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EFFECTS OF SPECIFIC PROGRAMMED TRAINING ON PHYSICAL FITNESS, PHYSIOLOGICAL AND PERFORMANCE RESPONSES IN ELITE JUDOKAS

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Abstract
Aim of this research was to determine the effects of specific programmed training on morphological characteristics, motoric and functional abilities of elite judokas. Seven judo athletes (24.71±3.35 years), that have won at least one medal in the European Judo Championship or in the World or European Judo Cup during previous two years participated in study. The sub elite group consisted of 7 athletes (26.14±3.39 years) that have only won medals in national competitions (Bosnia & Herzegovina). Skin-fold (suprailiac) was significantly reduced in experimental group after the applied treatments ($F = 5.38$, $P = 0.039$). Furthermore, significant interaction effect appeared ($F = 6.94$, $P = 0.022$), which indicates significantly greater effect on the increase in volume of Right forearm in the experimental group after applied program, whereas in the control group, these values had smaller average size in the final measurement. Bench Press ($F = 121.00$, $P = 0.000$), Deep squat ($F = 14.03$, $P = 0.003$), Dead lift ($F = 27.56$, $P = 0.000$) and Hand Grip Right ($F = 22.91$, $P = 0.000$). In variables of power evaluation effects of applied treatment were also significantly better in favor of experimental group with Single high jump ($F = 10.48$, $P=0.007$), Single long jump ($F = 12.79$, $P = 0.004$) and Medicine ball toss ($F = 47.25$, $P = 0.000$). After six months of applied training protocol, regarding anthropometric measurements in experimental group of judokas, at the same time occured a reduction in the percentage of fat and suprailiac skinfold as well as an increase the of the right forearm circumference at a significant level of deduction. Furthermore, the significant increase in all variables of strength and coordination is noticable. The experimental treatment also resulted in a significant increase in aerobic and anaerobic power, as well as judo-specific fitness, whereas no significant changes were occured in flexibility variables and left-hand grip.

Key words: **Judo, selection, training**

Introduction

Judo is a dynamic, highly intense intermittent sport that requires complex skills and tactical excellence for success (Dégoutte et al., 2003). Judokas during matches perform a great variety of actions whereas requirements of each match are extremely high (Drid et al., 2011; Franchini et al., 2013). In large international competitions it is characteristic for judokas to have 5-7 matches per day (Franchini et al., 2011a), with each one lasting actively for five minutes. If judoka achieves an Ipon, the match ends immediately. However, if the match ends in a draw, the bout continuous until the "golden point" is achieved. Active combat is intercepted with short breaks for fixing sports equipment, in order for athletes to return to their starting positions if they left the competition area, for making judicial decisions and others (Franchini et al., 2013). These interruptions add to the total duration of the match, often leading to overall time of match duration up to 9 minutes.

The problem of planning in training process is the most complex in the theory of sports training due to the large number of objective factors that affect all types of athlete's preparation and finally on sport performance. It is necessary to consider the sports characteristics and individualization for both planning and the selection of training means and methods. In order to minimize errors, as well as to safely and economically achieve desired goals that correspondent to individual characteristics of the athletes, top coaches bring their programming means, loads and methods of training to the highest level.

Base of each planning and programming is precise diagnostic methods for evaluation of the initial characteristics of athletes. Diagnostics of the athlete's current condition is conducted through general and specific procedures and tests, with the aim of assessing motor and functional abilities, health status, anthropometric characteristics, and psy-

chosocial dimensions (Franchini et al., 2011a). Based on the results of diagnostic procedures, results are then compared with a model performance characteristic in order to identify the skills and characteristics that need to be developed and improved with a curriculum. Assessing athlete's capabilities and characteristics are also the primary information that provides insight into the proper application of the training load.

To be effective, judo techniques should be applied correctly with effective use of torque, power, speed, and force. This short burst of energy is mainly carried out by means of anaerobic metabolism. In contrast, during the match without throwing attempts and during recovery process an aerobic work is dominated. Specific importance of aerobic metabolism is reflected in the process of recovery between matches (Stojanovic et al., 2009; Franchini et al., 2011a). Therefore, it is obvious that for successful judo performance it is necessary for athlete to possess energy-motoric capacity that will enable proper manifestation of techniques and strategies. Development of aerobic power and aerobic capacity, as well as muscle power, may be important to some intermittent specific tasks in judo (Detanico et al., 2011).

It seems that the majority of male judokas have values of maximal oxygen consumption (VO_{2max}) between 50 and 65 ml/kg/min (Callister et al., 1990, Callister et al., 1991, Little et al., 1991; Mickiewitz et al., 1991; Gariod et al., 1995; Suay et al., 1999; Sterkowicz et al., 1999; Borkowski, et al., 2001; Degoutte et al., 2003; Franchini et al., 2005; Trivić et al., 2009; Pocecco and Burtscher, 2013). Elite judokas also show better coordination abilities than sub-elite judokas (Drid et al., 2010; Drid et al., 2013) and their untrained peers in coordination tests (Sertic et al., 2006; Bala and Drid, 2010). Based on structural analysis of judo, it is logical that motor abilities of coordination and power are considered the most important ones for success in a match (Đapić-Caput et al., 2013).

The aim of this research was to determine the effects of specific programmed training on morphological characteristics, motoric and functional abilities of elite judokas.

METHODS

Experimental approach to the problem

Specific program for experimental group was divided into four separate training stages that lasted six months. Training stages were made of micro cycles, which in its content, purpose, and objectives corresponded to the general, specific, situational, competitive, or regenerative microcycle.

The main event of the first training stage was European championship. The first training stage consisted of overall eight micro cycles (two general, two specific, two situational, one competitive and one regenerative). The total number of training days was 61. The second training phase consisted of six micro cycles (one general, one specific, two situational, one competitive and one regenerative). The main event for this stage was the World Cup, with total number of 41 training days. During third training stage of the specific program three World Cups were held. Third phase consisted of seven micro cycles (one general, one specific, one situational, three competitive and one regenerative. Total number of training days was 51. The World Championship was the main event for the fourth training stage. This stage of specific program consisted of five micro cycles (one general, one specific, one situational, one competitive and one regenerative). With this regenerative micro cycle ended specific program in a duration of six months and preparation for final measurement and testing begun. This fourth training phase was the shortest, 31 training days in total.

