

EDN: HBDXAO
УДК 796.853.232

Investigation of Effects of Short-Term Strength Training Interventions on Sport Performance in Elite Male Judokas

Aleksander Yu. Osipov^{a, b, c}, Vladimir M. Guralev^c,
Vladimir I. Lyakh^d, Tatyana I. Ratmanskaya^a,
Anna V. Vapaeva^a and Mikhail D. Kudryavtsev^{a, c, e*}

^a*Siberian Federal University*

Krasnoyarsk, Russian Federation

^b*Voino-Yasenetsky Krasnoyarsk State Medical University*

Krasnoyarsk, Russian Federation

^c*Siberian Law Institute of the Ministry of Internal Affairs
of the Russian Federation*

Krasnoyarsk, Russian Federation

^d*Academy of Physical Education in Krakow*

Krakow, Poland

^e*Siberian State University of Science and Technology*

Krasnoyarsk, Russian Federation

Received 20.04.2022, received in revised form 05.10.2022, accepted 17.10.2022

Abstract. Sports performance of elite judo athletes is dependent on the high level of technical skills and physical fitness, including strength capacities: power, muscular strength, muscular endurance and other. This study investigated the effects of short-term (4-/6- or 8-week) specific strength interventions on sports performance in male elite judokas. Thirty six elite male judokas (aged 18–22 years) practiced in short-term (4-/6- or 8-week) strength training intervention added to the regular judo training. To determine sports performance, all athletes were evaluated with regards to their performance during the five judo tournaments within three months in post-intervention. The judokas' individual sport performance was evaluated in accordance with guidelines of the German potential analysis system (PotAS). There were significant ($p \leq 0.05$) differences in sports performance points among the groups in the first judo tournament in favor of judokas, who practiced 4-week strength training intervention. All judokas demonstrated similar mean sports performance points during the second and third judo tournaments. There were significant ($p \leq 0.05$) differences in sports performance points in favor of judokas, who practiced 6- or 8-week strength training intervention during the fourth and fifth judo tournaments. The short-term (4-/6- or 8-week) strength training interventions are not equally effective to increase sports performance of elite male judokas within three months in post- strength

© Siberian Federal University. All rights reserved

* Corresponding author E-mail address: valeo_tei@mail.ru

ORCID: 0000-0002-2277-4467 (Osipov); 0000-0002-1270-6540 (Guralev); 0000-0001-6257-0488 (Lyakh); 0000-0001-9544-1674 (Ratmanskaya); 0000-0002-8081-8974 (Vapaeva); 0000-0002-2432-1699 (Kudryavtsev)

intervention. The final decision for the specific duration (4-/6- or 8-week) of strength training intervention can be decided according to an judoka's medal challenges during the competition season: high sports performance in near future (during the month) or an increase in sports performance after one-two months.

Keywords: combat sports, judo athletes, physical conditioning, weight training, athletic performance, potential analysis system (PotAS).

Research area: theory and methodology of physical education, sports training, health-improving and adaptive physical culture.

Citation: Osipov A. Yu. et al. Investigation of effects of short-term strength training interventions on sport performance in elite male judokas. *J. Sib. Fed. Univ. Humanit. soc. sci.*, 2023, 16(2), 274–286. EDN: HBDXAO (online 2022)



Исследование влияния краткосрочных силовых тренировок на соревновательные результаты элитных дзюдоистов

А.Ю. Осипов^{а,б,в}, В.М. Гуралев^б, В.И. Лях^г,
Т.И. Ратманская^а, А.В. Вапаева^а, М.Д. Кудрявцев^{а,в,д}

^аСибирский федеральный университет

Российская Федерация, Красноярск

^бКрасноярский государственный медицинский университет

имени профессора В. Ф. Войно-Ясенецкого МЗ РФ

Российская Федерация, Красноярск

^вСибирский юридический институт МВД России

Российская Федерация, Красноярск

^гУниверситет физического воспитания

Польша, Краков

^дСибирский государственный университет науки

и технологий имени М. Ф. Решетнева

Российская Федерация, Красноярск

Аннотация. Спортивные результаты элитных дзюдоистов зависят от высокого уровня технических навыков и физической подготовки, включая силовые показатели: мощность, мышечную силу, выносливость и др. В данном исследовании изучалось влияние краткосрочных (4-6 или 8 недель) специальных силовых тренировок на спортивные результаты у мужчин-дзюдоистов. Тридцать шесть элитных дзюдоистов-мужчин (в возрасте 18–22 лет) использовали краткосрочные (4-6 или 8 недель) силовые тренировки дополнительно к регулярным тренировкам по дзюдо. Для определения влияния на спортивные результаты все спортсмены были оценены в отношении их выступления во время пяти турниров по дзюдо в течение трех месяцев после окончания силовых тренировок. Индивидуальные спортивные результаты дзюдоистов оценивались в соответствии с руководящими принципами немецкой системы анализа потенциала (PotAS).

На первом турнире по дзюдо были выявлены достоверные ($p < 0,05$) различия в спортивных результатах в пользу дзюдоистов, которые использовали 4-недельные силовые тренировки. Все исследуемые спортсмены продемонстрировали одинаковые спортивные результаты во время второго и третьего турниров. Выявлены достоверные ($p < 0,05$) различия в спортивных результатах в пользу дзюдоистов, которые практиковали 6- или 8-недельные силовые тренировки во время четвертого и пятого турниров по дзюдо.

