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Effect of five-week preparatory training period on aerobic and anaerobic performance of male judo athletes

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Summary

Introduction. The physiological demands of a judo match strain both anaerobic and aerobic systems. The purpose of the present study was to examine the effect of five weeks of training during a preparatory period on anaerobic and aerobic performance of well trained male judokas.

Material and methods. The subject of the present study were nine male judo athletes, members of a collegiate team. Before and after five-week training, all participants performed a graded exercise test on the treadmill for the determination of anaerobic threshold and the 30 s Wingate test for lower body. After each workload, the capillary blood from finger tips was taken for lactate determination during incremental exercise and 5, 7, 9, 11, 13, and 30 minutes after cessation of the 30 s Wingate test.

Results. Five-week training period resulted in statistically significant increase of velocity at anaerobic threshold (V_{AT}), determined in a graded exercise test. The peak power, in terms of relative (W/kg) values, measured in the Wingate test for lower body, was similar before and after the five-week training period, however the relative mean power was significantly higher after this training period finished. The blood lactate concentration, 30 minutes after cessation of the Wingate test, was significantly lower after the five weeks of training in comparison with the values before training.

Conclusions. The obtained data shows that the five-week preparatory training period resulted in the increase of aerobic fitness of male judo athletes. The results of the current study in well trained male judokas may provide useful information for coaches and trainers in optimizing training programs.

Introduction

The physiological demands of a judo match strain both anaerobic and aerobic systems [1,2]. Judo is a combat sport characterized by sudden, explosive attacks and counterattacks, which are executed repeatedly for a duration of up to 8 minutes, depending on the scores obtained by the contestants [3,4]. Judo matches consist of brief repeated bouts of supramaximal and maximal intensity, and the majority of energy required for this type of exercise is provided through anaerobic alactic system and glycogenolysis ending in lactate formation [5]. On the other hand, the maintenance of the intermittent work performed during the match, as well as the recovery process during the short intervals between matches, are mainly supported by aerobic metabolism [6]. Degoutte et al. [7] established that a judo match led to a rise in levels of plasma free fatty acids, despite a high concentration of lactate (12.3 mmol/l), therefore it appears that muscle glycogen is not the only substrate used during such effort. From a metabolic point of view, judo is considered to be a mixed, aerobic and anaerobic sport [8]. Thus, the judo athletes must achieve a high level of physical fitness and condition to be successful in international competitions [3].

Preparatory training periods are held to improve athlete's performance, especially aerobic capacity, and consist not only of common activities for strength, power, and endurance but are also supplemented by sport-specific exercises with technical and tactical elements [9].

The purpose of the present study was to examine the effect of five weeks of training in a preparatory period on anaerobic and aerobic performance of well trained male judokas.

Material and methods

The subject of the present study were nine male judo athletes, members of a collegiate team, who volunteered for the study. A detailed description of the study as well as an explanation of the risks and benefits of participation was provided; all subjects were familiar with the exercise protocol, were fully informed about multiple capillary blood sampling, and all gave

Table 1. Physical characteristics of judokas before and after five-week training (mean ± SD)

Variable	Before five-week training	After five-week training
Age (years)	22.7 ± 2.5	
Body mass (kg)	85.7 ± 4.7	85.3 ± 4.4
Body height (cm)	176.7 ± 5.4	
BMI	27.4 ± 4.9	27.3 ± 4.7
Fat free mass (FFM, kg)	71.7 ± 4.5	72.6 ± 4.0
Fat content (%)	14.6 ± 3.6	14.2 ± 3.3
Training experience (years)	13.3 ± 3.4	

Table 2. Five-week training characteristics

Training	Phase 1	Phase 2
Time (weeks)	2	3
Total duration of training (h)	60	45
Low intensity (HR < 150 beats/min)		
hours	21	9
%	35	20
Moderate intensity (HR – 151-170 beats/min)		
hours	18	13.5
%	30	30
High intensity (HR > 170 beats/min)		
hours	21	22.5
%	35	50

their written consent, in accordance with and with prior approval of the Ethics Committee of the University of Physical Education, in compliance with the Helsinki Declaration. Their physical characteristics are given in Table 1.

