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THE INFLUENCE OF A TRAINING PROGRAMME ON THE SPECIAL PHYSICAL FITNESS OF *JU-JITSU* TRAINEES

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ABSTRACT

The purpose of training in ju-jitsu is developing characteristic adaptation to physical activity and optimizing body functions so as to obtain maximal achievements. A means to an end is mastering the fighting technique and develop the essential level of special physical fitness. The aim of this paper was to determine the influence of a modified circuit training conducted according to an original program on level of special physical fitness of ju-jitsu trainees. Ju-jitsu trainees having similar somatic parameters and training experience (3-5 years) were included in the research. 30 participants between the age of 21 and 28 have been selected by means of a purposeful selection. On the basis of different variants of a circuit training and governed by the guidelines of a functional training for trainees, we have developed a training programme which aims to develop special strength, stamina and speed skills. STATISTICA PL software was used to compile the results. In order to determine statistical significance of differences between pre- and posttest measurements in the evaluated group of Ju-Jitsu contestants, a t-test for related groups was used.
In conclusion, the proposed training programme proceeds at a high level of intensity, which resembles start activity (which is indicated by the heart rate frequency measurement and lactic acid blood concentration) and may be used in ju-jistu training. The experimental training programme has exerted positive influence on the participants' with respect to the number of movements made, which can affect their effectiveness in fight.

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INTRODUCTION

According to rules in ju-jitsu both long and short distance attacks, as well as ground fighting are allowed. In ju-jitsu fights are characterized by acyclic movements and frequent changes in fighting conditions. It comprehensively affects trainees and, by activating all muscle groups, engages the whole body broadly and uses all elements of trainees' motor skills (Ambroży 2008). In the course of fight the position of a trainee constantly changes which requires that they are quick. Changeable intensity of a physical effort, on the other hand, requires specific endurance capacity. Ju-jitsu is a direct fight which requires maximal nerve and muscle effort in a relatively short time (Sterkowicz 1998).

The aim of a sports training in ju-jitsu is developing characteristic adaptation to physical activity and optimizing body functions so as to obtain maximal achievements. A means to an end is mastering the fighting technique and develop the essential level of special physical fitness. In a ju-jitsu training, apart from doing typically specialist exercises (repeating techniques, combinations, counter-attacks and some parts of the fight), selected exercises can be used to improve general and special physical fitness in the form of station circuits. As one variant of training forms in ju-jitsu, circuit training is a way of conducting a training session which develops muscle strength and to some degree speed and resistance to physical fatigue. Taking into consideration the type of work of muscles, it is classified in the group of dynamic methods of strength training with the use of medium weights. From a methodological point of view, this kind of training is used as a method developing endurance-strength skills. Variants of the circuit training give a broad range of options of modifying this way of conducting classes (Ambroży 2007). In order to develop special skills it is essential to make sure in the course of a training programme preparation that strength training engages the muscle groups that are used in the allowed techniques and develop the so-called postural muscles. In the evaluation of special physical fitness technical efficiency tests (examples: Sterkowicz and Ambroży 2003), as well as special strength and endurance tests are used. The comparison of the results of general physical fitness tests and the results of sports achievements, a number of factors, which characterize selected trainees' level of training, is found.

The test of special physical fitness (TSSR), which is used in the evaluation of special physical fitness of judo and ju-jitsu trainees, is carried out by means of *ippon-seoi-nage* throw repeated with maximal speed. This throw is done in the following way: after leaning the opponent forward, we drag them on the back and throw them forward over the left or right shoulder. Two competitors *(uke)*, face each other at a distance of 6 meters in places marked by a tape sticking to the mat. The tested trainee *(tori)* starts in the middle, being placed forward to one of their fellow trainee. On command: *Hajime* the trainee is to do the following: move as fast as possible and make three *ippon-seoi-nage* throws, changing partners. The task of their fellow trainees is to perform falls, rise up quickly and stand on the place marked on the mat. Interval effort consists in doing as many throws as possible in three series lasting 15, 30 and 30 s respectively, with 10 second intervals. The interval starts on *Matte* command.

