to lay the foundation for higher training loads at the elite level [18, 19]. To determine the most effective strength periodization training model is important to improve judo athletes' performance. Various periods of strength training, and different judo-performance variables should be investigated to establish the best combination required to improve performance of judokas [20].

The principle of training periodization emphasizes on different approaches to manipulating training workload and load over time. It was assumed that more frequent changes of the major exercise variables should be advantageous for strength and power development compared to traditionally periodized training programs. However, the current body of literature fails to provide evidence for the superiority of a certain periodization model in enhancing maximum strength and power output in subjects with advanced training level [21]. Franchini et al. [20] demonstrated that different (linear and undulating) strength training protocols are equally effective to increase judo performance of athletes in a judo-specific test, isometric and dynamic maximal strength, and strength endurance, but not to change rating of perceived effort responses or technical actions during judo match. Harries et al. [22] show that periodization is effective to improve training adaptations but the most effective periodization approach for muscular strength development for athletes is yet to be determined. There are needs a new methodological approaches aimed at the formation and improvement of physical fitness [23] and strength and sporting performance of combat athletes in the process of longer training periodization [24].

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. It is known that coaches and selection professionals pay close attention to the physical fitness and strength performance of combat athletes, starting with the sport selection procedure [25]. In this regard, muscle strength and power were identified as decisive physical fitness attributes in judo [19]. Also, explosive strength and strength endurance are particularly important in judo, since these abilities are correlated with the sports level of elite judokas [26]. The majority of Russian judo coaches adhere to the position that it is necessary for judokas to form dominant strength strategies for competitive duel with an opponent [27]. Bolotin et al. [28] indicate that most young male judokas (16-18 years old) using power alone as the leading physical quality in competitive matches. Casals et al. [29] show, that the training program of elite male judo athletes should aim to increase their muscle mass. Some investigations suggest the importance of lower-body strength and power for junior judokas and provides information for professionals working with these athletes [30].

Judo – ***noun*** an intermittent combative sport requiring technical, tactical, and psychological skill that creates great muscle-strength and power demands on both the upper and lower body [5, 6].

Combat sport – ***noun*** a sport in which one person fights another, e.g. wrestling, boxing and the martial arts [50].

Physical conditioning – ***noun*** same as conditioning ***noun*** the work or programme used to bring somebody or something to a good physical state [50].

Performance – ***noun*** the level at which a player or athlete is carrying out their activity, either in relation to others or in relation to personal goals or standards [50].

Special Judo Fitness Test – test used to diagnose specific physical fitness in judo, structurally very similar to the structure of judo actions [51].

Maximal muscular power – describes the highest level of power (work/time) achieved in muscular contractions [52].

Strength training – ***noun*** training that aims to build muscle strength, usually resistance training [50].

Circuit training – ***noun*** a form of sports training that involves performing different exercises in rotation [50].

CrossFit – ***noun*** extreme conditioning program (created by Greg Glassman), comprises a mix of elevated intensity functional movements by using basic Olympic weightlifting techniques, power training, exercises with body-weight, and aerobic training [34].

CrossFit training – routines involve exercises using large groups of muscles, high number of repetitions, fast execution speed and short recovery periods [35].

Resistance – ***noun*** opposition to a force [50].

Exercise – ***noun*** **1.** physical or mental activity, especially the active use of the muscles as a way of keeping fit, correcting a deformity or strengthening a part. **2.** a particular movement or action designed to use and strengthen the muscles ■ ***verb*** **1.** to undertake physical exercise in order to keep fit and healthy **2.** to subject

Kostrzewa et al. [26] suggest paying particular attention to the strength of the muscles of the lower extremities in the training process of judo. It is known, that strength training provided the greatest training specific results in youth with consistently large magnitude improvements in lower body strength [31]. Upper limb strength and endurance indicators also be taken for the prescription of training programs in judo [32].