Установлено, что краткосрочные (4-6 или 8 недель) силовые тренировки не будут одинаково эффективными для повышения уровня спортивных результатов элитных дзюдоистов-мужчин в течение трех месяцев после их применения. Окончательное решение на использование определенной (4-6 или 8 недель) силовой тренировки может быть принято в соответствии с медальными задачами дзюдоиста в течение соревновательного сезона: высокие спортивные результаты в ближайшем будущем (в течение месяца) или увеличение уровня спортивных результатов через один-два месяца.

Ключевые слова: спортивные единоборства, дзюдоисты, физическая подготовка, силовые тренировки, спортивные результаты, система анализа потенциала (PotAS).

Научная специальность: 5.8.5 – теория и методика спорта.

Цитирование: Осипов А. Ю. и др. Исследование влияния краткосрочных силовых тренировок на соревновательные результаты элитных дзюдоистов. *Журн. Сиб. федер. ун-та. Гуманитарные науки*, 2023, 16(2). С. 274–286. EDN: HBDXAO (онлайн 2022)

Introduction

Currently, more than 200 countries are members of the International Judo Federation (IJF), and activities, such as competitions and games in various regions (Takezawa, 2021). Competitive judo is a demanding Olympic discipline, which requires a high level of special tactical and technical skills as well as physical fitness (Franchini, Del Vecchio, Matsushigue, et al., 2011). The general fitness requirements for combat activity include the flexibility, speed, power, muscular endurance, muscular strength, aerobic capacity, agility, balance, coordination, and body composition (Vagner, Cleather, Kubovy, et al., 2021). Judokas are required to compete at maximum performance for 4-min in most competitions, in addition, judo fight it requires a proper combination of complex and competition-specific muscle strength due to its competitive characteristic (Takezawa, 2021). Elite judokas, who participate in national and international judo competitions, follow various complex training programs, geared toward traditional strength and endurance training,

tactical and technical practice as well as judo fight simulation such as Randori (Franchini, & Takito, 2014). These athletes thus face the challenge of maintaining a steady, high level of physical and sporting performance during a long competition season (Jaworska, Laskowski, Ziemann, et al., 2021; Osipov, Slizik, Bartik, et al., 2021). This challenge entail the scientists and judo practitioners' concern for the identification of effective means and methods for the elite athletes' training (Manolachi, Potop, & Manolachi, 2021; Ahmedov, Gardašević, Norbojev, et al., 2020). It's known that strength, correct posture, effective movements, and balance are critical in competition judo. Explosive strength and strength endurance are particularly important in judo, since these abilities are correlated with the sports level of elite judokas (Kostrzewa, Laskowski, Wilk, et al., 2020). Sports performance of elite combat athletes is dependent on the high level of technical skills and high level of physical fitness components. *Tatlici, et al.*, (2021) indicate that dynamic/static balance and strength are two

performances that can reduce the risk of sports injuries and increase athletic performance in combat sports. Serrano-Huete, et al., (2016) indicate that judo is a combat discipline that requires complex skills and tactical excellence, conditional capacities such as maximal isometric and dynamic strength also play a key role for throwing techniques involving lower and upper body muscle groups. Strength training, whether general and/or specific, is undoubtedly prescribed for a best judoka's athletic performance (Almeida, de Souza, Aidar, et al., 2018). Almeida, et al., (2021) reported that strength and power levels are widely considered a potential predictor of judo performance, therefore, the application of a power-oriented training program that enhances leg pushing capacity of judokas is crucial to improve there performance.

The specificity of the judo training process can pose a challenge for judo coaches and strength/conditioning professionals as they need to determine an optimal training program for their athletes, involving appropriate and effective strength training methods. Russian scientists indicate that the important issues of special strength training in elite combat athletes that are still contradictory for scientific community, in particular, what are the optimal proportions of the special strength training and traditional strength training in elite combat athletes (Dvorkin, Akhmetov, & Dvorkina, 2019). Franchini, et al., (2015) stated that different strength training protocols (weightlifting-type exercises, complex training connecting strength exercises to judo actions, etc.) should be investigated to establish the best combination required to improve performance of elite judokas.

The importance in competition judo of the different types of strength/conditioning and power training systems is well-known (Ouergui, Franchini, Selmi, et al., 2020; Escobar Molina, Chiroso Ríos, Torres Luque, et al., 2009). Imed, et al., (2020) reported that effective judo training for elite judokas should be based on Randori and different (eccentric and concentric) resistance exercises. Saraiva, et al., (2017) state that strength trainings with intensities 80–90 % of strength and power for 12 weeks have a

significant impact on the specific performance of junior judokas. Brazilian scientists reported that the high-intensity interval training (HIIT) methods and standard judo training promoted greater effects on physiological and neuromuscular adaptations in judo athletes than other methods: sprint interval training, resistance or aerobic training (da Silva, Neto, Lopes-Silva, et al., 2021). The investigation conducted by Russian experts, reported that higher competition performance (total judo matches win) in elite junior male judokas after regular Cross-Fit® training sessions compared with usual judo training program (Osipov, Nagovitsyn, Zekrin, et al., 2019). Branco et al., (2021) concluded that 8-week of strength training was positive for general and specific performance in under-18 judokas.