Immediately after physical effort and after a one minute break, heartbeat frequency HR was measured. On the basis of the following formula: the sum of HR measurement after effort and an one minute break / the sum of throws in three series, TSSR index can be calculated (Sterkowicz and Ambroży 1992, 2003).

TSSR tests enable to evaluate trainees' level of preparation at a particular stage of training. By repeating them, it is possible to evaluate progress or decrease in physical fitness. Analysis of test results, on the other hand, enables to modify training effectively.

The aim of this paper was to determine the scope of a modified circuit training conducted according to an original program on ju-jitsu trainees' level of special physical fitness.

On the basis of research results and evaluation of trainees qualified to the project, an attempt to evaluate whether the proposed training programme can be implemented into ju-jitsu training cycle was made.

The conducted research allowed to formulate the following research questions:

1. At what level of intensity (heart beat frequency and lactic acid blood concentration measurement) accomplishment of a training unit of an experimental research project takes place?
2. Does the experimental training programme influence trainees' level of special physical fitness?

MATERIAL AND RESEARCH METHOD

Ju-jitsu trainees having similar somatic parameters and training experience (3-5 years) were included in the research. 30 participants between the age of 21 and 28 have been selected by means of a purposeful selection.

On the basis of different variants of a circular training and governed by the

guidelines of a functional training (Ambroży 2008) for trainees, we have developed a training programme which aims to develop special strength, stamina and speed skills.

The concept of the experimental training programme was based on the rule of „small strength circuits" (Ambroży 2007) in which there is an additional assumption that is doing suitably grouped exercises: strength, functional and targeted ones. Each training unit is divided into three small circuits (**Table 1**):

- the circuit of strength training (with the use of barbells, dumb-bells and weights),
- the circuit of exercises developing functional fitness (plyometric and coordination exercises),
- the circuit of targeted exercises (exercises engaging those parts of muscles which are most often used in sporting competitions).

Doing particular exercises was time limited – 30 seconds, except for the circuit of strength training which the aim was to make 15 repetitions which were also time limited, but in this case the limit was 45 seconds. The training starts with shaping exercises (5-10 minutes). Each training unit finishes with stretching exercises (10-15 minutes).

STRENGTH CIRCUIT	SKILLS CIRCUIT	TARGETED EXERCISES CIRCUIT
Classic squat combined with overhead barbell presses	A workout of lower limbs with the use of coordination ladders.	Straightening arms at chest height with elastic tapes attached to a ladder.
Pull-ups to the chest height with arms splayed narrowly.	A transition to support, jumping up high with knees placed against the chest.	Stepping forward and moving a medicine ball from above head at the same time.
Pressing barbells alternately when lying on an exercise ball.	High knee run in place. *Skipping A* with barbells in hand.	Doing press-ups on a *bosu*[1] ball and returning to the posture, transferring *bosu* over the head alternately with straightening arms at chest height.
Swinging one's limb with kettlebells[2] starting from square stance[3]	Jumping over a hurdle combined with going under the hurdle.	Pulling up torso to a suspended rope with a simultaneous twist of the body.
Twists of the body with a place kept in both hands combined with raising the knee up in an equivalent position.	A knee bend combined with a one-leg jump on a *plyo-box*[4]	*Tsugi-ashi* stepping pattern between plates.

Table 1. The training programme used in the research project

[1] Bosu Ball – is a fitnesss training device, consisting of an inflated rubber attached to a rigid platform.
[2] A kettlebell – is a training device with a decentralized centre of gravity. Most often it is a cast-iron ball with a handle.
[3] Square stance – a starting position which is characterized by a wide low stance.
[4] *Plyo-box* – a training device used for plyometric exercise.