Many experts, who studied strength qualities of judo athletes, determine methods of pedagogical stimulation for the purpose of their development. However, until recently there has not been a single view of the methods of development of strength qualities of judokas [3]. In classical training systems, endurance and resistance exercises are very often separated. Nowadays, in sport training it is postulated to combine both types of exercises [33]. One of the types of combined strength workout is CrossFit training [34]. CrossFit training sessions routines involve exercises using large groups of muscles, high number of repetitions, fast execution speed and short recovery periods [35]. CrossFit training is considered an effective method of increasing and maintaining high performance of elite athletes in martial arts [36, 37]. Türker & Yüksel,[38] found a significant positive effect of classic CrossFit trainings on the anaerobic power performance of wrestlers. Osipov et al. [39] point a positive impact a 12 week CrossFit training sessions on a performance of junior male judokas.

Physical fitness is of great importance to have a remarkable performance during the competition. Therefore, becoming necessary to incorporate different tests to acknowledge specific characteristics of the athletes in training protocols. Regular monitoring of physical and strength performance increases the likelihood of success in the competition [40]. Detanico et al. [41] highlight the importance of considering the training experience and outcomes of physical tests, in the planning of individual training programs in young judo athletes. All tests, regardless of the type, must possess three basic requirements: validity, reliability and objectivity that guarantee the goodness of the information that is collected [42].

Today judo coaches and strength professionals offer different strength training protocols and strength performance periodization programs in judo training [20]. Experts ask an important question arises as to how combined workouts including strength and endurance exercises will affect the body and performance of judo athletes. An more important question concerns the proportions of types of exercises, their intensity and duration. Also important to determine which values of strength and conditioning tests will serve as objective markers of sports performance of elite judokas.

Thus, the purpose of the study was knowledge about the impact of a 12-week various strength training protocols on the strength and sporting performance of junior male judo athletes.

MATERIAL AND METHODS

Participants

Junior male judokas (17.29 ±0.47 years old) volunteered for this study after reading and signing an informed consent form. All judokas (n =36) were brown (n =29) or black (n = 7) belt, competed in regional and national level for more than 4.03 ±0.12 years and had previous experience with the tests conducted. The average body weight of the athletes 84.46 ±3.27 kg. There was no significant difference between participants for physical fitness and strength performance before the study beginning. All procedures were in accordance with the Declaration of Helsinki and approved by the local university ethics committee (Siberian Federal University). All ethical norms and principles have been met in full.

The study design

The main base of the study was the Sports wrestling academy named after D.G. Mindiashvili (Krasnoyarsk, Russian Federation). The overall study period was 12 weeks. All athletes had a total training time amount of 28-30 hours per week. The total amount of strength workouts had about 4.3-5.0 hours per week. All judokas were randomly divided into equal groups. All participants s completed a 12-week training program. Strength training was performed four times per week (Monday, Wednesday, Friday, Saturday), according to the group assignment. Each group used an individual strength training protocol. On the intermediate two days (Tuesday and Thursday), all athletes followed the same training program, focused on technical skills, randori and grappling. All participants rested for one day per week (Sunday).

the body, or part of it, to repetitive physical exertion or energetic movement in order to strengthen it or improve its condition [50].

Training session – *noun* a period of time during which an athlete trains, either alone, with a trainer or with their team [50].

Periodization – *noun* the act of planning a long-term training schedule for professional athletes, working around competitions [50].

Randori – sparring in judo in which both participants practice attacking and defending [53].

Group 1 (n = 12) used a four resistance workouts for each week. The amount of each strength workout was 70-80 minutes. The athletes practiced resistance workouts with weight (70-85% of the maximum level for their single repetition). Basic strength exercises: deadlifts, bench press, push press, back squats, push–ups, planks and others (dumbbell bench press, dumbbell incline bench press, dumbbell lunge, lower back extension, leg press, leg extension, hanging leg raise). The judokas performed one basic strength exercise (deadlifts, bench press, back squats) and 3-4 non–basic strength exercises at each resistance workout. The athletes performed 4-5 sets (8-12 reps in each set) in each strength exercise. Rest interval between sets and exercises was about 2-3 minutes, according to the experts' recommendation for muscular strength training [43].