This study adopted a quasi-experimental design. After familiarization with all tests procedures, athletes were submitted to a physical fitness test battery. Initial and final measurement was performed before and after 6 months of training. Measurements consisted of: a) anthropometry measurements – body mass, body height, skin-fold thickness at four sites (biceps, triceps, sub-scapular, suprailiac), limb circumferences (forearm, upper arm, thigh, waist, chest) and body fat percentage; b) maximal strength evaluation – bench press, deep-squat, dead lift and handgrip maximal isometric strength; c) power evaluation – single high-jump, single long-jump and medicine ball toss for a distance; d) strength endurance evaluation –chin up, bench press with body weight until exhaustion and deep-squat with body weight until exhaustion; e) coordination evaluation – coordination with stick and envelope test; f) flexibility evaluation – side leg raise (hip flexion), sit and reach, straight leg raise (hamstring flexibility), shoulder flexibility test; g) aerobic capacity evaluation – maximal relative and absolute oxygen uptake, maximal heart rate value, running speed at maximal oxygen uptake, relative oxygen uptake at ventilatory threshold; h) anaerobic power evaluation – The maximal power; i) judo-specific fitness – Judo throw with athlete's "favorite" or "best" technique. The test battery was conducted on three non-consecutive days, one week before the training protocol started and three days after the ending of the 6-month training protocols.

Subject sample

Fourteen male judokas participated in the study. The elite group, consisted of 7 athletes (24.71 ± 3.35 years), that have won at least one medal in the European Judo Championship or in the World or European Judo Cup during previous two years. The sub elite group consisted of 7 athletes (26.14 ± 3.39 years) that have only won medals in national competitions (Bosnia & Herzegovina).

Training protocols

General microcycles make a significant portion of the overall preparation in judokas. Main goal of general microcycle in the specific program for experimental group is directed towards the development and preservation of basic skills such as general aerobic, aerobic-anaerobic, and muscular endurance, as well as general Judo motion technique forms. Higher training volume and lower intensity are the main features of the general microcycle specific program.

Table 1 General microcycle

Day		1.	2.	3.	4.	5.	6.	7.
Morning	P	AeE	AeE*	AeE+AnE (Fartlek)	Rest	AeE*	RT	Rest
	S	ALE	Tech	ALE		ALE	Fle	
Afternoon	P	Tech	Rest	ME*	ME	Tech	ME*	
	S	Fle		Tech	Tech	Bal	Tech	
Training session		2	1	2	1	2	2	
Goal	***Aerobic and glycolytic muscle endurance development***							
Notes	AeE-aerobic endurance; AnE-anaerobic endurance; Tech-Technique; ALE-alactate exercise; ME-muscle endurance; Fle-Flexibilty; Bal-Balance; RT-recovery training; P-primary objective; S-secondary objective. *- a key training.							

In order to develop general aerobic endurance and aerobic capacity, 30-40 minutes running (continuous method), and training with modified specific methods that were adjusted for the development of aerobic energy capacity were applied. After aerobic training, alactic short sprints were performed in order to engage fast motor units, which are usually inactive during aerobic training (Komi, 2003). Furthermore, sprints help in breaking the monotony as well as in increase of the emotional intensity during aerobic training (Issurin, 2009). Along with continuous methods for general endurance development, fartlek method was used as well. In addition to aerobic endurance, trainings for maximal oxygen uptake (VO_{2max}) improvement were implemented with interval methods of 3-5 minutes activity at intensity of 80-90%.

In the means of strength development, the objectives were aimed at muscular endurance. For the muscular endurance development circular method of training, which included various body segments (arms, legs, and torso) has been applied. In general, microcycle for strength training in judokas multi-joint exercises (dead lift, squat, and bench press) were dominated. Strength training was carried out in the afternoon, for this time of day was the most benefit for most athletes to mobilize maximally their body. The general and specific microcycles were significantly represented through unilateral (*e.g.* one-handed curl, single squats) and bilateral exercises (*e.g.* push dumbbells overhead rowing with dumbbell) due to different types of movements and situations that occur in combat. Furthermore, exercises of relative type (with own body weight *e.g.* rope climbing) and absolute type (*e.g.* exercises with free weights).

After strength training completion, low intensity technical tasks in about 10 minutes duration were performed. The aim was to establish neuromuscular control of movement that was disrupted by intense stimuli during previous strength training (so called *muscle tone increase*). The following training session in the cycle (second day) is conducted in medium intensity and predominantly focused on cardio-respiratory system activation. The overall number of training sessions aimed on development of basic endurance and strength skills in a specific experimental group was significantly lower compared to traditional program followed by control group.

This combining of aerobic and strength training requires additional explanation. Namely, aerobic training reduces strength, whereas strength training stimulates increase in muscle mass that has relatively low oxidative capacity (Wilmore and Costill, 1993) and influence in negative manner on aerobic fitness. For this reason, an increase in muscle mass should be followed by an increase of the aerobic enzyme and mitochondrial mass, and therefore is necessary to combine endurance and strength trainings. However, with a combination of aerobic and strength training, it is necessary to take into account the incompatibility (negative impact) of these two types of trainings. By way of explanation, the strength training efficiency is dependent on the relationship of testosterone and cortisol, which affects protein synthesis in skeletal muscles (Issurin, 2010). In this way, after endurance training ratio of hormones mentioned above stays reduced in following hours, and therefore not suitable for strength development (Viru et al., 1992). The body of an athlete cannot effectively respond to training stimulus that simultaneously activates a variety of physiological system (Issurin, 2009). Intense glycolytic workload causes intense metabolic response and hormonal changes that may last two or three days (Viru, 1995). Consequently, the trainings that were focused on the strength development were not taken immediately after an exhausting aerobic workout.

All technical trainings in general microcycle were aimed at improving basic technical details and elements (*e.g.* automatisation, biomechanical efficiency, and full range of motion). Furthermore, keeping the "feel for fight" was a goal with technical training application.