Suitable statistical methods were used (one factor analysis of variance Anova and post *hoc Shaffe test*) and no significant differences in the group of participants were found. The experiment lasted for 8 weeks with 4 training units a weekThe participants of the project were subjected to specialist examination before and after the project. This enabled to evaluate the scope of influence of the training programme on the participants. All participants were informed about the assumptions of the experiments and took part in it of their own will. The participants could have any medical contraindications against making physical effort. The scope of research obtained a positive opinion (No./77/KBL/OIL/2010) of the Bioethics Committee at the Regional Medical Chamber in Cracow.

In order to evaluate the level of intensity of a training unit, physiological tests were conducted in the course of the training unit in the first and sixth week of the experimental cycle. The tests were conducted by means of the test apparatus including:

- Lactate Scout lactometer: the measurement of lactic acid concentration,
- POLAR expulsor pump, models: F-55 and FT-4: used to measure heart rate frequency.

Special physical fitness was evaluated by means of the TSSR rest (presented above). At the first setting, a warm up was performed, which included a 5 minute jog (moderate intensity) and several *ippon-seoi-nage* throws done at a slow pace so as to adapt to the distance and partners. The test consisted of three stages of effort (A = 15 s; B and C = 30s), separated by 10 second intervals. In each series of throws, the participant (*tori)* gets a grade on the basis on the maximal number of *ippon-seoi-nage* throws performed on two partners *(uke)* A and B, standing on the mat at the distance of 6 m. The outline of the experiment is presented in Figure 1.

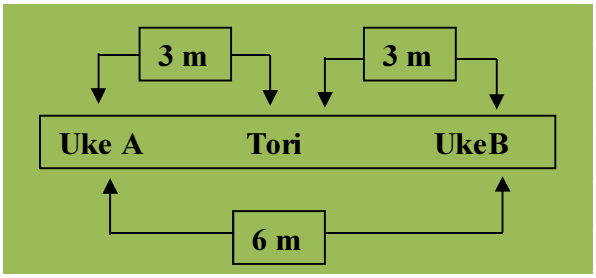

Fig. 1. The outline of the TSSR Test

Both *uke* A and B were the same weight and height as *tori* (the person evaluated in the test). Immediately after the C cycle and a minute later hart rate frequency was measured with the use of a sport tester. Throws done in the following cycles: A, B and C were added and the following index was calculated:

Final HR (beats/min.) immediately after performing throws + HR 1 min after the test

The number of throws (A+B+C)

STATISTICA PL software was used to compile the results. In order to determine statistical significance of differences between pre- and posttest measurements in the evaluated group of Ju-Jitsu contestants, a t-test for related groups was used.

RESULTS

Statistical analysis using a student t-test (Table 2) has shown that there are statistically significant differences in average pre- and post-test results of the following variables: average heart rate frequency – the pre-test result (mean=149,77; sd=4,72) was statistically higher (mean difference=1,20) than the post-test result (mean=148,57; sd=4,58), p<0,001, the highest heart rate frequency – the pre-test result (mean=180,13; sd=6,69) is statistically significant higher (mean difference=2,77) than the post-test result (mean=177,37; sd=5,97), p<0,001. As table 3 shows, the original training influenced

the following factors as well: lactic acid concentration before – the pre-test result (mean=3,83; sd=1,66) is statistically significantly lower (mean difference=-0,16) than the post-test result (mean=3,99; sd=1,61), p<0,001) and lactic acid concentration after – the pre-test result (mean=11,45; sd=2,04) is statistically significantly higher (mean difference=0,28) than the post-test result (mean=11,17; sd=2,00), t(29) =25,131; p<0,001.

	Pretest		Posttest		Student t-test (df=29)			
	mean	sd	mean	sd	Differences between measurements		t	p
					mean	sd		
Average heart rate frequency	**149,77**	**4,72**	**148,57**	**4,58**	**1,20**	**1,06**	**6,180**	**0,000**
The highest heart rate frequency	**180,13**	**6,69**	**177,37**	**5,97**	**2,77**	**1,55**	**9,798**	**0,000**

Table 2. The comparison of post- and pre-test measurements of Ju-Jitsu trainees with respect to physiological characteristics (average heart rate frequency, the highest heart rate frequency) – student t-test for dependent samples.