Group 2 (n = 12) used a two resistance workouts and two special fitness (circuit) workouts for each week. The amount of each resistance workout had 70-80 min. The resistance workout structure was similar to that of group 1 workout. The amount of each circuit workout had 50-55 min. Each circuit included 8 different movements per circuit. Workout circuit: pull-ups 30 sec; barbell squats (with weight: 45-60 kg) 30 sec; push-ups 30 sec; regular deadlifts (with weight: 55-65 kg) 30 sec; pull the weight up towards your chest (with weight: 25-35 kg) 30 sec; each leg lunches (with weight: 20-30 kg) 30 sec; bench press (with weight: 40-50 kg) 30 sec; bench jumps (bench height 70 cm) 30 sec. Total motor time in each circuit 4 minutes (time of one competitive judo match). All judokas completed at least 9-10 circuits in each circuit workout. All athletes performed the movements as possible quickly. The rest interval between training circuits was 2 min (1-4 circuit) and 2.5 min (5-8 circuit).

Group 3 (n = 12) used a three CrossFit workouts and one resistance workout for each week. The amount of each resistance workout had 70-80 min. The resistance workout structure was similar to that of group 1 workout. The amount of each CrossFit workout had 55-60 min. The athletes practiced functional workouts: fast run (sprint 10 m) 60 sec; barbell squats (with weight: 45-50 kg) 45 sec; push-ups 45 sec; jumping jacks (with weight 16 kg) 60 sec; kettlebell swings (16-24 kg) 60 sec; fast walking with weight (36-48 kg) 120 sec; plank 120 sec, and other functional exercises in different combination. Each CrossFit set lasted 4 minutes (time of one competitive judo match). All athletes completed at least 10 sets in each CrossFit workout. The rest interval between training sets was 2 min (1-5 set) and 2.5 min (6-10 set).

Procedures

The general and specific tests were used in our study. The general tests show the strength performance level of the athletes (IHST – *Isometric Handgrip Strength Test*, Bench Press, Back Squat, Squat Jump and Pull-Up). The specific test (SJFT – *Special Judo Fitness Test*) show the specific physical performance level of the judo athletes. All athletes were submitted to the tests in the study beginning and study ending.

Special Judo Fitness Test (SJFT). The execution of the SJFT followed the original recommendations by S. Sterkowicz et al. [44]. The SJFT is divided into three active periods (A, 15 sec; B and C, 30 sec) with 10-sec intervals between them. During each period, the athlete being evaluated throws 2 partners (separated from each other by a distance of 6 m) as many times as possible using the Ippon-seoi-nage technique. Heart rate (HR) is measured immediately after and 1 min after the end of the test. Polar H10 HR monitors (China) were used to evaluate the indicators of HR recovery after a test load. The number of throws is summed and an index is calculated as follows: final HR (bpm) + HR1 min after the test (bpm) divided by the number of throws. The lower the index, the better is the SJFT performance [41]. All participants involved with the SJFT presented similar height and body mass characteristics. The index SJFT values for all participants compared to the SJFT classificatory tables for junior judo athletes [16, 17].

Isometric Handgrip Strength Test (IHST). This test is to measure the maximum isometric strength of the hand and forearm muscles. The participants hold the dynamometer (DMER 120-0.5. Russia) in the dominant hand to be tested, with the arm at right angles and the elbow by the side of the body. The handle of the dynamometer is adjusted if required – the base should rest on the first metacarpal (heel of palm), while the handle should rest on middle of the four fingers. When ready the subject squeezes the dynamometer with maximum isometric effort, which is maintained for about 3-5 seconds. No other body movement is allowed. The participant should be strongly encouraged to give a maximum effort. Three test trials were performed and the best was used for further analysis.