Specific microcycle focuse on developing of specific abilities and skills that directly influence on success in judo bout. On a base of motoric and energetic structure of judo, it can be concluded that all types of strength are necessary for succesfull sport performance (repetitive, maximal, explosive, isometric), as well as high energetic capacity (aerobic, aerobic-anaerobic, anaerobic) with high level of speed, flexibility and coordination. All relevant factors for judo success were covered with specific program. Through functional training as well as with combining compatible training modalities, authors tried to develop multiple abilities and skills through one session and mi-

Table 2 Examples of general microcycle

Goal	Aerobic power and capacity development	Aerobic energy capacity development	Muscle endurance development
Duration	40'	70'	80'
Method	continuous	Modified continuous Specific	circular
Intensity	100-105% from VO_{2max}	60-70%	40-60 %
Location	Nature (outdoor)	Judo hall	Gym
INTRODUCTION	Easy pace running	Parterre bout of low intensity, 2 x 5 minutes with 2 minutes break between	Easy pace running
PREPARATION	Specific exercises for flexibility, coordination and strength for the overall treatment of the locomotor apparatus	Specific exercises: for coordination (four series of ukemi technique: Mae- ukemi, Ushiro-ukemi and Yoko-ukemi), flexibility (individual stretching) and strength (4 series: crawling on elbows on the mat, and pulling on partners weight by holding kimono sleeves on the mat)	Specific exercises for flexibility, coordination and strength for the overall treatment of the locomotor apparatus
MAIN	Running 4x4 minutes with 3-5 minutes break between intervals	Practicing technical-tactical techniques in the parterre for 20 minutes, continuous method 2 minutes break Practicing techniques in place and movement in standing position (*Uchikomi*) for 25 minutes, continuous method	Squat Dead lift on flat feet Force twitch Leg extensions (trainer) Hip flexion (trainer) Inclined bench press Upright rowing Biceps curls Push-ups on a loom Pullover Trunk flexion (trainer - with the weight) Military thrust (trainer) shoulder shrugging Pull-ups 10-15 repetition with 15-30'' minimal break between exercises
FINISHING	Stretching and loosening exercises, autogenic training	Stretching and loosening exercises, autogenic training	General judo technique patterns, stretching and loosening exercises, autogenic training

crocycle. However, particular accent was on development of maximal, explosive and glycolitic strength, followed by anaerobic lactate energy capacity, as key skills for succes in judo.

Philosophy of specific microcycle for experimental group of judokas is resulting from the complexity of judo match that is characterized by interval loads of very intensive actions (mainly in anaerobic mode) with intervals of short breaks. Therefore, logical sequence of interval training method prevalence in which judoka must engage almost all muscle groups in predictable and unpredictable dynamic movements, consequently resulting in a very high-energy consumption. In addition, exercises of relative strength type (with own body - rope climbing, chin-ups, push-ups) and absolute type (free weight) were combined. The goal was to enable a high degree of adaptation and high fitness level with heavy loads application by engaging a large part of the muscle through interval method.

With strength training in specific microcycle for judokas, total strength exercises were dominating (Bench press, Dead lift). For maximal and explosive strength development, a transforming series method is used. This method refers to stational pairing exercise method. The basic principle of pairing is reflected in a series of exercises for the same muscle groups. The first exercise is load of 1RM followed by plyometrics and judo techniques. Furthermore, exercises of explosive power were combined with exercises of high-coordination. Exercises for explosive power were

performed in the morning training sessions, always at the beginning of the main part of the training, for it is reported to be the best athlete's physical condition to perform explosive exercises (Issurin, 2009). Notes for development of other segments of strength applied in this microcycle are the same as described in general microcycle.

Table 3 Specific microcycle

Day		1.	2.	3.	4.	5.	6.	7.
Morning	P	MS ExS	AGP*	Rest	Tech	AGC *	RT	Rest
	S	AIA	Tech		Bal	Fle	Fle	
Afternoon	P	Tech	RT	MS* ExS	AIA	Rest	ExS	
	S	Fle	Fle	Tech	Fle		Tech	
Training session		2	2	1	2	1	2	
Goal	Specific abilities development (anaerobic glicolytic power and capacity, maximal and explosive strength)							
Notes	AGP-anaerobic glicolytic power; AGC-anaerobic glicolytic capacity; AIA-alactic abilities; MS-maximal strength; ExS-explosive strength; RT-recovery training; Fle-Flexibilty; Bal-Balance; Tech-technique; P- primary objective; S- secondary objective *- a key training.							

Table 4 Examples of specific microcycle

Goal	Lactate tolerance training	Specific strength development of the lower extremities, back, and abdominal muscles	Development of general and specific speed, maximum and explosive strength
Duration	60'	75'	60'
Method	Interval	Repetitive	Transforming series
Intensity	90-100%	80-90% from 1RM	85-100%
Location	Athletic track	Judo hall	Indoor hall
INTRODUCTION	Easy pace running (10min)	Easy pace running Individual treatment of the locomotor apparatus (10min)	Easy pace running (5min)
PREPARATION	Specific exercises for flexibility, coordination and strength for the global treatment of the locomotor apparatus (10min)	Specific exercises for coordination and balance, gymnastic floor elements (switch, roll forward and backward, cartwhell and handstands) (10min)	Specific exercises for flexibility, coordination and strength for the global treatment of the locomotor apparatus (10min)
MAIN	Running 5 x 400 m With 3-5 minutes break between intervals (30min)	Legs 1. Exercise: Squats with a partner on shoulders (Kata-Guruma position) 4 series, 6-10 repetitions 2. Exercise: Lunge - left and right leg (scissors) with partner in the initial position for Ippon-Seoi nage technique 4 series, 6-10 repetitions Back (Trunk) 1. Exercise: Forward bend with partner on shoulders (Kata-Guruma position) 4 series, 6-10 repetitions Abdomen (Trunk) 1. Exercise: Clamped legs around partners waist who is standing up and assisting in a way of holding feet of another judokas kimono while he performs exercises 4 series, 6-10 repetitions 2. Exercise: Parallel raising legs with fixed weights for joints (2-4 kg) (judoka performes this exercise by raising his feet parallel from the ground in the air, in the prone position while holding onto the feet of a partner who is standing and returning judokas legs back in the initial position). (45min) **Note: 2-minute break between sessions**	Squat + High jump + Sprint + Technique or Dead lift + Medicine ball toss + Sprint + Technique 3 - 4 minutes break between series (30min)
FINISHING	Stretching and loosening exercises, autogenic training (10 min)	Stretching and loosening exercises, autogenic training (10 min)	Stretching and loosening exercises, autogenic training (10 min)

