Effect of physical endurance on fighting and the level of sports performance in junior judokas

Authors' Contribution:
A Study Design
B Data Collection
C Statistical Analysis
D Manuscript Preparation
E Funds Collection

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Source of support: Departmental sources

Received: 12 October 2009; **Accepted:** 5 December 2009; **Published online:** 21 January 2010

Abstract

Background and Study Aim: This study attempted to produce answer to the question: Is physical endurance in judo contestant at junior age related to the adopted fighting strategy and the level of sports performance?

Material/Methods: The study covered 10 judo contestants from three clubs in Poland. First stage encompassed registration of their competitive activity level. On the basis of this record, contestant's fighting activity, efficiency and level of performance was assessed. Another stage of the investigations focused of evaluation of their aerobic and anaerobic endurance on the basis of testing methods used in the Institute for Human Physiology in the University School of Physical Education in Cracow. The strength of the relationship was concluded based on the value of Spearman's rank correlation coefficient.

Results: As was observed on the basis of statistical analysis, level of anaerobic endurance shows strong relationship with the method of fighting observed among young judokas. Time to reach maximal power seems to be of particular importance. Its value correlated with efficiency of contestants' actions taken during second phase of fight and with the level of sports achievement.

Conclusions: The results of the present study should be taken into consideration by judo club coaches during planning and implementation of training schedules among young contestants.

Key words: judo • VO_2max • maximal anaerobic power

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Background

Judo – a martial art which originates in Japan. Throws and grappling to immobilize opponents are allowed during fight.

According to some physiologists, physical endurance is 'an ability of human body to perform specific physical activities, expressed in the level of maximal effort and efficient course of recovery process' [1].

Its best indicator is level of sports achievements during competitions [2]. This view seems to be legitimate only in sports without a complex structure of movements, e.g. cycling, cross-country skiing or running. In this disciplines of sports, physical endurance is a key factor which determines sports achievements. However, it remains unclear if this is the case in martial arts (e.g. **judo**, wrestling), where level of sports achievement observed in a contestant (besides specific profile of their psychical abilities) is a resultant of a bigger number of factors, which include, first of all, technical skills, motor abilities (strength, speed and endurance) and tactical skills, being primary in relation to these components [3].

A starting point for preparation of the strategy of recruitment, selection and training of candidates for professional sportsmen in a particular discipline of sport should be preceded by determination of 'master model'. In practice, this means pointing to optimal level of all dominat-

ing components of a competitive sportsman, conditioning the success in the sport. Higher level of sports rivalry should typically correspond to more detailed models and greater amount of information. Opinions of sport theoreticians on importance of physical endurance in judo contestants are divided. Adoption of individual indexes of physical endurance as model values, without previous determination of their relationship with the course and scores in sports fight is insufficient. This opinion is supported by previous results of the investigations, achieved by the authors of this study, carried out among a group of senior contestants [4]. The investigations revealed that efficiency of effort-related mechanism of oxygen uptake, expressed in relative values of **VO_2max**, was one of main factors which determine efficient judo fighting. Determination of the effect of these factors on junior judokas' performance might considerably contribute to efficient optimization of training process.

VO_2max – maximal oxygen volume, which can be taken by the body within one minute of maximal physical exertion

Overriding aim of this study was to provide answers to the following questions:

1. Is there any correlation between aerobic and anaerobic endurance and effectiveness of actions taken by the competitors?
2. Is there any correlation between aerobic and anaerobic endurance and sport results achieved during junior-level competitions?

Material and Methods

The study covered 10 judokas from weight divisions under 73 kg (n=3), under 81 kg (n=2), under 90 kg (n=2) and under 100 kg (n=3), from four clubs: Wisla Cracow (n=3), MOSiR Bochnia (n=3), Czarni Bytom (n=2) and Sokol Myslenice (n=2). Each of the studied contestants has already won at least fifth place in national junior and older junior championships. In order to select objects to the studied group, chronological age and competition experience was also taken into consideration.

During selection matches before Junior Poland Cup (Bytom, 29.09.2007) and Junior Poland Cup (Warsaw, 20.10.2007), tournament matches were registered (n=58). During analysis of matches, technical actions of individual contestants were recorded (analysis of selection matches encompasses only those with contestants who were qualified for central competition). The considered elements also included decisions made by the judges and referees and the part of a match where technical action was performed. Competition was divided into two parts: phase I – first two minutes of the match, phase II – third and fourth minutes. If extra time was used, it was included in second part of the match.