1-RM Bench Press Test. This test is a measure of the maximal weight a participant can lift with one repetition. All test procedures were explained to the participants. All participants should perform an adequate warm up. The participant should a rest (two to four minutes), then perform the one repetition maximum attempt with proper technique. If the lift is successful, rest for another two to four minutes and increase the load 2.5-5%, and attempt another lift. If the participants fails to perform the lift, should rest (two to four minutes) and attempt a weight 2.5-5% lower. Keep increasing the weight until a maximum left is performed for the five attempts after the warm-up sets. The values were calculated (maximal weight lifted per body weight).

1-RM Back Squat Maximum Test. This is a specific maximum strength test for the lower body, using the squat exercise. After an adequate warm up, the participants stands under the bar, with feet shoulder-width apart. The knees should be in line with the toes. The participants take the weight on shoulders, then bend at the knees and hips to lower the body. Ensure the head and neck are in a neutral position with eyes facing forward (avoid rounding of the spine). Lower the body until the knees are at a right angle, then push back up to a standing position (move in a slow, smooth and continuous movement). The one repetition is performed for maximum weight in an ascending sequence. If the repetition is successful, rest for two minutes and increase the load 2.5-5%, and new attempt (maximum: five attempts). If a weight is failed, another attempt may be made. The values were calculated (maximal weight per body weight).

Squat Jump Test. Each participant must to place their hands on their hips and must lower themselves into a semi-squat position (thighs are parallel to the ground or even higher with knee joints at about 90 degrees or a bit more) and pause for 2-3 seconds. After the 2-3 second pause, the athlete is then free to jump explosively as high as possible but must attempt to land in the same location on the platform as they took off from. The participants must perform three jumps so that performance averages or their best score can be calculated. Height of each jump was estimated using the Opto-jump Modular (Microgate Engineering, Italy) and was expressed in cm.

Pull-Up Test. This test used is a measure of upper body strength. All participants grasp the overhead bar using an overhand grip (palms facing away from body), with the arms fully extended. The participants then raise the body until the chin clears the top of the bar, then lowers again to a 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. As many complete pull-ups as possible are performed.

Sporting Performance (SP). To determine sporting performance, each athlete was evaluated with regards to their performance during the 8 judo competitions (regional and national judo tournaments), which were held within 3 months after the end of the study. We determined the ratio between the total number of competitive matches and the number of won competitive matches for each athlete (total number of matches per number of won matches). The participants' total values achieved were used for further analysis.

Statistical analysis

Statistical processing of the results was carried out using the SPSS Statistics 17.0 software. All values are expressed as means and standard deviations (SD or ±). The reliability of differences in the study results was determined using the one-factor ANOVA test for independent measures. A p value of ≤0.05 was considered statistically significant.

RESULTS

There were no significant differences in test results for all participants' group at the study beginning. All studied athletes showed a similar strength and specific fitness performance tests results. The index SJFT for all participants demonstrated values within the Regular (12.24-14.73) level (SJFT classificatory tables for junior judo athletes). The sporting performance values were not evaluated at the study beginning. The overall test results of the participants in the study beginning are shown in Table 1.

There were no significant effects of strength training protocol on IHST, bench press, squat jump and special performance index (SJFT) for all studied athletes in the study ending. The index SJFT for all participants demonstrated values near to the Good (11.05-12.23) level (SJFT classificatory tables for junior judo athletes). An higher positive impact of resistance strength training protocol was found for athletes (group 1) on back squat results. The

Table 1. Test results of the studied judo athletes in the study beginning.