Major glycolytic loads that cause a very pronounced reaction of the organism, such as maximum heart rate, maximum oxygen debt, and maximum accumulation of lactate in the blood (Bompa, 2000) were applied in this microcycle. In addition, a sudden increase in stress hormones (adrenaline, noradrenaline, and cortisol) occurs, whereas the level of testosterone (anabolic hormone) decreases over a period of 24 hours or more (Issurin, 2010).
Considering all this, it can be concluded that the significant characteristics of a specific microcycle are fatigue accumulation and insufficient recovery. In order to reduce these consequences, based on the monitoring of training responses, recovery training has been applied with different methods and techniques of recovery. Recovery trainings were apllied immediately after intense glycolytic training or 24 hours later in the morning sessions. Stretching exercises were usually combined with light jogging of short duration (within regenerative zone).
In addition, it is important to highlight the relationship between intensity and volume in this microcycle. The high level of intensity and low volume are general characteristics of specific microcycle.
Precompetitive microcycle emphasize the competitive model of exercise that uses the maximum load (high intensity - low volume). Specifically, this microcycle contains the largest load for judo sport. The main objective of this microcycle is to transform accumulated skills from general and specific microcycle into a specific physical and technical-tactical preparation, as well as to rise to a higher level already existing level of fitness and specific technical and tactical abilities.

Table 5 Precompetitive microcycle

Day		1.	2.	3.	4.	5.	6.	7.
Morning	P	ExS	Sit-Spe*	AeE	Sit-Spe*	RT	ExS *	Rest
	S	Tech	AGP	AIA	AGC	Fle	Tech	
Afternoon	P	Tech	RT	Rest	Tech	MS	ME	
	S	Fle	Fle		AIA	Tech	Tech	
Training session		2	2	1	2	1	2	
Goal	Development of situational- specific abilities							
Notes	Sit-Spe- Situational-specific training; AGP-anaerobic glicolytic power; AGC-anaerobic glicolytic capacity; AIA-alactic abilities; ME-muscle endurance; MS-maximal strength; ExS-explosive strength; RT-recovery training; AeE-aerobic endurance; Fle-Flexibilty; Tech-technique; P-primary objective; S-secondary objective. *- a key training.							

Table 6 Examples of precompetitive microcycle

Goal	Training plan of precompetitive microcycle	Training plan for 2nd precompetitive microcycle
Duration	70’	90’
Method	Modified specific interval	Modified Interval
Intensity	85-100%	90-100%
Location	Judo hall	Judo hall
INTRODUCTION	Easy pace running (10min)	performing techniques without a partner in motion (5 min) overall treatment of the locomotor apparatus individually and in pairs (exercises of static and dynamic stretching) (10min)
PREPARATION	Specific exercises for flexibility, coordination and strength for the overall treatment of the locomotor apparatus (10min)	Specific exercises: for coordination (six series of ukemi technique: Mae- ukemi, Ushiro-ukemi and Yoko-ukemi) and balance (15min)
MAIN	Bout (attack every 15’’ in a duration for 10 to 15’’) Bout time is 5’ with active break (streching) in a duration of 3’ (overall 40 min)	Randori (with a transition to parterre) Series: 5 x 5 bouts, with stopping the time for referee decision Isolation bout one at a time Break between bouts 5 min (overall 50 min)
FINISHING	Stretching and loosening exercises, autogenic training (10min)	Stretching and loosening exercises, autogenic training (10min)

It is precisely in this microcycle that stressful technical and tactical tasks apply. Targeted skills are specialized and key exercises are closely associated with the competitive activity. In particular, specific exercises during training were used, simulating the rhythm, speed and power that is required in competitions.

Trainings with overlapping coefficient up to 5 times were applied. Given that this is the most demanding microcycle, it is of great importance monitoring judokas stress, and consequently implementation of recovery training and resources (trainings, methods and recovery techniques are described in a specific microcycle). In addition to these basic goals in precompetitive microcycle, it is important to maintain various forms of strength (maximum, explosive, static strength, endurance in strength) or general aerobic energy capacity.

Aforementioned abilities were maintained with general and specific exercises along with strength training (strength training or aerobic endurance 1 or 2 times during microcycle). Furthermore, it is important to emphasize that general and specific exercise trainings were combined with situational and technical-tactical training and exercises. Combining general, specific and technical-tactical training and exercises (integration) in precompetitive microcycle, produces the great effects of training, and thus is more cost effective.

Competitive microcycle is the final part of each specific training phase program of the experimental groups. This microcycle was directed towards achieving maximum competitive performance and full recovery before competition. Judokas were entering this microcycle with a lot of accumulated fatigue from previous microcycles, situational or precompetitive. Moreover, an important factor of this microcycle are long-term travel to the venue of the competition, which also can include changing time zones, climate, altitude, diet, etc. Therefore, workload reduction is of primary importance at the beginning of the competitive microcycle in order to ensure and facilitate the recovery of athletes and timely achieve the state of supercompensation. Targeted load reduction in the competitive microcycle, in addition to physiological and energy benefits, results in significant mood improvements, which are mainly associated with the recovery (Mujika et al., 2004).

Table 7 Competitive microcycle

Day		1.	2.	3.	4.	5.	6.	7.
Morning	P	Tech-Tac	Sit-Spe*	RT	Tac *	Rest	C	RT
	S	AIA	Tac		Fle			
Afternoon	P	MS	Rest	Rest	Rest			Rest
	S	Fle						
Training session		2	1	1	1			
Goal	Preparation for competition, supercompensation							
Notes	Tech-Tac- technical-tactical preparation; Tac-tactical training; AIA-alactic abilities; MS-maximal strength; RT-recovery training; Sit-Spe- situational-specific training; Fle-flexibility; C-competition; P-primary objective; S-secondary objective. *- a key training.							

Modeled exercises and tasks that are specific to judo competitions are used in this microcycle. The emphasis was on maximum speed when performing specific judo techniques, creating specific tactics, raising motivation and control emotional tensions ahead of the competition. Trainings were based on the simulation of technical-tactical competitive situations. The simulation included the technical and tactical combinations and tasks through the expected competitive situations, with an attempt to approximate the level of concentration to the competitive level. Trainings in this microcycle are taken at the time of day when the performance in the competition was expected.