The athletes reported to the laboratory in the morning, after a standardized breakfast consumed 2 hours before the start of exercise. Initially, the height and body mass of subjects were measured using standard techniques, then the percentage of body fat was estimated using the method given by Durnin et al. [10], by measuring the skinfold thickness at the biceps, triceps, suprailiac, and subscapular sites with a Harpender caliper. Two measurements were made at each site and the mean was used for the assessment of the percentage of body fat. The measurements were taken on the left site of the body with the subjects in standing position.

Training in the preparatory period lasted for five weeks and it was divided into two phases, which differed in volume and intensity of exercises (Table 2). This training period included low intensity exercises (continuous runs, tactical and technical skills, *uchi-komi* in place, *jaku-soku-geiko* in motion, and strength training), moderate intensity exercises (runs and forced marches in mountains, tactical and technical skills with set pace, *uchi-komi*, *randori,* and *sute-geiko*), and high intensity exercises (sprint runs – 60, 100 and 300 m, sparring fights, circuit training, and *uchi-komi*). Levels of exercise intensity were based on the heart rate reaction [9].

Before and after five-week training, all participants performed a graded exercise test on the treadmill (Saturn, H-P-Cosmos, Germany) for the determination of anaerobic threshold and the 30 s Wingate test. Velocity of the treadmill started at 8 km/h. The running velocity was increased every 3 minutes by 2 km/h at 0 degrees incline until the athlete reached volitional exhaustion. At the end of every workload, the capillary blood was taken from the finger tip to measure the lactate (LA) concentration. The anaerobic threshold (AT) is defined as the running velocity associated with 4 mmol/l blood lactate concentration during incremental exercise test [11]. The heart rate was monitored throughout the exercise duration using a polar telemetric monitor (Polar Vantage NV, Finland).

The Wingate test was performed after standardized warm-up (5 minutes leg cycling at a self-directed pace against zero resistance). On verbal command, the athletes started the exercise. Leg cycling was performed using a mechanically-braked Monark 834 ergometer (Sweden), with the resistance of 7.5% of body mass. The total number of revolutions performed during the 30 s interval and the single revolution time were measured using an electromagnetic gauge, and the power was calculated using a computerized MCE system, version 4.5 (Poland). The peak power (P_{max}) was computed from the highest power output registered during a 0.01 s interval and the mean power (P_{mean}) was defined as the average power generated during the 30 s interval. The capillary blood from finger tips was taken for lactate determination after each workload during incremental exercise and 5, 7, 9, 11, 13, and 30 minutes after cessation of the 30 s Wingate test. The lactate concentration was assessed using a Dr Lange analyser calibrated with 4 and 10 mmol/l lactate standard solutions.

Data were reported as mean values and standard deviation (x ± SD), and conventional descriptive statistical methods were used. Normal distribution was analyzed using the Shapiro-Wilk test. The significance of differences between particular pairs of means was estimated using the two-way variance analysis ANOVA and Tuckey's post hoc test. the significant levels were established at $p<0.05$.

Results

The data in Table 3 show that the five-week training period resulted in statistically significant increase in velocity at the anaerobic threshold (V_{AT}) determined in a graded exercise test, while the anaerobic threshold heart rates (HR_{AT}) were similar before and after training.

Table 3. Velocity and heart rate at the anaerobic threshold before and after five-week training (mean ± SD)

Variable	Before five-week training	After five-week training
V_{AT} (km/h)	10.6 ± 1.7	12.2 ± 1.0*
HR_{AT} (beats/min)	163.3 ± 17.0	168.8 ± 12.5

* Significantly higher compared with data before training (p<0.05)

Table 4. The peak and mean power in 30 s leg cycling, and the blood lactate concentration during 30 min recovery before and after five-week training (mean ± SD)

Variable	Before five-week training	After five-week training
Power (W/kg)		
P_{max}	11.1 ± 1.5	11.2 ± 1.5
P_{mean}	8.2 ± 0.5	8.5 ± 0.7^{A}
LA (mmol/l) during recovery		
5’	10.9 ± 1.9^{B}	9.9 ± 2.2^{B}
7’	12.6 ± 2.1	11.5 ± 2.1
9’	13.0 ± 2.6	11.8 ± 3.0
11’	12.7 ± 2.8	11.4 ± 2.5
13’	12.0 ± 2.9^{B}	10.6 ± 2.4^{B}
30’	6.9 ± 2.6***	5.0 ± 1.1^{C,***}