Tests	Group 1 (n = 12) Mean±SD	Group 2 (n = 12) Mean±SD	Group 3 (n = 12) Mean±SD	p-value
IHST	52.49 ±5.22	51.25 ±6.35	52.31 ±5.18	0.670720
Bench Press	1.19 ±0.09	1.15 ±0.07	1.18 ±0.11	0.176579
Back Squat	1.33 ±0.11	1.31 ±0.06	1.35 ±0.08	0.794375
Squat Jump	23.52 ±2.51	22.96 ±3.18	23.31 ±2.68	0.894646
Pull-Up	20.42 ±3.17	19.95 ±3.12	21.08 ±2.25	0.476457
SJFT	12.42 ±0.15	12.47 ±0.14	12.45 ±0.11	0.581785
SP	–	–	–	–

participants (group 1) presented better (p≤0.05) performance in the back squat test than other participants. An higher positive impact of mixed (resistance + CrossFit) strength training protocol was found for athletes (group 3) on pull-up results. The athletes (group 3) performed better than other participants in the dynamic pull-up test (p≤0.05).

There is a significant (p≤0.05) impact of strength training protocol on the sporting performance values of participants' group at the study ending was found. The sporting performance values of judokas (group 2) were significantly (p≤0.05) differs than group 1 and group 3. These results indicate a lower number of won competitive matches by group 2 judokas. The overall test results of the participants in the study ending are shown in table 2.

DISCUSSION

The comparison of specific strength performance of judo athletes allows estimating the influence specificity of sport and identifying criteria for success in judo. Due to the specific requirements of judo, obtained results of this study will provide useful information that relates to impact of various strength training protocols on the isometric and dynamic strength performance of junior male judokas.

Previous scientific studies proposed SJFT classificatory tables for junior judo athletes [16, 17]. According to these data the index SJFT values for junior judokas characterize the Regular (12.24-14.73) and Good (11.05-12.23). We found a positive change in the index SJFT values in all athletes' group during the study period. The positive dynamics of the index SJFT values, from the Regular to a Good level, was identified. The improvement SJFT values show the effectiveness of using strength workouts in this training period. The SJFT is predominantly anaerobic in nature, therefore an improvement in the index SJFT values may be the result of increased muscle power of athletes. Improving the index SJFT values is necessary because the number of throws completed during the SJFT has been shown to be related to technical effectiveness of judo athletes during judo competition [16].

Table 2. Test results of the studied judo athletes in the study ending.

Tests	Group 1 (n = 12) Mean±SD	Group 2 (n = 12) Mean±SD	Group 3 (n = 12) Mean±SD	p-value
IHST	53.26 ±5.49	52.84 ±4.51	53.08 ±5.35	0.949585
Bench Press	1.23 ±0.09	1.21 ±0.12	1.22 ±0.06	0.709198
Back Squat	**1.49 ±0.06***	1.43 ±0.03	1.46 ±0.07	0.040577
Squat Jump	25.49 ±3.57	24.86 ±3.94	25.20 ±3.45	0.858038
Pull-Up	22.19 ±2.43	21.76 ±3.24	**23.53 ±3.22***	0.031386
SJFT	12.33 ±0.08	12.35 ±0.11	12.29 ±0.06	0.258910
SP	1.49 ±0.09	**1.56 ±0.11***	1.45 ±0.08	0.034439

Note: (reliability of differences)*p≤0.05

Franchini et al. [12] indicate that judo athletes would present an increase in upper-body anaerobic power, lower-body muscle power, upper-body aerobic power and strength endurance, but would present no difference in the SJFT performance, during strength training periodization (18-week). There is a significant difference between initial and post intervention index SJFT values of all participants were found in our study. It is possible that these results are related to the overall duration of study. In a shorter training periodization period (e.g. 6-week), increase in the SJFT performance of judo athletes was observed [46].