Russian scientists and sport/judo professionals reported a low level of competition sports performance in significant part of Russian elite male judokas during the last five competition seasons (Adolf, Sidorov, Kudryavtsev, et al., 2018; Osipov, Kudryavtsev, Fedorova, et al., 2017). Sport professionals attribute this to insufficient special physical fitness, including strength capacities, in most Russian judo athletes (Kabanova, Kuzmenko, & Ivankov, 2020; Osipov, Guralev, Nagovitsyn, et al., 2020). Power and strength are the most important physical performance indicators in judo (Uriarte Marcos, Rodríguez-Rodríguez, Alfaro-Saiz, et al., 2021). It's known, that lack of strength capacities delays the correct execution of the various judo throwing techniques, accelerates the onset of tiredness, and harms the precision of the movement (Blais, & Trilles, 2006). Manolachi, et al., (2021) reported that important of the judo sports training in stages depends on the motor skills and workout volume and intensity as main components of the specific training. The planning of judo training includes: dynamics of performance capacity evolution; methods of training; structure of training exercises; volume and intensity of effort; duration and nature of breaks; zone of energetic changes and other factors. Henry, (2011) stated that maximize training effect without leading to stagnation seems to vary considerably throughout the strength and conditioning community.

Some studies indicated that strength training programs tend to lose their efficiency after only 2-week, however, another studies indicated strength gains can continue up to 6-week within a single strength training program. Despite compelling evidence for the effectiveness of strength/resistance and HIIT in judo, there is still inconclusive evidence regarding the effects of different short-term strength training intervention on competition performance in elite male judokas. Little information is available concerning the short-term specific strength intervention to judo-specific training despite the widespread use of these modalities among athletes and judo coaches. In support of the need for this study, planning the training process and the development of technical-tactical skills are among the highest rated professional activities conducted by judo professionals and judo coaches (Franchini, Brito, Fukuda, et al., 2014).

This study investigated the effects of short-term (4-/6- or 8-week) specific strength interventions on sports performance in male elite judokas. The authors suggested that different duration of specific strength intervention will have a different impact of judokas' sports performance. However, authors hypothesized that longer strength intervention (8-week) will have a higher impact of judokas' sports performance.

Material & methods

Participants

Thirty six male judokas were recruited to take part in this study. All judokas were from 2 different judo clubs and competed with each other in the same region (Krasnoyarsk region). To take part in this study, the subjects were required to present the following characteristics: not have any diseases or sport injuries (more than six months); experienced with judo training (more than four years); aged equal to or higher than 18-year old and less than 22-year old; taken part in official regional and national judo competitions during the current year; trained at least five times per week; be a brown or black belt in judo; competed in the higher lightweight (66-kg) and the under heavyweight (100-kg) categories; experienced with weight training (more than one year); not involved

with any process of weight loss during 4-week before this study.

This study complied with the Declaration of Helsinki. All ethical principles were observed. All procedures were approved by the local ethics committee of the Institute of Physical Culture, Sport and Tourism, Siberian Federal University. All athletes gave informed consent to participate and publish the results of this study.

The research design

The overall period of this study conducted about 28-week (October, 2021 – April, 2022). The first stage of this study (strength intervention during the 4-/6- or 8-week) was conducted in the athletic gyms and fighting rooms of Sports wrestling academy named D.G. Mindiashvili and Sport judo school of Olympic reserve (Krasnoyarsk, Russian Federation). The second stage of the study (measurement of sports performance of study subjects) was conducted during the five regional and national judo tournaments (January – March, 2022). The overall date analysis was conducted during the third stage of this study (April, 2022).

Scientists indicate that for most variables, a sample size of more than the eight study subjects was big enough to detect changes in the dependent variables, with 80 % confidence and smaller error (Franchini, et al., 2015). Considering the possibility, all study subjects were randomly formed in three equal study groups. All groups were submitted to specific strength intervention added to the regular judo training program. All study subjects performed the same judo training sessions during the 12-week and were involved only with judo and the strength training protocol presented in this study. All athletes performed only judo training (Uchi-komi & Nage-komi and Randori & grappling) in the first 4-week (October, 2021). Athletes (group 1) performed strength training intervention during the last 4-week in the first stage of this study (December, 2021). Judokas (group 2) performed strength training intervention during the last 6-week and athletes (group 3) performed strength training intervention during the last 8-week (November – December, 2021).

Strength training was conducted in a different period from the judo training session with 5–6 hour interval between these 2 types of training. The regular judo training sessions (Uchi-komi & Nage-komi) for all study subjects were conducted 6-time per week and included running warm-up and calisthenics exercises (15–20 min), falling techniques (Ukemi-waza; 10–15 min), throwing technique repetition (Uchi-komi; 20–25 min), throwing technique repetition including the throwing phase (Nage-komi; 35–40 min), cool-down exercises (10–15 min). The Randori training sessions were conducted 2-time per week and included running warm-up and calisthenics exercises (15–20 min), falling techniques (Ukemi-waza; 5 min), throwing technique repetition (Uchi-komi; 5–10 min), throwing technique repetition including the throwing phase (Nage-komi; 5–10 min), judo fight simulation (Randori & grappling; 30–35 min), cool-down exercises (10–15 min). This judo training sessions division was based on previous investigations comparing of elite judo athletes' needs (Jaworska, et al., 2021; Manolachi, Potop, Manolachi, & Dorgan, 2021; Ahmedov, et al., 2020; Harris, Foulds, & Latella, 2019; Koptev, Osipov, Kudryavtsev, et al., 2019; Franchini, & Takito, 2014).