^{A} Significantly higher compared with data before training (p<0.001)
^{B} Significantly lower compared with 7, 9, and 11 min of recovery (p<0.01)
^{C} Significantly lower compared with data before training (p<0.05)
*** Significantly lower compared with 5, 7, 9, 11, and 13 min of recovery (p<0.001)

The peak power, in terms of relative (W/kg) values, measured in the Wingate test for lower body was similar before and after five-week training, however the relative mean power was significantly higher after this training period finished (Table 4). As follows from the current study, the blood lactate concentration 30 minutes after cessation of the Wingate test was significantly lower after five-week training in comparison with values before this training period. The maximal blood lactate concentration, both before and after training, was reached at nine minutes after completion of the 30 s exercise test, but there were no significant differences between these values.

Discussion

This study examined changes in anaerobic and aerobic performance of well trained male judo athletes during the five-week preparatory period, in order to acquire knowledge about their adaptation to training. However, test protocols (graded exercise, Wingate test) do not reflect exactly the intermittent character of a judo match.

It is well known that judo athletes with low fat percent demonstrate higher performance [12,13]. Callister et al. [14] reported that more successful male athletes had lower body fat than non-successful ones. As seen in Table 1, the body fat percentage of judo contestants before and after five-week training was 14.6% and 14.2%, respectively, and it was similar to the level determined by Koral et al. [15] in national and international judo athletes (13.7%), but higher than in high level Canadian senior judokas (10.4%) [16], and lower than in Italian senior judo contestants (17.4%) [17].

It was established that the anaerobic threshold (AT) is a better index of aerobic work capacity than the maximal oxygen uptake (VO_2max), especially in well trained athletes [18]. In the present study, velocity at AT both before (10.6 km/h) and after five-week training (12.2 km/h) was similar or higher compared with data reported by other authors [3, 6]. Franchini et al. [19], when studying elite judo athletes, determined that the threshold velocity was 10.8 km/h. There is no available data showing how the threshold velocity of male judo athletes changed in effect of training during the preparatory period. As showed by data obtained in the current study, five-week training resulted in the increase of aerobic capacity, which means that it caused adaptive changes facilitating better oxygen utilization in re-synthesis processes ATP.

Kim et al.[2] established that in South Korean male judokas from the national team the peak and mean power of legs in the Wingate test was 14.7 and 8.8 W/kg, respectively. A lower peak power (12.4 W/kg) was achieved by male judokas from Polish national team [5] and Italian male athletes (12.4 W/kg) [21]. Zupan et al. [22], studying 457 athletes in sports which require short bursts of peak power and a high anaerobic capacity during competition, proposed a classification of peak and mean power based on the Wingate test. According to this classification, the competitors in the current study are in the below average category (10.96-11.64 W/kg) for the peak power, and in the average category for the mean power (8.02-8.90 W/kg).

It is well known, that the lactate accumulation is associated with a performance decrease, and hence lactate removal after high intensity effort seems to be important for improving the subsequent performance [23]. Judo athletes must frequently compete in several combats on the same day, so the athlete who is able to remove the lactate faster will begin the next match with a greater chance to reach high performance [23]. A judo match induces high blood lactate accumulation, indicating imbalance between lactate production and its removal and utilization [24]. It is believed that training elicits an increase of the lactate transport from muscles to blood and its utilization from blood, mainly through its oxidation in muscles [25]. As follows from the current study, the blood lactate concentration after cessation of the 30 s Wingate test was significantly higher after 30 min recovery before five-week training than at the end of this period. This suggest that, with better aerobic fitness, judo athletes recovery from high intensity exercise was enhanced through improved lactate removal [26].

Conclusions

1. The obtained data showed that five-week training in the preparatory period, divided in two phases differing in volume and intensity of exercise, resulted in the increase of aerobic fitness of male judo athletes. This is in accordance with theoretical foundations of training, which assume that a preparatory period develops a high level of physical conditioning to facilitate future training.
2. The results of current study of well trained male judokas may provide useful information for coaches and trainers in optimizing training programs.

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