The main objective of ***regenerating microcycles*** is the recovery and revitalization of the athlete's body after competitive microcycle. Bearing in mind that during specific program there is a significant number of important contests and competitions that cause great physical and emotional stress with increased secretion of stress hormones (Issurin, 2010), after each competitive microcycle regenerating or recovering microcycle followed. Content of a regenerating microcycle is mainly composed to accelerate the process of mental and physical regeneration. It consists mainly of activities of low intensity and volume, with methods and procedures usually relating to adequate nutrition, sauna application, massage, contrast baths and stretching. Sports games, such as football or basketball, are not included in the content of this microcycle because of the high risk of injury.

Balance and flexibility in the specific program. Exercises for the development and preservation of flexibility and balance were applied in every single microcycle, within each workout (usually in introductory-preparatory and final part of the training). Balance training operators have been implemented in the introductory part of the training in the warm up phase, as part of a dynamic stretching with and without an external load. Furthermore, a various unstable surface (balance boards, pillows, bossu balls, etc...) were used when working with an external load, or while performing specific judo techniques. Dynamic stretching was a part of the introductory part in training. Combining movement performance (maximum range of motion), and simulation of judo techniques performance was used.

Table 8 Examples of competitive microcycle

Goal	Training plan for competitive microcycle	Training plan for 2nd competitive microcycle
Duration	90 minutes	70 minutes
Method	Modified interval	Specific interval
Intensity	90-100%	50-60%
Location	Judo hall	Judo hall
INTRODUCTION	performing techniques without a partner in motion (5 min) overall treatment of the locomotor apparatus individually and in pairs (exercises of static and dynamic stretching) (10min)	Easy pace running (5 min)
PREPARATION	Specific exercises: for coordination (six series of ukemi technique: Mae- ukemi, Ushiro-ukemi and Yoko-ukemi) and balance (15min)	Specific exercises for flexibility, coordination and strength for the overall treatment of the locomotor apparatus (10min)
MAIN	Randori (with a transition to parterre) Series: 5 x 5 bouts, with stopping the time for referee decision Isolation bout one at a time Break between bouts 5 min (overall 50 min)	*Uchikomi* in movement 5 series x 3 minute Ne waza, practicing parterre techniques (Osaekomi waza, Kansetsu waza, Shime waza) 3 series x 5 minutes Kumi kata 3 bouts x 5 minutes 1 minute of rest between series (overall 45min)
FINISHING	Stretching and loosening exercises, autogenic training (10min)	Stretching and loosening exercises, autogenic training (10min)

Dynamic stretching exercises programs were adjusted to imitate judo activity movements, where body was optimally prepared for the awaiting efforts during training. In the final part of the training in order to relax the muscles and accelerate recovery after exercise as well as to reduce body temperature and prevent injuries static stretching was applied (Facción, 1995).

Control group training program

The control group followed the standard training program, largely based on the principles of linear or traditional periodization, which is a common training model applied in Bosnia and Herzegovina. The main differences in control group program in relation to the specific program of experimental group is that results from the initial measurement were not used for training programming, nor the individual training zones were calculated for development of functional and motor abilities for control group. Control group had a significantly higher number of trainings for the development of general fitness levels, which means more time spent on the improvement of general skills, and less time for the development of specific and situational abilities in relation to program the experimental group. For development of general fitness level, solely general methods were used (*e.g*. for aerobic energy capacity development only running exercises). Control group did not use the transforming series in strength training. During basic preparation, trainings and exercises were not supplemented with technical tasks of low intensity in order to establish neuromuscular control of movement that is disrupted by intense stimuli during strength training. Furthermore, after aerobic sessions (*i.e*. longterm cyclic movements) athletes of control group did not perform alactic sprints for activating fast twich fibers. Recovery trainings were not a part of control group preparation, and no-load control via Heart rate monitor and lactate concentration was performed. Training load for control group was based on a subjective assessment of coaches and athletes, whereas program that was conducted with a control group was not focused on all competitions defined by official competitive calendar.

Anthropometry

Anthropometric profile. The following anthropometric measures were taken from all participants: body mass (Avery Ltd., Model 3306 ABV, Crosswell, UK), body height (Holtain Ltd., London, UK), skin-fold thickness (Harpenden;

Baty Intl, West Sussex, UK) at four sites (biceps, triceps, sub-scapular, suprailiac), and limb circumferences (Gulick anthropometric tape; Creative Health Products, Plymouth, USA) at five sites (forearm, upper arm, thigh, waist, chest). The body fat percentage was estimated through manual bioimpedance (MaltronBioScan 920-2, Edinburgh, UK).

Test battery

Handgrip strength. Maximum handgrip strength for both hands was measured with a portable Takei handgrip dynamometer (Takei Scientific Instruments CO, Tokyo, Japan). The athletes were standing comfortably with the shoulder adducted. The dynamometer, which had been previously adjusted to the size of participants' hands, was held with the arm parallel to the body without squeezing the arm against the body. The position of the hand remained constant in a downward direction, the palm did not flex on the wrist joint. The subjects were required to exert a maximum voluntary contraction on the dynamometer for 5 seconds. All subjects performed 3 trials, the best performance was used for further analysis.

Isokinetic knee strength. The thigh muscle strength was measured using an isokinetic dynamometer (Biodex Corp., Shirley, New York, USA) according to standard protocols (Gleeson and Mercer, 1996; Madsen, 1996). The machine was calibrated prior to every test and the range of motion (ROM) was set at 90º. All subjects performed a 10-min general warm-up, followed by a specific warm-up consisting of 3-4 repetitions at the testing speed (60 deg/s) for quadriceps (Q) (knee extensor) and hamstrings (H) (knee flexor) muscles in order to prepare the subjects for testing. Two minutes after the warm-up, the athletes performed 5 repetitions of maximum voluntary contractions of leg muscles for 3-4 s. The peak torque values were recorded for right and left knee extensors (KE-R and KE-L respectively), and right and left knee flexors (KF-R and KF-L respectively), by the same experienced examiner.