A higher handgrip strength is expected from combat sports, judo specifically (due to judogi usage). Sterkowicz et al. [47] are reported greater handgrip strength in junior judo athletes when compared to students of the same age and body mass (47.6 ±9.3 vs. 45.2 ±5.5 kg). Trivic et al. [48] provides the data of handgrip strength analyses in relation to age, gender, and weight categories of elite cadet sambo athletes. The handgrip strength performance of sambo athletes changed according to their weight category except in 84 kg in male athletes (52.0 ±2.8). Our results show approximately the same impact of various strength training protocols on isometric handgrip strength performance of all participants (on average 53.06 ±5.11). It can be assumed that 12-week various strength training protocols have a significant impact on the handgrip strength of judokas. Soyal & Çelik [49] indicate that the 6-week strength training sessions (resistance training with weight) applied to junior judo athletes caused significant changes in their handgrip power values. We found that over 12-week of using various strength training protocols, all participants almost equally improved their IHST values. It can be assumed that the possibility of the hand grip power increasing does not depend on the specific of strength training protocol, a depend on longer period of strength training.

Kostrzewa et al. [26] suggest paying particular attention to the strength of the muscles of the lower limbs in the training process of judokas. The lower limbs are more important for achieving high scores in judo than the upper limbs. In our study, the athletes (group 1), who had a higher strength performance of the lower limbs (back squat), showed more significant ($p \leq 0.05$) sporting performance, than athletes (group 2). However, there were no significant differences between sporting performance values of athletes (group 1) and athletes (group 3). So this inference was confirmed only partially. Prieske et al. [19] indicate that changes in body composition and physical fitness were not associated with sporting success in judo competition. Young judoka with larger seasonal gains maximal strength are not necessarily those athletes with more successful performance in competition. Our study indicate that judokas who has significantly ($p \leq 0.05$) higher strength performance indicators (back squat and pull-up) demonstrated significantly ($p \leq 0.05$) higher sporting performance in competition.

Kostikiadis et al. [7] indicate that the 4-week training program, including mainly using circuit training, did not improve upper and lower body strength and power of athletes. In our study positive changes were found, from initial to post intervention values, in many strength performance indicators of judokas, who used 12-week circular training. To admit, that results in some strength performance tests (back squat and pull-up) were low of these athletes, than athletes, who used other strength training protocols. Harries et al. [22] suggest that novelty or training variety are important for stimulating further strength development of athletes, but the most effective approach for muscular strength development for athletes is yet to be determined. Hartmann et al. [21] indicate that to maximize the speed-strength in the short term, elite athletes should perform strength-power training twice per week. Our study has revealed a positive impact of various strength training protocols on strength and sporting performance values of judo athletes (group 1 and group 3), who practiced resistance and mixed (CrossFit + resistance) workout four per week, during the 12-week.

Any inferences made in the present study have some limitations, associated with the low number of participants. At the same time there was no difference between groups for age, physical fitness and strength performance in the study beginning. In spite of being homogeneous in terms of chronological age, investigated 17 years old participants were still in the process of growth and maturation and that could have interfered with their perceived exertion, well-being, and recovery measures after strength workout.

CONCLUSIONS

As in other martial arts, there is no universal training plan for judo that could be implemented to equally improve strength and sporting

performance. Judo experts and coaches offer various strength training protocols and different strength training periodization to improve performance of judo athletes. Our study demonstrated that 12 weeks of different strength training protocols: resistance workouts and mixed strength workouts, are equally effective to increase strength performance of judokas in a maximal isometric handgrip strength (IHST), dynamic maximal strength (bench press and squat jump) and special judo performance (SJFT). However, a higher positive impact of specific strength training protocols was found for athletes (group 1) on back squat test and for athletes (group 3) on the pull-up test. Also, a higher impact of resistance workouts (group 1) and strength mixed (resistance + CrossFit) workouts (group 3) was found on a sporting performance (won competitive judo matches) of studied judo athletes. Therefore, it is recommended to elaborate individual training protocols that would improve the athletes' physical fitness. Implementing new training methods and perfecting the former ones will help optimize training. Other strength training protocols and longer periods of strength training periodization should be investigated to establish the best combination required to improve strength performance of judokas.

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