Analysis also encompassed ineffective actions, which were not given points by the judges. This concerned situations when a contestant considerably threw his opponent out of balance ('flying phase' was observed). These actions were assigned 0 note. In total, 137 technical actions were recorded. On the basis of the collected data, indexes which determine activity and effectiveness of actions among the study participants were calculated. Activity index (WA) was calculated from the formula: **WA=ΣA/NW**, where: ΣA is a total of the attacks, NW – number of matches the contestant fought. Activity index calculated for phase 1 was **WA1**, with **WA2** for phase 2. Another index, **RWA** (difference for the activity index), was implemented to reflect variability of activity during competition. It was calculated as: **WA=WA1-WA2**. Effectiveness index (WS) expressed an arithmetic mean of scores for attacks (**WS1** as calculated for phase 1 of the match and **WS2** for the second phase). Difference in efficiency index was calculated from the formula: **RWS=WS1-WS2**.

Level of sports achievement was a total of scores won by the contestants during both tournaments, according to the following point scale:

- for selection matches: 1st: 1st place – 3 points, 2nd place – 2 points, 3rd place – 1 point, 5th place – 0.5 points;
- for central competition: 1st place – 7 points, 2nd – 5 points, 3rd – 3.5 points, 5th – 1.5 points, and 7th – 0.5 points.

During another stage of the investigations, the indexes which determine aerobic and anaerobic endurance were measured. The tests were performed in an air-conditioned room in the Department of Physiology and Biochemistry at the University School of Physical Education in Cracow on 27th October 2007.

The program involved e.g. biometric measurements (BH – body height, BM – body mass) and structural body measures (LBM – lean body mass, FM – fat mass, PF – percentage fat content) and physiological tests (measurement of indexes which determine aerobic and anaerobic endurance in contestants).

In order to evaluate anaerobic endurance, Wingate test was employed [5]. Choosing this test was entirely deliberate as it is highly specific test which allows for assessment of anaerobic endurance. This is because share of anaerobic energy processes in overall effort reaches nearly 90% in judokas. Main exercise was preceded with 5-minute warm-up using bicycle ergometer with individually selected intensity of 50% VO_2max with pedaling rate of 60 rpm, three 5-second maximal accelerations at 2nd, 4th and 5th minute. Two minutes after the warm-up, participants performed 30-second maximal

Table 1. Statistical characteristics of chronological age and experience and basic parameters of somatic built among the study participants (n=10).

	Mean	Minimum	Maximum
Age (years)	17.5	16.0	18.0
Competitive experience (years)	8.4	7.0	11.0
Body height (cm)	180.4	173.0	186.0
Body weight (kg)	85.8	72.0	101.2
Lean body mass (LBM)	72.1	64.4	79.0

Table 2. Characteristics of indexes of activity, efficiency and the level of achievements for the study participants (n=10).

	Mean	Minimum	Maximum
WA	2.1	1.0	3.5
WA1	1.0	0.3	2.0
WA2	1.6	0.7	2.2
RWA	–0.5	–1.7	0.5
WS	3.4	2.4	6.8
WS1	4.0	2.2	7.0
WS2	3.2	0.8	6.8
RWS	0.8	-3.2	6.3
PO	3.3	1.0	6.0

physical exercise. The objective for a studied person was that they would achieve, as soon as possible, maximal rhythm of pedaling and maintain it as long as possible. External resistance of pedaling was selected individually and amounted to 8.3% of body weight. During the test, computer was employed to evaluate mean power (MP), total work (TW) **maximal anaerobic power**, 'power drop index' (WSM), time to reach maximal anaerobic power (TO MAP) and time to maintain maximal anaerobic power (TU MAP).

Maximal minute oxygen intake was assessed by means of indirect methods. Graded exercise test on bicycle ergometer was preceded by three-minute warm-up with intensity of 110 W and frequency of pedaling (RPM) of 60 rpm, after which, every 2 minutes, power was incremented with 20W. The exercise was performed until the tested person was not able to maintain the rhythm signaled by the metronome. The following parameters were measured during the test: duration of exercise (DE), minute ventilation (V_E), respiratory quotient (RQ), frequency of respiration (FR), tidal volume (TV), minute oxygen intake (VO_2) and heart rate (HR). Duration time for graded exercise test (DE) and VO_2max were treated as indexes of current and potential endurance capacity of the body. Before the test, and 3 minutes after completion of the test, blood tests from earlobe were taken, which was used to determine lactic acid (La) concentration by means of enzymatic methods. For physiological tests, fully professional measurement apparatus was used, being an equipment owned by the certified laboratory in the Department of Physiology and Biochemistry at the University School of Physical Education in Cracow. Table 1 presents characteristics of age, experience and fundamental parameters of somatic built among the study participants.

During analysis of the results, STATISTICA package software was employed. For statistical analysis, Spearman rank correlation coefficient (Rs) was used [6].

Maximal anaerobic power – maximal power generated by the body during anaerobic test.