Isokinetic shoulder strength. Concentric and eccentric strength measurements for left and right arms were performed on the Biodex isokinetic dynamometer at 60 deg/s (Biodex Corp., Shirley, New York, USA). The subjects warmed up using an upper-body ergometer for approximately 5 minutes. During testing, all subjects were positioned in the supine position with straps placed across the chest and hips. The tested arm was positioned with the shoulder abducted to 90º and the elbow flexed to 90º. The strength was tested through a ROM of 150º, between 60º of internal rotation and 90º of external rotation, for both the internal (I) and external (E) rotation tests. The athletes performed three sub-maximal trials to familiarize with the testing procedure and the dynamometer. Both concentric and eccentric testing consisted of 5 maximal reciprocal repetitions for 3-4 s, standardized instructions were given to push as hard and fast as possible. The concentric muscle torques were measured first, followed by the eccentric torques assessments.

Dynamic strength tests. The one repetition maximum (1-RM) test for bench press and squat were performed using free weights (Hoffman, 2002). The judo athletes warmed up with a light resistance and then achieved a 1RM effort within 3 to 5 attempts. No bouncing was permitted, as it would have artificially boosted strength results. The bench press testing was performed in the standard supine position: the subject lowered Olympic weightlifting bar to mid-chest, then pressed the weight until his arms were fully extended. The squat exercise required the player to rest an Olympic weightlifting bar across the trapezius at a self-chosen location. The squat was performed to the parallel position, achieved when the greater trochanter of the femur was lowered to the same level as the knee. The subject then lifted the weight until his knees were extended. Previous studies have demonstrated good test-retest reliabilities for these strength measures (Hoffman et al., 1990; Hoffman et al., 1991). The 1RM deadlift was tested by following the protocol and exercise execution guidelines described by Baechle et al. (2000).

Muscular endurance. In addition to the 1RM tests, bench press and deep-squat exercises were performed with free weights equal to weight of judokas until exhaustion with the same equipment. The number of pull-ups until exhaustion was reported as an indicator of upper body strength.

Muscle power. The high-jump and long-jump were chosen as a measure of leg power. For both jumping tests, the judokas attempt their maximum jump distance; they performed 3 repetitions and the best result was noted for analysis. In order to evaluate a measure of the upper-body power, the subjects participated in the standing medicine-ball throw. They were instructed to hold the 5-kg medicine ball with both hands, quickly bring the ball up to touch their chest at about nipple level, and execute an explosive chest-type pass, pushing the ball forward and upward at an angle approximately 30 above horizontal. The same instructions and demonstrations were given to all subjects before testing.

Aerobic profile. The maximal oxygen uptake was estimated in all participants. The ventilatory and metabolic indices were measured at rest for one minute, then for another minute on a treadmill at a speed of 3 km/h; then, starting at 7 km/h, the workloads incremented progressively at a rate of 0.5 km/h every 30 s until exhaustion (CPET, COSMED, Torino, Italy). The inclination was equal to 2% throughout the trial. The test was considered completed when the oxygen uptake reached plateau, and the respiratory and ventilator quotients reached reference values, the perceived state of each participant being monitored throughout the test. The expiratory airflow was measured by gas turbine with a mask; oxygen and CO2 were determined in expired air, the latter by infrared gauge. Before each test, the volume was calibrated by 5 inspiratory and expiratory strokes at different flows with a 3-l syringe; the gas analyser was calibrated with two gas mixtures of known oxygen and CO2 concentrations (20.9% O2, 0.03% CO2 and 16.0% O2, 5.0% CO2, respectively).

Anaerobic profile. In order to evaluate the anaerobic power, a maximal power test was used for estimating the alactate component. The MaxPower Test was performed with a subject pedalling at maximal speed (the highest possible) on a bicycle ergo-meter (Technogym HC600, Rome, Italy)

for a period of 8 seconds. The results of the test are given as an average value of the Watts in the 8 s period.

Specific-judo performance. The judokas also were submitted to a specific-judo performance test, the 30 seconds Tokui Waza Test. Two judokas (*uke*) were positioned at 4 m distance from one another, and the test executor (*tori*) was 2 m from *ukes*. During 30 s, *tori* throws opponents using his "favourite" or "best" technique, as many times as possible (figure 1). Performance is determined by the total number of throws completed by the judo athlete.

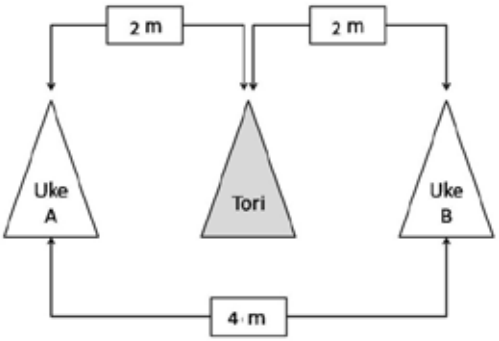

Figure 1 30 seconds Tokui Waza Test.

Statistics

All values are expressed as means ± standard deviation. The distribution of normality was analysed by a Shapiro-Wilk test. A two-way (time of measurement and training protocol) analysis of variance with repeated measures was applied to compare performance in the physical tests and the anthropometrical measurements. All analyses were performed using SPSS v. 20.0 for Windows. Effect sizes were calculated using eta squared (h^2). The statistical significance was set at $p < 0.05$.

RESULTS

Table 9 presents the anthropometric variables before and after the two training programs. It is noticeable that values of Skin-fold (suprailiac) was significantly reduced in experimental group after the applied treatments ($F = 5.38$, $P = 0.039$). Furthermore, significant interaction effect appeared ($F = 6.94$, $P = 0.022$), which indicates significantly greater effect on the increase in volume of Right forearm in the experimental group after applied program, whereas in the control group, these values had smaller average size in the final measurement. Within both groups in the final measurement was noticeable significan decline in percentage of Body Fat ($F = 5.86$, $P = 0.032$).

Table 9 Anthropometric variables before and after the two training programs.