	Pretest		Posttest		Student t-test (df=29)			
	Mean	sd	Mean	śr.	sd		mean	p
					mean	sd		
Lactic acid concentration before	**3,83**	**1,66**	**3,99**	**1,61**	**-0,16**	**0,06**	**-15,099**	**0,000**
Lactic acid concentration after	**11,45**	**2,04**	**11,17**	**2,00**	**0,28**	**0,06**	**25,131**	**0,000**

Table 3. The comparison of post- and pre-test measurements of Ju-Jitsu trainees with respect to physiological characteristics (lactic acid concentration before and after) – student t-test for dependent samples.

As **figure 2** and **table 4** show, research results indicate a statistically significant influence of the experimental training on the number of performer throws in TSSR test, the post-test results (mean=24,14; sd=1,96) was statistically significantly higher than the pre-test results (mean=22,31; sd=2,44)(mean difference=-1,83)p<0,001. A change in the scope of index, calculated after the test finished, was also observed. The pre-test result (mean=15,14; sd=2,12) is statistically significantly higher (mean difference=1,21) than the post-test result (mean=13,93; sd=1,46), t(28) =6,810; p<0,001. Index reduction points to the positive influence of the training on the level of special physical fitness.

No statistically significant differences between the pre- and post-test results in *HRpo* results [t(28) =-1,696; p=0,101] and *Hr rest* [t(28) =0,239; p=0,813] have been observed.

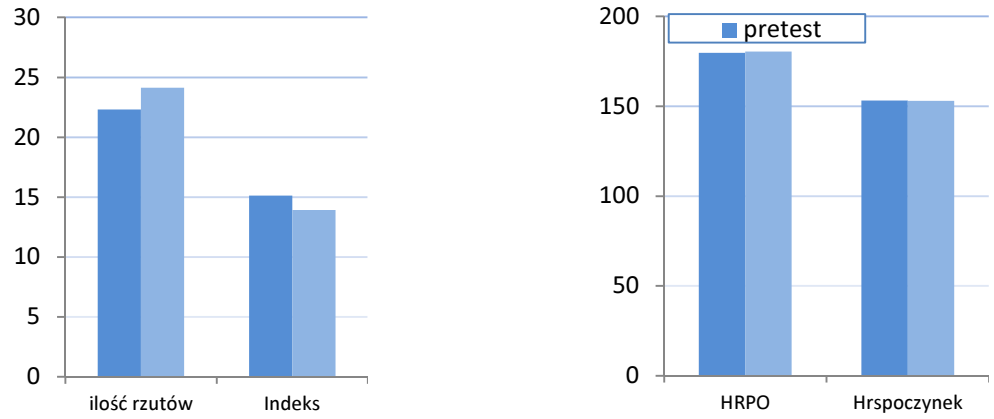

Fig. 2. Graphic presentation of average results of the examined group of *Ju-Jitsu* trainees – the specialized test (the number of throws, heart rate frequency after effort – Hr after, heart rate frequency in the resting phase – Hr rest, Index).

	Pretest		Posttest		Student t-test (df=28)			
	mean	sd	mean	sd	Differences between measurements		t	p
					mean	sd		
The number of throws	**22,31**	**2,44**	**24,14**	**1,96**	**-1,83**	**1,26**	**-7,839**	**0,000**
Hr after	**179,79**	**5,76**	**180,48**	**5,02**	**-0,69**	**2,19**	**-1,696**	**0,101**
Hr rest	**153,10**	**6,87**	**153,00**	**6,51**	**0,10**	**2,34**	**0,239**	**0,813**
Index	**15,14**	**2,12**	**13,93**	**1,46**	**1,21**	**0,96**	**6,810**	**0,000**

Table 4. The comparison of pre- and post-test measurements of Ju-Jitsu trainees with respect the result of the specialized test (the number of throws, Hr after, Hr rest; Index). Student t-test for dependent samples.