Strength training exercises were selected taking into the knowledge for power, resistance, strength and high-intensity interval aerobic training in health young adults (Alves, et al., 2021; Pedro Nunes, et al., 2021; Nagovitsyn, Osipov, Kudryavtsev, et al., 2020; Sawczyn, 2020; Grgic, & Schoenfeld, 2019; Peitz, Behringer, & Granacher, 2018; Behm, Young, Whitten, et al., 2017), professional athletes (Loturco, Dello Iacono, Nakamura, et al., 2022; Samsonova, Tsipin, & Golubev, 2021; Sanchez-Sanchez, Ramirez-Campillo, Petisco, et al., 2021; Türker, & Yüksel, 2021; Ioannidis, Apostolidis, Hadjicharalambous, et al., 2020; Rodrigues, et al., 2018; Sandbakk, 2018), elite combat athletes (Tatlici, et al., 2021; Dvorkin, et al., 2019; Podrigalo, Cynarski, Rovnaya, et al., 2019; Osipov, Kudryavtsev, Iermakov, et al., 2018) and elite judokas (Osipov, Guralev, Iermakov, et al., 2022; Branco, et al., 2021; Osipov, et al., 2021; Takezawa, 2021; Tomazin, Almeida, Stern, et al., 2021; Loturco, Na-

kamura, Winckler, et al., 2017; Franchini, et al., 2015; Henry, 2011). Strength training intervention program involved 8–10 strength exercises: barbell bench press, barbell back and front squat, lunges with weights, deadlifts, bent-over row, pull-ups, dumbbell shoulder press, kettlebell swing (kettlebell's weight – 16–24 kg), overhead press and thruster. After adequate warm-up (10–15 min) all subjects performed 4–5 sets (8–12 reps in set at 65–80 % of 1MR) in strength exercise. Each subject performed 5–6 strength exercises during each strength training session, to result in 2 training sessions during the each week training sessions, for mastering all strength exercise. The rest interval between the sets was 2 min; interval of rest between the strength exercises was 3 min. The overall knowledge about strength intervention and judo training program outline in Table 1.

Procedures

The simple and robust measurement of sports (competition) performance of studied judokas was used in this study. To determine competition performance, each study subject was evaluated with regards to their performance during the five (the 3-regional and 2-national) judo tournaments which were scheduled within three months in post-intervention period (January – March, 2021). The athletes' individual rank position during the tournaments was evaluated in accordance with guidelines of the German potential analysis system (PotAS) for elite sports. PotAS is a project of the Federal Ministry of the Interior, Building, and Community, Germany for evaluating performance elements of all sport disciplines according to specific criteria (organization, athlete development, sporting success) (Büsch, Rebel, Wendt, et al., 2018). This potential analysis system to analyze the competition success of judokas used successfully by scientists and judo professionals (Prieske, Chaabene, Gäbler, et al., 2020). The individual rank position for each athlete during the competition was evaluated using a graded special point scale: first place (gold medal) – 30 points; second place (silver medal) – 25 points; third place (bronze medal) – 20 points; fifth-sixth place – 15 points; seventh-eighth place – 10 points; ninth-twelfth

Table 1. Training program of elite male judokas during the first stage of this study (October – December, 2021).

Day	Training
Monday	MT (100–110 min) – Uchi-komi & Nage-komi ET (80–90 min) – Strength training
Tuesday	MT (100–110 min) – Uchi-komi & Nage-komi ET (70–80 min) – Randori & grappling
Wednesday	MT (100–110 min) – Uchi-komi & Nage-komi ET (80–90 min) – Strength training
Thursday	MT (100–110 min) – Uchi-komi & Nage-komi ET (80–90 min) – Strength training
Friday	MT (100–110 min) – Uchi-komi & Nage-komi ET (70–80 min) – Randori & grappling
Saturday	MT (100–110 min) – Uchi-komi & Nage-komi ET (80–90 min) – Strength training
Sunday	Rest

Note: * – MT – morning training; ET – evening training.

place – 5 points; other place (attendance) – 1 point. The athletes' final points achieved were used for further scientific analysis.

Statistical analysis

The collected data were analyzed using IBM SPSS Statistics for Windows 20.0 (Armonk, NY: IBM Corp.). All study values are expressed as means and standard deviations (Mean±SD). The normal distribution of data was assessed and confirmed using the Shapiro–Wilk test. Homoscedasticity assumption made for all data was checked using the Levene's test. For normally distributed variables the one-factor ANOVA test for independent measures (including Tukey post-hoc test) to compare the means of independent samples was conducted. The level of significance was set at $p < 0.05$.

Results

The significant difference was found between groups concerning the mean sports performance points of athletes in judo tournaments. There were significant ($p < 0.05$) differences in sports performance points among the groups in the first judo tournament (January, 2022) in favor of judokas, who practiced 4-week strength training intervention (group 1). There were no significant differences in sports performance points among the groups

in the second and third judo tournaments (January – February, 2022). All studied athletes demonstrated similar mean sports performance points during this competition period. There were significant ($p < 0.05$) differences in sports performance points in favor of judokas, who practiced 6- or 8-week strength training intervention (group 2 and group 3) during the fourth and fifth judo tournaments (February – March, 2022). Athletes (group 1), who practiced 4-week strength training intervention, had a significantly ($p \leq 0.05$) lower sports performance points during this period. The overall information about judo athletes' sports performance points in full period of this study outlined in Table 2.