Variable	Experimental (n = 7)		Control (n = 7)	
	Initial	Final	Initial	Final
Body mass (kg)	92.00 ± 11.28	89.04 ± 8.91	99.14 ± 15.32	98.57 ± 16.41
Height (cm)	178.57 ± 7.73	178.57 ± 7.83	186.21 ± 6.50	186.21 ± 6.50
Bicep (mm) SF	4.41 ± 1.10	4.11 ± 0.66	4.34 ± 0.78	4.28 ± 0.73
Triceps (mm) SF	8.78 ± 3.48	8.12 ± 2.61	7.45 ± 2.17	7.48 ± 2.21
Subscapular (mm) SF	12.84 ± 3.87	11.91 ± 3.17	11.82 ± 1.91	11.87 ± 1.32
Supraillac (mm) SF*	18.37 ± 9.16	15.87 ± 7.30	15.34 ± 3.65	15.41 ± 4.06
Left forearm (cm) LC	30.35 ± 2.17	31.07 ± 2.11	31.50 ± 2.19	31.50 ± 2.27
Right forearm (cm) LC*	30.92 ± 2.22	31.71 ± 2.05	31.85 ± 2.62	31.64 ± 2.39
Left upper arm (cm) LC	37.14 ± 4.23	37.78 ± 3.90	37.21 ± 3.21	37.28 ± 2.94
Right upper arm (cm) LC	36.71 ± 3.80	37.71 ± 3.72	37.78 ± 3.09	37.85 ± 3.19
Left thigh (cm) LC	60.92 ± 3.34	61.71 ± 2.97	62.00 ± 4.96	62.42 ± 5.46
Right thigh (cm) LC	60.85 ± 3.21	61.71 ± 2.75	62.57 ± 5.43	62.64 ± 5.82
Chest (cm) LC	104.78 ± 10.38	105.50 ± 7.17	110.78 ± 7.95	111.42 ± 8.13
Waist (cm) LC	92.78 ± 7.22	90.85 ± 5.52	93.57 ± 9.25	93.78 ± 9.95
Body mass index	28.70 ± 3.40	27.81 ± 2.81	28.47 ± 3.93	28.34 ± 3.86
Body fat (%)*	17.40 ± 3.98	16.17 ± 3.50	16.11 ± 2.22	16.04 ± 1.78

SF: Skin-fold, LC: Limb circumferences.

Table 10 presents the fitness and specific performances of judo athletes before and after applied training programs. Effects of program showed statistically significant changes in tests of absolute strength in favor of experimental group in following variables: Bench Press ($F = 121.00$, $P = 0.000$), Deep squat ($F = 14.03$, $P = 0.003$), Dead lift ($F = 27.56$, $P = 0.000$) and Hand Grip Right ($F = 22.91$, $P = 0.000$). In variables of power evaluation effects of applied treatment were also significantly better in favor of experimental group with Single high jump ($F = 10.48$, $P=0.007$), Single long jump ($F = 12.79$, $P = 0.004$) and Medicine ball toss ($F = 47.25$, $P = 0.000$). Better results for experimental group were also found within muscle endurance variables, Chin up ($F = 20.35$, $P=0.001$), Bench Press with body weight ($F = 16.34$, $P = 0.002$) and Deep squat with body weight ($F = 17.67$, $P = 0.001$). In addition, significant effect of changes on average values were determined with Coordination with stick ($F = 29.92$, $P = 0.000$), Envelope test ($F = 34.21$, $P = 0.000$) and side leg raise ($F = 5.44$, $P = 0.038$), all in favor of experimental group.

Table 10 Fitness and specific performances of judo athletes before and after applied training programs.

Variable	Experimental (n = 7)		Control (n = 7)	
	Initial	Final	Initial	Final
Bench Press (Kg)**	127.14 ± 19.11	145.00 ± 18.93	153.57 ± 28.38	155.71 ± 27.90
Deep squat (Kg)**	139.29 ± 24.22	166.43 ± 15.46	171.43 ± 28.68	172.86 ± 27.81
Dead lift (Kg)**	196.43 ± 26.72	220.71 ± 22.62	207.86 ± 26.90	205.71 ± 22.62
Hand Grip Left (Kg)	54.91 ± 5.42	58.20 ± 5.26	58.37 ± 3.55	57.55 ± 4.20
Hand Grip Right (Kg)**	56.85 ± 6.20	61.28 ± 7.31	62.58 ± 7.17	63.47 ± 7.77
Single high jump (m)**	2.98 ± 0.19	3.10 ± 0.20	2.98 ± 0.08	3.00 ± 0.13
Single long jump (m)**	2.58 ± 0.34	2.76 ± 0.32	2.50 ± 0.13	2.53 ± 0.14
Medicine ball toss (m)**	5.38 ± 1.02	5.90 ± 1.12	5.87 ± 0.50	5.84 ± 0.54
Chin up (freq.)**	25.14 ± 7.86	33.29 ± 8.84	25.00 ± 11.37	25.00 ± 9.48
Bench Press with body weight (freq.)**	17.57 ± 5.06	23.14 ± 5.04	20.29 ± 11.57	21.29 ± 10.02
Deep squat with body weight (freq.)**	20.14 ± 8.37	28.29 ± 4.64	24.86 ± 9.90	24.43 ± 7.89
Coordination with stick (s)**	4.43 ± 0.83	4.15 ± 0.83	4.98 ± 1.12	5.36 ± 0.95
Envelope test (s)**	24.66 ± 0.48	23.99 ± 0.62	25.20 ± 1.25	25.59 ± 1.19
Side leg raise (cm)*	41.42 ± 5.56	50.71 ± 8.86	46.42 ± 7.48	50.71 ± 7.86
Sit and reach (cm)	15.85 ± 5.14	17.00 ± 5.03	13.64 ± 7.05	13.57 ± 5.41
Straight leg raise, L (cm)	92.14 ± 4.87	94.28 ± 5.34	91.42 ± 6.26	90.00 ± 5.77
Straight leg raise, R (cm)	90.00 ± 2.88	92.85 ± 3.93	87.14 ± 2.67	87.85 ± 2.67
Shoulder flexibility test (cm)	94.14 ± 9.37	89.42 ± 5.79	92.00 ± 17.88	93.00 ± 16.89
VO_{2max}/BW (ml·kg·min)**	52.52 ± 5.18	55.81 ± 5.49	51.02 ± 5.92	49.70 ± 6.13
$VO_{2\ max}$ (L)**	4.74 ± 0.74	4.87 ± 0.73	4.96 ± 0.49	4.80 ± 0.52
HR_{max} (freq.)	190.00 ± 9.12	192.29 ± 7.54	187.43 ± 7.11	187.14 ± 7.33
vVO_{2max}** (km/h)	15.29 ± 1.38	16.57 ± 0.97	15.45 ± 1.28	15.43 ± 1.13
VO_{2max}/BW at VenT (ml·kg·min)	40.74 ± 4.35	45.57 ± 4.84	35.72 ± 6.47	35.61 ± 6.64
Max Power test (W)**	544.57 ± 64.39	608.29 ± 66.45	539.43 ± 64.55	552.71 ± 55.88
30 sec Tokui Waza (freq.)**	14.29 ± 1.38	15.71 ± 1.11	14.14 ± 1.95	14.00 ± 1.29