RESULTS SUMMARY AND DISCUSSION

In the course of the project, by means of *Polar* sport-testers and *Lactate Scout* lactometer, an attempt was made to evaluate the influence of the experimental training unit on the organism of jui-jitsu trainnes. Heart rate frequency and lactic acid blood concentration were measured. Average heart rate frequency oscillated at the level of 75-85% HR_{max}, which would make effort in experimental training in the group of mixed strain between anaerobic threshold (AT) and the uncompensated metabolic acidosis threshold (TDMA) (Cempla and Mleczko 1989). Such range is considered to be the most optimal in body adaptation to intensive effort (Pate and Branch 1992). The highest value of heart rate frequency among trainees in the experimental training groups in the course of exercises feel within the range of 85-95% HR_{max}, which suggests that effort made in the course of the experimental training counts as submaximal. Wołkow (1972) notices that such kind of effort is also related to the highest values of oxygen consumption. Given substrate oxidation processes that take place in such values, heart rate frequencies and the duration time of a training unit, the scope of intensity of the experimental training counts as mixed effort.

On the basis of the conducted research, Tabata et al. (1996) prove that training conducted at the moderate intensity level results only in improvement in aerobic performance. High intensity trainings, on the

other hand, influence the improvement in aerobic and anaerobic systems providing energy. Kruszewski et all. (2008), who investigated muscle strength development methods, compared the effects of the training conducted with the use of the modified method of isometric tension with lifting heavy weights training. After the completed 4 week experiment the author concludes that the absolute and relative strength development in the group using the lifting heavy weights training can be determined by a high intensity of training units.

In the third minute after the exercises in the experimental small circles, lactic acid blood concentration was measured with the use of specialist apparatus – *Lactate Scout.* The results obtained in each group were above 8 mmol·l- l^{-1}, and sometimes exceeded 10 mmol·l- l^{-1}. Hübner-Woźniak and Lutosławska (2000) classify training which ends in such a way as heavy, anaerobic effort. Roniker (1987) treats the obtained values of lactic acid concentration as the results of intensive interval work. The observed level of lactic acid may be a factor which facilitates an increase in anaerobic threshold level, especially if its concentration exceeds the results obtained so far. Kozłowski and Nazar (1983) highlight that the anaerobic threshold may be moved even in well-trained trainees. The continued training leads to the increase of VO_2 max, which results from the increase in effort tolerance in the direction of uncompensated metabolic acidosis threshold (TDMA).

The abovementioned results may be substantiated in the course of work-out and rest duration in the experimental circuit training. Active work-out in one of the small circuits was 150 seconds, which was followed by a 60 second break. The time interval: 150-180 seconds of interval, which is treated as shaping the capacity of lactic acid anaerobic metabolism and aerobic strength. In addition, the used break can be beneficial for training requiring the support of high work-out intensity (Gabryś 2000).

Effort made in the course of the experimental training seems to be adequate for the representatives of sports disciplines in which changeable effort is often subjected to sudden fluctuation. In the course of fight heart rate frequency reaches up to 200 beats per minute. The performed work interrupted in 3 to 1 ration (activity to rest ration) may result in the increase of lactic acid concentration even to 16 mmol/l (Keul 1969, Nikiforow i Wiktorow 1974). When analyzing the physiological reaction of body to a boxing fight stimulated on a punch bag, he stated that immediately after four two-minute rounds lactic acid concentration on average amounted to 13,6 mmol·l^{-1} and heart rate frequency reached the highest value of approximately 192 beats/minute. The results of the conducted analysis enabled the author to state that amateur boxers should be able to tolerate high lactic acid concentration amounting to even 14-15 mmol·l^{-1}.