Discussion

This scientific work investigated to associations between duration of strength training intervention (4-/6- or 8-week) and sports performance of studied elite male judo athletes. All participants were submitted to a specific strength training intervention and then participated in five judo tournaments during the three months (January – March, 2022). In this investigation, we have particularly support our hypothesis about different effects of duration specific strength intervention on sports performance in elite male judokas. This study sug-

Table 2. The overall findings in judo athletes' sports performance after strength intervention

Judo tournaments	Group 1 (n=12)	Group 2 (n=12)	Group 3 (n=12)	<i>p</i> <
1 tournament (R)	14.62±9.40*	7.75±6.09	6.43±5.72	0.038
2 tournament (R)	10.23±7.16	11.14±7.59	12.26±9.21	0.856
3 tournament (N)	8.72±6.41	13.18±8.06	13.27±10.33	0.406
4 tournament (R)	5.86±4.61*	13.65±8.02	14.12±9.50	0.038
5 tournament (N)	6.82±5.37*	15.14±7.96	15.65±9.95	0.040

Note: * – $p < 0.05$ – (significance level); R – regional tournament; N – national tournament.

gested that different duration (4-/6- or 8-week) of strength training intervention have a different effect on sports performance of participants. Judokas, who performed 4-week of strength training intervention, demonstrated a higher sports performance during the first month in post-intervention (January, 2022). However, judokas, who performed 6- or 8-week of strength training intervention, demonstrated a higher sports performance during the two last months in post-intervention (February – March, 2022). We doesn't robust evidences, which support our other hypothesis about higher impact of longer strength intervention period (8-week) on sports performance in study subjects. Judokas, who performed 6- or 8-week of strength training intervention, demonstrated a similar sports performance during the all judo tournaments (January – March, 2022).

Escobar Molina, et al., (2009) reported that a significant factor that could contribute to improvement in strength capacities is the order in which strength and aerobic capacity were trained: first trained aerobic capacity followed by strength training. In our strength training intervention protocol as carried out by all groups, strength capacities were trained apart from technical judo training and Randori & grappling, during the one training day. Since judokas who performed 6- or 8-week of strength training intervention demonstrated an increase in mean sports performance points during the five judo tournaments, may be suggests that training strength apart from other training during the one training day, appears to be the correct sequence. Judo/conditioning professionals state that the optimum time to training strength qualities is between 8–12 weeks,

besides 6 hours was the time needed to recovery and increase strength without interference (Osipov, et al., 2021; Saraiva, et al., 2017; Escobar Molina, et al., 2009). In our study strength training protocol applied has proved to be more effective for the two groups, who performed 6- or 8-week of strength training.

Blais, & Trilles, (2006) reported that for judo athletes, as in many sports activities, strength development has become an important element of sport performance. Because judo is characterized by the control of complex motor skills, strength development should not be addressed separately from the development of judo technique. In our case, all participants performed strength and judo technique (Uchikomi & Nage-komi)/fight simulation (Randori) training exercises during the one training day, but in time separately. The positive effect of such strength/conditioning training protocols on the sports performance of participants has been statistically validated by the present investigation. Its use could be extended to a larger group of elite male judokas and used to complement traditional judo pre-competition training program.

Tunisian investigators reported that effective judo training program for elite judo athletes should be based on Randori (fight simulation) and different methods of resistance training (Imed, et al., 2020). However, these researchers don't provide accurate knowledge on the duration and types of strength exercises, but note a high level of tired and injuries in athletes, who practiced similar intensive training. In our case, none of the study subjects had any significant injuries or diseases in post-strength intervention (in January, 2022). Therefore,

strength intervention protocols, which were used in this study, can be recommended for precompetition strength/conditioning training in elite male judokas.

Henry, (2011) indicated that functional strength/resistance training can aid in developing an effective and well-balanced strength training program for judo athletes, when understood and applied appropriately. This researcher reported that regularly strength/resistance 3–4 week training phases in elite judokas using the undulating periodization method allow for optimum adaptations to occur without the onset of stagnation or the risk of overtraining. Ullrich, *et al.*, (2016) state that independent of the periodization model, 4-week of muscular power training induced moderate gains in maximal lower-body, upper-body, and total body strength in previously trained young judoka. Blais, & Trilles, (2006) reported that judokas, who used 8-week specific strength training program, improved their judo-throwing techniques performances. This study demonstrated that subjects, who performed 4-week strength intervention protocol, demonstrated a significantly ($p < 0.05$) lower sports performance points during the period of two last months of competition period (February – March, 2022) in comparison with subjects, who used 6- or 8-week strength intervention. However, participants, who performed 4-week strength intervention protocol, demonstrated a significantly ($p < 0.05$) higher sports performance points in the first judo tournament in post-intervention (January, 2022). Anyway other strength training protocols and longer periods of strength/conditioning training of judokas should be investigated to establish the best combination required to improve sports performance of elite judo athletes (Franchini, *et al.*, 2015).

Conclusions

This study suggested that short-term (4-/6- or 8-week) strength training interventions are not equally effective to increase sports performance of elite male judokas within three months after strength intervention. The final decision for the specific duration (4-/6- or 8-week) of strength training intervention can

be decided according to an judoka's medal challenges during the competition season: high sports performance in near future (during the month) or an increase in sports performance after one-two months. We express hope that these findings may have important implications in sports science, helping judo coaches to better select appropriate strength/conditioning training strategies to increase the competition level of their elite judo athletes. Other periods of strength training, and different judo-performance variables should be investigated to establish the best combination required to improve sports performance of elite male judokas.