The effect of applied program on absolute oxygen consumption variable (VO_{2max}) is found statistically significant ($F = 12.31$, $P = 0.004$), as well as in relative values. Furthermore, it has been determined statistically significant effect of program on following variables: Speed at maximal oxygen consumption (vVO_{2max}) ($F = 13.19$, $P = 0.003$), Relative oxygen consumption at ventilatory threshold (VO_{2max}/BW at VenT) ($F = 21.81$, $P = 0.001$), Maximal anaerobic power test in watts ($F = 29.94$, $P = 0.000$). Variable that determines specific abilities of judokas, 30 seconds Tokui Waza effects of the applied treatman was statistically better in favor of experimental group ($F = 12.10$, $P = 0.005$).

DISCUSSION

After six months of applied training protocol, regarding anthropometric measurements in experimental group of judokas, at the same time occured a reduction in the percentage of fat and suprailiac skinfold as well as an increase the of the right forearm circumference at a significant level of deduction. Furthermore, the significant increase in all variables of strength and coordination is noticable. The experimental treatment also resulted in a significant increase in aerobic and anaerobic power, as well as judo-specific fitness, whereas no significant changes were occured in flexibility variables and left-hand grip.

Franchini et al., (2011a) found in their research procentage of fat tissue in judokas to range from 4-9%, except for heavy weight categories (+100 kg men). In our study, higher percentage of fat occured, but it should be taken into account that dominated sample of judokas was from the higher weight categories. Furthermore, it would be impossible to determine individual body composition or fitness profile for all judokas due to different weight categories. However, there are similarities in some factors in terms of the characteristics and somatotype dominance mesomorphous type (Franchini et al, 2011a).

Lower extremities strength is of great importance during the execution of the throwing techniques in judo. The research that was conducted on judokas from Finland (Fagerlund and Hakkinen, 1991) showed that the level of international judo athletes possesses a higher value levels in power speed curve for Squat jump (SJ), compared to a group of recreational level judokas. Moreover, the time for which international group of judokas achieve half of the maximum power is shorter. Muscle groups that are activated during the execution of the throwing techniques are mainly located in the lower part of the body and given that these techniques are performed with high speed and high resistance against the opponent, the differences between these two levels of competitors (international and recreational) may be the result of such adaptations. No differences were found in results for bench press between these two groups. In another study of Franchini et al. (2007) authors compared a similar level of judokas (national main team with a reserve team), and found no differences in the values of 1RM for bench press, squat, and arm stroke. As the pushing and pulling phases during a judo match are conducted many times during the fight for grip that precedes technique application, these improvements would guarantee a better maintenance of these actions (Franchini et al., 2014). Typically, the grip dispute during the match is maintained through forearm strength endurance (Franchini et al., 2011b; Franchini et al., 2013), the high-intensity technical actions executed to throw the opponent are related to lower-body muscle power (Blais et al., 2007), and some movements to immobilize the opponent involve whole-body maximal strength (Franchini et al., 2011a, Franchini et al., 2013). Thus, judo athletes need to develop a wide range of strength abilities in order to execute the technical actions used to score during the match (Franchini et al., 2013).

Handgrip, as static manifestations of power in judo, is important in standing position in order to maintain the distance as well as to provide resistance when pulling opponent out of balance (Franchini et al, 2011a). The improvements in maximal isometric handgrip strength and in isometric strength-endurance chin-up performance are important adaptations to the grip dispute during the match, which is the longest action performed during judo combat (Calmet et al., 2010; Marcon et al., 2010; Miarka et al., 2012). Furthermore, athletes also improved their dynamic maximal strength in row, bench-press and squat exercises and the strength endurance in bench-press and squat exercises. Experimental group of judokas showed significantly higher values for handgrip compared to previous reserarch findings (Franchini et al., 2005a; Spieser et al., 2012; Cortell-Tormo et al., 2013), which could be explained with their higher body mass.

Some of the most common techniques at the 2013 World Championships were those throws that require execution with balance and explosion of a single leg that is planted on the mat surface, including *Uchi mata* and *Osoto gari.* This observation suggests the importance of lower-body training, with particular focus on single-leg exercise when training judo athletes.

One study determined that periodized strength training would lead to adequate increases in muscular strength of first-class judo athletes, allowing the ability to perform movements and techniques faster and more efficiently during a match (Bratic et al., 2008).

Studies comparing performance variables from athletes who have undergone both periodization models tend to favor undulating periodization as the superior method (Monteiro et al., 2009; Prestes et al., 2009). Periodically alternating volume and intensity may supply the neuromuscular system with the stimulus needed for adaptation to occur and, at the same time, allows the body to recover and regenerate (Poliquin, 1988). With stepwise periodization, the continuous increases in intensity over the course of a training cycle subjects the body to ever-increasing levels of stress, requiring a light or unloading week for regeneration (Poliquin, 1988).

Possessing tactical excellence and having the ability to execute an array of complex skills necessary for success in judo competition requires the ability to move well and efficiently; this means that the athlete must excel in basic movement patterns and be absent of postural distortions, faulty movement patterns, and muscular imbalances (Henry, 2011).

Some evidence exists for higher values of maximum oxygen consumption (VO_{2max}) and ability for faster resinthesys of gastrocnemius creatin phosphat in judokas that normally receive points in the decisive moments in match compared to other judokas scoring earlier in the match that show better performance in the Wingate test for lower body (Gariod et al., 1995). Additionally, faster recovery after high-intensity intermittent activity is also associated with aerobic abilities (Franchini et al., 1999; Franchini et al., 2011a). Athletes with higher aerobic power were probably able to perform submaximal activities with lower sense of effort compared to athletes with lower aerobic power (Franchini et al., 2011a).

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