Results

As results from the analysis of the data contained in Table 2, contestants performed 2.1 technical actions per match on average, with the dispersion of this index from 1.0 to 3.5. In first phase of the fight, average activity of attacks (WA1) amounted to 1.0 actions per match while individual results ranged between –1.7 and 0.5, whereas mean value amounted to 0.5. Effectiveness index (WS) during fight amounted, on the average, 3.5 points per technical action and ranged from 2.4 to 6.8 points. For first two minutes of the fight and two lasts (with extra time) amounted to 4.0 and 3.2 points respectively. Difference in efficiency index (RWS) adopted values from 3.2 to 3.9, with mean value of 0.8.

Index determining level of achievement (PO) showed values from 1.0 to 6.0, with its mean value being 3.3 points.

Table 3. Indexes of anaerobic endurance in contestants (n=10).

	Mean	Minimum	Maximum
TW (J·kg^{-1})	268.3	265.0	273.0
MAP (W·kg^{-1})	11.3	10.2	12.3
WSM (W·kg·s^{-1})	0.2	0.1	0.3
TOMAP (s)	3.5	2.1	4.4
TUMAP (s)	3.6	2.5	4.9
LA 3 min po WANT(mmol·l^{-1})	13.5	11.3	15.1
Δ LA 3min po WANT(mmol·l^{-1})	11.5	9.7	13.0

Table 4. Indexes determined during graded exercise test (n=10).

	Mean	Minimum	Maximum
VO_2max	40.6	32.2	46.8
HRmax	189.6	181.0	204.0
HR_{TDMA}	164.7	151.0	173.0
%HRmax	86.9	83.4	90.5
%VO_2max	71.0	59.5	82.6
Δ LA	9.8	7.9	11.4

Table 5. Statistically significant correlation between the values of indexes which determine fighting methods combined with the level of achievement and the values of indexes which determine their physical endurance.

Correlated indexes	n	Rs	t(N-2)	Level
WS2 & TOMAP	10	–0.814	–3.972	0.004
RWS & TOMAP	10	0.684	2.658	0.028
PO & TOMAP	10	–0.725	–2.982	0.017
WS1 & HRmax	10	–0.723	–2.968	0.017
WS2 & %HRmax	10	–0.790	–3.647	0.006
WS2 & Δ LA	10	0.644	2.383	0.044

Total work in Wingate test (Table 3), being 268.3 J·kg^{-1} on the average, showed rather a small width of range for individual results of this index (from 265.0 to 273.0 J·kg^{-1}). Maximal anaerobic power (MAP), being, in relative approach, at the level of 11.3 W·kg^{-1}, was characterized by higher dispersion, from 10.2 to 12.3 Wkg^{-1}. Power drop index showed values from 0.1 to 0.3 W·kg^{-1}·s^{-1}, with the mean value 0.2 W·kg^{-1}·s^{-1}.

Mean value of time to reach (TOMAP) and maintain (TUMAP) maximal anaerobic power amounted to 3.5 and 3.6 s, respectively, with the minimal and maximal values being respectively: TOMAP – 2.1 and 4.4 s, TUMAP – 2.5 and 4.9 s.

After anaerobic test, lactic acid concentration in blood amounted, on the average, to 13.5 mmol·l^{-1}. Individual results of La, ranging among the contestants from 11.3 to 15.1 mmol·l^{-1}, might point to a difference in tolerance to homeostasis disturbances. Rise in this index amounted to 11.5 mmol·l^{-1}.

Average level of maximal minute oxygen uptake (VO_2max) amounted to 40.6 ml·kg^{-1}·min^{-1}. Its individual levels, ranging from 32.2 to 46.6 ml·kg^{-1}·min^{-1}, point to huge differentiation of potential aerobic exercise capacity in the studied persons (Table 4). Average level of maximal heart rate (HRmax) 189.6 bpm (181 to 204 bpm) proves that all the persons performed the graded exercise at actually maximal body exertion. At the threshold of decompensated metabolic acidosis, heart rate (HR_{TDMA}) amounted, on the average, 164.7 bpm (od 151 do 173 bpm), which comprised 86.9% of the maximal heart rate (%HRmax). Test exertion caused increment of lactic acid concentration (Δ LA) by 9.8 mmol·l^{-1} on the average (7.9–11.4 mmol·l^{-1}).

The indexes which determine fighting methods and the level of achievements correlated with indexes which determine anaerobic endurance in the contestants (Table 5). Very high negative correlation (0.7≤Rs>0.9) was observed between the time to reach maximal anaerobic power (TOMAP) and:

- effectiveness index in second phase of match (WS2) and
- level of achievement (PO).