Limitations

Any inferences made in this study have some limitations. These limitations associated with the total low number of participants and short strength intervention in training routine. Furthermore, the general results of this study could be influenced by rapid weight loss procedures in judokas for competition success. Most of subjects performed strategies for rapid weight loss (which is an acute loss of body mass) in the 5–8 days prior to the competition. Also, we should be acknowledged as a methodological limitation of this study, the lack of a passive control group (elite male judokas, who not practiced a short-term strength intervention in pre-competition training).

Acknowledgements

We would like to thank the personnel of Sports wrestling academy named D. G. Mindiashvili and Sport judo school of Olympic reserve (Krasnoyarsk, Russian Federation), all athletes, judo coaches and strength professionals, who participated in the study and anonymous reviewers for their careful reading of our manuscript and their comments and suggestions.

Conflicts of interest

The authors declare that this scientific work was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

References

- Adolf V., Sidorov L., Kudryavtsev M., Osipov A., & Bliznevsky A. Precompetitive fitness methods applied by Russian judo teams prior to international events. In *Teoriya i Praktika Fizicheskoy Kultury*, 2018, 9, 66–68.
- Ahmedov F., Gardašević N., Norboyev K., Umarov K. Differences of duration of the fight depending on the stage of the judo competition. In *International Journal of Human Movement and Sports Sciences*, 2020, 8(6), 380–383. doi:10.13189/saj.2020.080609
- Almeida F., Padial P., Bonitch-Góngora J., de la Fuente B., Schoenfeld B., Morales-Artacho A., Benavente C., Feriche B. Effects of power-oriented resistance training during an altitude camp on strength and technical performance of elite judokas. In *Frontiers in Physiology*, 2021, 12, 606191. doi:10.3389/fphys.2021.606191
- Almeida H., de Souza R., Aida F., da Silva A., Regi R., Bastos A. Global active stretching (SGA®) practice for judo practitioners' physical performance enhancement. In *International Journal of Exercise Science*, 2018, 11(6), 364–374.
- Alves A., Marinho D., Pecêgo M., Ferraz R., Marques M., Neiva H. Strength training combined with high-intensity interval aerobic training in young adults' body composition. In *Trends in Sport Sciences*, 2021, 28(3), 187–193. doi:10.23829/TSS.2021.28.3–3
- Behm D., Young J., Whitten J., Reid J., Quigley P., Low J., Li Y., Lima C., Hodgson D., Chaouachi A., Prieske O., Granacher U. Effectiveness of traditional strength vs. power training on muscle strength, power and speed with youth: A systematic review and meta-analysis. In *Frontiers in Physiology*, 2017, 8, 423. doi:10.3389/fphys.2017.00423
- Blais L., Trilles F. The progress achieved by judokas after strength training with a judo-specific machine. In *Journal of Sports Science & Medicine*, 2006, 5(CSSI), 132–135.
- Branco B., Marcondes V., de Paula Ramos S., Badilla P., Andreato L. Effects of supplementary strength program on generic and specific physical fitness in cadet judo athletes. In *Journal of Strength and Conditioning Research*, 2021. doi:10.1519/JSC.0000000000003983
- Büsch D., Rebel M., Wendt R., Horn A., Granacher U. One year PotAS Commission- Objectives, asks, and current state. In *Leistungssport*, 2018, 48, 4–9.
- da Silva L., Neto N., Lopes-Silva J., Leandro C., Silva-Cavalcante M. Training protocols and specific performance in judo athletes: A systematic review. In *Journal of Strength and Conditioning Research*, 2021. doi:10.1519/JSC.0000000000004015
- Dvorkin L., Akhmetov S., Dvorkina N. Special strength trainings in elite wrestling sports. In *Teoriya i Praktika Fizicheskoy Kultury*, 2019, 5, 72–74.
- Escobar Molina R., Chiroso Ríos I., Torres Luque G., Hernandez G., Miranda Leon T., Feriche Fernandez-Castany B., Padial Puche P. Effects of strength and endurance training in the mesocycle in the performance in judokas. In *Ido Movement for Culture. Journal of Martial Arts and Anthropology*, 2009, 9, 170–180.
- Franchini E., Branco B., Agostinho M., Calmet M., Candau R. Influence of linear and undulating strength periodization on physical fitness, physiological, and performance responses to simulated judo matches. In *Journal of Strength and Conditioning Research*, 2015, 29(2), 358–367. doi:10.1519/JSC.0000000000004060
- Franchini E., Takito M. Olympic preparation in Brazilian judo athletes: description and perceived relevance of training practices. In *Journal of Strength and Conditioning Research*, 2014, 28(6), 1606–1612. doi:10.1519/jsc.0000000000000300
- Franchini E., Brito C., Fukuda D., Artioli G. The physiology of judo-specific training modalities. In *Journal of Strength and Conditioning Research*, 2014, 28(5), 1474–1481. doi:10.1519/JSC.0000000000000281
- Franchini E., Del Vecchio F., Matsushigue K., Artioli G. Physiological profiles of elite judo athletes. In *Sports Medicine (Auckland, N.Z.)*, 2011, 41(2), 147–166. doi:10.2165/11538580-000000000-00000
- Grgic J., Schoenfeld B. A case for considering age and sex when prescribing rest intervals in resistance training. In *Kinesiology*, 2019, 51(1), 78–82.