Even in case of mixed fights, including *Ju-Jitsu*, where the fight might take place on the feet (with the use of inter alia boxing techniques) or take the form of ground fighting – *ran dori,* the intensity may vary. Sterkowicz determines the intensity of *Ju-Jitsu* training units in the range from 150-180 heart beats per minute, where the threshold of 180 heart beats may be exceeded several times in the course of doing exercises (Sterkowicz 1998). The analysis of training fights conducted by Ambroży (2008) has shown that confrontation on the feet is related to average heart rate frequency of 166 beats/minute, and lactic acid concentration after such type of fights amounts to 9,6 mmol·l^{-1}. A three minute ground fighting has resulted in an increase in heart rate frequency to 183 beats/minute. Lactic acid concentration, on the other hand, has reached approximately 11,2 mmol·l^{-1}. In order to check the influence of the experimental training on the participants'

special physical fitness a specialized TSSR test has been used. It has to be mentioned that the aim of the targeted circuit of the training programme was to strengthen and activate muscle groups directly engaged in movement tasks of the specialization.

After participating in the TSSR test, *Ju-Jitsu* trainees performed a greater number of *ippon-seoi-nage* throws than before the circuit training. The improvement in results obtained in the test after the stage of experimental training can be a proof of a more effective muscle work of a trainee, engaged in the performance of the throw technique, as well as more dexterous movement on the mat (moving between two *uke*). Blais et al. (2007) highlight that strength training, targeted by a suitable selection of exercises, should reflect a trainee's movement on the mat. Moreover, used training stimulus have to correspond to time characteristics of the fight and required muscle endurance. Fulfilling these requirements should lead to a noticeable improvement in the physical targeted fitness of trainees. This thesis is supported by methodological assumptions of development of a circle of targeted exercises in the experimental training. The idea of selected exercises in this set was to engage muscle groups that are used in sports competition. When analyzing the TSSR test results, we need to make a reference to research by Blaise et al. as well. The authors made an evaluation of main moments of strength in the course of doing *morote seoi-nage* throw in particular joints. The results have shown that lower rather than upper limbs generate strength. The following distribution of powers influencing particular joints has been observed: knee joint 24%, hip joint 29%, torso 29% (Blais et al. 2007).

In the divison of judo techniques *morote seoi nage* and *ippon seoi nage* are included in the group of grips – *Te Waza* (Witkowski et al. 2009). Despite such classification, there is a high probability of a similar engagement of lower limb in the trainee who performs a throw.

In the proposed experimental training each of small circuits – strength, targeted and fitness circuit – is devoid of isolated exercises and engages the whole body in a multifaceted work-out, especially torso and lower limbs. The improvement which was observed after the experiment as a result of a greater number of throws can be directly linked to such a selection of exercises. At the same time *Ju-Jitsu* trainees observed an increase in strength, which may be the reason for performing a greater number of throws.

As literature shows, trainees having a greater level of muscle strength are more effective when performing a task because of a greater movement economy. This leads to an increase in endurance capacity of a trainee in the course of a specific effort (Wisløff and Helgerud 1998, Millet et al. 2002). Observations of heart rate frequency in the course of the specialized test as well as at rest before and after the experimental training programme displayed similar characteristics. According to the author of the test, professor Sterkowicz (1995), one of signs of the improvement in specialist endurance in the test is among other things an increase in the number of throws in particular periods, but also a decrease in heart rate values with a subsequent improvement in the number of throws. Such an opinion is supported by other researchers (Franchini et al. 1999).

In the group that participated in the experimental training, despite the fact that a decrease in post-workout heart rate frequency has not been observed, performing a greater number of throws at the same heart rate may be indicative of facilitation of function of the circulatory system at the time of specialized effort. Kemi et al. (2011) have proven than a dynamic strength training can improve the economy of movement, which results in the intensity up to 30% and raise in the aerobic limit to 21%.

CONCLUSION

1. The proposed training programme proceeds at a high level of intensity, which resembles start activity (which is indicated by the heart rate frequency measurement and lactic acid blood concentration) and may be used in ju-jistu training.
2. The experimental training programme has exerted positive influence on the special physical fitness of participants' with respect to the number of movements made, which can affect their effectiveness in fight.
3. The proposed training programme may be implemented as strength training in ju-jitsu training in the preparatory period. The positive effects presented in TSSR test after the period of small circles may be indicative of the effectiveness of the used training form and methodological assumptions of its implementation.

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