Furthermore, a high positive correlation (0.5≤Rs>0.7) between TOMAP and the difference in efficiency index (RWS) was found.

Statistically significant relationships in the group of indexes which determine aerobic endurance was found between (Table 5):

- efficiency index in first phase of match (WS1) and maximal heart rate (HRmax) (very high negative correlation),
- efficiency index in second phase of match (WS2) and percentage of maximal heart rate at the threshold of decompensated metabolic acidosis (%HRmax) (very high negative correlation),
- WS2 and increment of lactic acid concentration (Δ LA) (high positive correlation).

Discussion

Model of competition [7,8] and physical endurance in judo contestants of senior category [9–11] have frequently been a subject of scientific research. It was proved that, during tournament matches for professional contestants, exertion of high intensity, based on phosphagen and glycolytic anaerobic transitions. However, it remains unclear if, during this type of effort in junior judokas, similar metabolic pathways are induced. In consideration of the fact that young sportsmen aged 17–19 are a direct base for national senior team and that this period provides another important stage in development of professional competitors, it was legitimate to carry out the investigations which would provide all the necessary information. In juniors, effective match time, being 4 minutes, is much shorter than in seniors (5 minutes). In this context, it can be supposed that the level of indexes determining aerobic endurance might be lower in younger competitors as compared to senior contestants. Values of VO_2max, being 40.6 $ml \cdot kg^{-1} \cdot min^{-1}$ in juniors did not, however, differ from the level of this index in seniors (40.8 $ml \cdot kg^{-1} \cdot min^{-1}$) investigated by Lech et al. [4]. However, considerable intergroup differences were found for heart rate at the threshold of decompensated metabolic acidosis (HR_{TDMA}). In juniors, average values of HR_{TDMA} (164.7 bpm) were considerably higher than in seniors (149.1 bpm). Lower values of HR_{TDMA} in seniors prove higher aerobic reserves and higher ability to work under conditions of oxygen deficiency. This finding can be confirmed by other distinct differences in the level of maximal anaerobic power (MAP), which is the index of phosphagen component of physical endurance of the body. In seniors, average results for MAP amounted to 12.2 $W \cdot kg^{-1}$ [4], whereas in younger contestants, this value was only 11.3 $W \cdot kg^{-1}$. Good expression of anaerobic source glycolytic capacity and power as well as body tolerance to acidification is the level of blood lactate (LA) after maximal exertion. In juniors, this value amounted to 13.5 $mmol \cdot l^{-1}$ and was by 3.35 $mmol \cdot l^{-1}$ lower than in seniors (15.6 $mmol \cdot l^{-1}$) studied by Lech et al. [4]. In snowboard and downhill skiers from Polish national team, high LA concentrations in blood after maximal exertion were also observed (14.46 $mmol \cdot l^{-1}$ and 17.81 $mmol \cdot l^{-1}$), which points to high share of glycolytic anaerobic transitions in sport exertion [12].

Significant relationship to the method of fighting among young judokas is proved by linear correlation between indexes which determine the method of fighting and indexes of anaerobic component of physical endurance. Time to reach maximal anaerobic power, treated by some authors as an index of starting speed, is of particular importance [13]. The lower the time to reach maximal anaerobic power, the higher efficiency of actions taken by the contestants, particularly in the second part of the match. It is remarkable that this index correlated considerably to the level of sport achievement. Its diagnostic importance is also proved by the results of similar studies for the group of juniors with more differentiated level of sports performance (regional competition matches were analyzed) and body mass (all weight categories were included) [14]. It was found that shorter time to reach maximal anaerobic power and lower value of power drop index corresponded to greater fighting activity of contestants.

High negative correlation between WS1 and HRmax observed in young judokas might point to the fact that the contestants who were characterized by higher exertion-related cardiovascular endurance showed better efficiency in first part of fight.

Moreover, as it was observed during the present investigations, efficiency of actions in fighting contestants is connected with high level of glycolytic anaerobic transitions (anaerobic endurance). This might be proved by very strong positive correlation between the increment of lactic acid concentration (ΔLA) and efficiency of actions in the second phase of the match and also, indirectly, high negative correlation between effectiveness of actions among contestants and percentage value of

maximal heart rate at the threshold of anaerobic transitions. As it was found in previously cited studies of senior judokas [8], decrease in HR value and%HRmax at the level of decompensated metabolic acidosis related to rise in activity in first three minutes of the fight. However, VO_2max was negatively correlated to the decline in activity during fight.

On the basis of the investigations, it is remarkable that aerobic capacity (VO_2max) in junior judokas does not have any significant relationship to activity and efficiency of actions during fight. This is likely to be caused by shorter, as compared to juniors, duration time for matches.

The results of the present study should be considered by club trainers during planning and realization of training among young contestants.

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