- Harris D., Foulds S., Latella C. Evidence-based training recommendations for the elite judoka. In *Strength and Conditioning Journal*, 2019, 41(2), 108–118. doi:10.1519/SSC.0000000000000426
- Henry T. Resistance training for judo: Functional strength training concepts and principles. In *Strength and Conditioning Journal*, 2011, 33(6), 40–49. doi:10.1519/SSC.0b013e31823a6675
- Imed G., Mouna T., Fatma A., Nizar S. Comparison of muscle damage parameters between the training session and after a fight amongst judokas. In *Journal of Physical Education and Sport*, 2020, 20(1), 71–78. doi:10.7752/jpes.2020.01009
- Ioannidis C., Apostolidis A., Hadjicharalambous M., Zaras N. Effect of a 6-week plyometric training on power, muscle strength, and rate of force development in young competitive karate athletes. In *Journal of Physical Education and Sport*, 2020, 20(4), 1740–1746. doi:10.7752/jpes.2020.04236
- Jaworska J., Laskowski R., Ziemann E., Zuczek K., Lombardi G., Antosiewicz J., Zurek P. The specific judo training program combined with the whole body cryostimulation induced an increase of serum concentrations of growth factors and changes in amino acid profile in professional judokas. In *Frontiers in Physiology*, 2021, 12, 627657. doi:10.3389/fphys.2021.627657
- Kabanova E., Kuzmenko G., Ivankov C. 2020, Excelling training of junior heavy weight judokas for high-speed confrontation strategy. In *Teoriya i Praktika Fizicheskoy Kultury*, 2020, 2, 63–65.
- Koptev O., Osipov A., Kudryavtsev M., Zhavner T., Klimuk Y., Vapaeva A., Kuzmin V., Mokrova T. Level increase of competitive readiness of elite judokas in the weight category of up to 60 kg (as an example is the national team of Kyrgyzstan). In *Journal of Physical Education and Sport*, 2019, 19(1), 716–721. doi:10.7752/jpes.2019.01103
- Kostrzewa M., Laskowski R., Wilk M., Błach W., Ignatjeva A., Nitychoruk M. Significant predictors of sports performance in elite men judo athletes based on multidimensional regression models. In *International Journal of Environmental Research and Public Health*, 2020, 17(21), 8192. doi:10.3390/ijerph17218192
- Loturco I., Dello Iacono A., Nakamura F., Freitas T., Boulosa D., Valenzuela P., Pereira L., McGuigan M. The optimum power load: A simple and powerful tool for testing and training. In *International Journal of Sports Physiology and Performance*, 2022, 17, 151–159. doi:10.1123/ijspp.2021-0288
- Loturco I., Nakamura F., Winckler C., Bragança J., da Fonseca R., Filho J., Zaccani W., Kobal R., Cal Abad C., Kitamura K., Pereira L., Franchini E. Strength-power performance of visually impaired Paralympic and Olympic judo athletes from the Brazilian national team: a comparative study. In *Journal of Strength and Conditioning Research*, 2017, 31(3), 743–749. doi:10.1519/JSC.0000000000001525
- Manolachi V., Potop V., Manolachi V., Dorgan V. Planning of effort parameters in the training of elite male judo athletes. In *Human. Sport. Medicine*, 2021, 21(2), 162–173. doi:10.14529/hsm21022
- Manolachi V., Potop V., Manolachi V. Optimal combination of training influences on the preparation of elite judokas in the annual cycle. In *Human. Sport. Medicine*, 2021, 21(1), 132–144. doi:10.14529/hsm210117
- Nagovitsyn R., Osipov A., Kudryavtsev M., Zakharova L., Lyulina N. Effect of training on street simulators with variable load on the strength women and men in powerlifting. In *Journal of Human Sport and Exercise*, 2020, 15(3proc), S 471-S 480. doi:10.14198/jhse.2020.15.Proc3.01
- Osipov A., Guralev V., Iermakov S., Ratmanskaya T., Galimova A., Kudryavtsev M. Impact of two different strength/conditioning training interventions on sport and strength performance of junior male judokas. In *Physical Activity Review*, 2022, 10(1), 98–106. doi:10.16926/par.2022.10.11
- Osipov A., Slizik M., Bartik P., Kudryavtsev M., Iermakov S. 2021, The impact of various strength training protocols on the strength and sporting performance of junior male judokas. In *Archives of Budo*, 2021, 17, 151–159.
- Osipov A., Guralev V., Nagovitsyn R., Kapustin A., Kovyazina G. Justification of using CrossFit® training in judo. In *Human. Sport. Medicine*, 2020, 20(S 1), 109–115. doi:10.14529/hsm20s114
- Osipov A., Nagovitsyn R., Zekrin F., Fendel' T., Zubkov D., Zhavner T. Crossfit training impact on the level of special physical fitness of young athletes practicing judo. In *Sport Mont*, 2019, 17(3), 9–12. doi:10.26773/smj.191014

Osipov A., Kudryavtsev M., Iermakov S., Jagiełło W. Increase in level of special physical fitness of the athletes specialising in different combat sports (judo, sambo, combat sambo) through of crossFit® training. In *Archives of Budo*, 2018, 14, 123–131.

Osipov A., Kudryavtsev M., Fedorova P., Serzhanova Z., Struchkov V., Glinchikova L., Nikitin N., Kuzmin V. Comparative analysis of the scientific views of Russian and foreign scientists on the problem of training skilled judo wrestlers. In *Journal of Physical Education and Sport*, 2017, 17(1), 288–293. doi:10.7752/jpes.2017.01043

Ouergui I., Franchini E., Selmi O., Levit D., Chtourou H., Bouhlel E., Ardigo L. Relationship between perceived training load, well-being indices, recovery state and physical enjoyment during judo-specific training. In *International Journal of Environmental Research and Public Health*, 2020, 17(20), 7400. doi:10.3390/ijerph17207400

Pedro Nunes J., Grgic J., Cunha P., Ribeiro A., Schoenfeld B., de Salles B., Cyrino E. What influence does resistance exercise order have on muscular strength gains and muscle hypertrophy? A systematic review and meta-analysis. In *European Journal of Sport Science*, 2021, 21(2), 149–157. doi:10.1080/17461391.2020.1733672

Peitz M., Behringer M., Granacher U. A systematic review on the effects of resistance and plyometric training on physical fitness in youth- What do comparative studies tell us? In *PLoS ONE*, 2018, 13(10), e0205525. doi:10.1371/journal.pone.0205525

Podrigalo L., Cynarski W., Rovnaya O., Volodchenko O., Halashko O., Volodchenko J. Studying of physical development features of elite athletes of combat sports by means of special indexes. In *Ido Movement for Culture. Journal of Martial Arts and Anthropology*, 2019, 19(1), 51–57. doi:10.14589/ido.19.1.5

Prieske O., Chaabene H., Gäbler M., Herz M., Helm N., Markov A., Granacher U. Seasonal changes in anthropometry, body composition, and physical fitness and the relationships with sporting success in young sub-elite judo athletes: An exploratory study. In *International Journal of Environmental Research and Public Health*, 2020, 17(19), 7169. doi:10.3390/ijerph17197169

Rodrigues B., Senna G., Simão R., Scudese E., Da Silva-Grigoletto M., Paoli A., Messina G., Bianco G., Bianco A., Dantas E. Traditional vs daily undulating periodization in strength and local muscle endurance gains on trained men. In *Journal of Human Sport and Exercise*, 2018, 13(2), 401–414. doi:10.14198/jhse.2018.132.11

Samsonova A., Tspini L., Golubev A. Hypoxic strength training model: Benefits for football elite training systems. In *Teoriya i Praktika Fizicheskoy Kultury*, 2021, 10, 95–97.

Sanchez-Sanchez J., Ramirez-Campillo R., Petisco C., Hernandez D., Nakamura F. Effects of short-term strength and jumping exercises distribution on soccer player's physical fitness. In *Kinesiology*, 2021, 53(2), 236–244. doi:10.26582/k.53.2.6

Sandbakk Ø. Practical implementation of strength training to improve the performance of world-class cross-country skiers. In *Kinesiology*, 2018, 50(Suppl. 1), 155–162.

Saraiva A., Borba-Pinheiro C., Reis V., Bitencourt da Silva J., Drigo A., Mataruna-Dos-Santos L., Novaes J. Order of strength exercises on the performance of judo athletes. In *Revista Internacional De Medicina Y Ciencias De La Actividad Física Y Del Deporte*, 2017, 68, doi:10.15366/rimcafd2017.68.002

Sawczyn M. Effects of a periodized functional strength training program (FST) on Functional Movement Screen (FMS) in physical education students. In *Physical Education of Students*, 2020, 24(3), 162–167. doi:10.15561/20755279.2020.0306

Serrano-Huete V., Latorre-Román P., García-Pinillos F., Morcillo Losa J., Moreno-Del Castillo R., Párraga-Montilla J. Acute effect of a judo contest on muscular performance parameters and physiological response. In *International Journal of Kinesiology & Sports Science*, 2016, 4(3), 24–31. doi:10.7575/aiac.ijkss.v.4n.3p.24

Takezawa T. Performance and biological response of middle-power under hyperbaric hyperoxic conditions in judo athletes – pilot studies. In *Archives of Budo*, 2021, 17, 43–50.

Tatlici A., Unlu G., Cakmakci E., Cakmakci O. Investigation of the relationship between strength and dynamic balance performance in elite wrestlers. In *Ido Movement for Culture. Journal of Martial Arts and Anthropology*, 2021, 21(3), 18–22. doi:10.14589/ido.21.3.3

Tomazin K., Almeida F., Stern I., Padal P., Bonitch-Góngora J., Morales-Artacho A., Strojnik V., Feriche B. Neuromuscular adaptations after an altitude training camp in elite judo athletes. In *International Journal of Environmental Research and Public Health*, 2021, 18(13), 6777. doi:10.3390/ijerph18136777

Türker A., Yüksel O. The effect of functional and supportive classic strength trainings in basketball players on aerobic strength, dynamic balance and body composition. In *Pedagogy of Physical Culture and Sports*, 2021, 25(1), 47–58. doi:10.15561/26649837.2021.0107

Ullrich B., Pelzer T., Oliveira S., Pfeiffer M. Neuromuscular responses to short-term resistance training with traditional and daily undulating periodization in adolescent elite judoka. In *Journal of Strength and Conditioning Research*, 2016, 30(8), 2083–2099. doi:10.1519/JSC.0000000000001305

Uriarte Marcos S., Rodríguez-Rodríguez R., Alfaro-Saiz J., Carballeira E., Uriarte Marcos M. Improving on half-lightweight male judokas' high performance by the application of the analytic network process. In *Frontiers in Psychology*, 2021, 12, 621454. doi:10.3389/fpsyg.2021.621454

Vagner M., Cleather D., Kubovy P., Hojka V., Stastny P. Effect of strength training programs on front push kick dynamics and kinematics. In *Archives of Budo*, 2021, 17, 237–251.