The effect on 4-month judo training period on anaerobic capacity, blood lactate changes during the post Wingate test recovery, and resting plasma cortisol, and testosterone levels in male senior judokas

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Summary

Introduction. Wingate test is a standardized laboratory effort, which is commonly used for examination of anaerobic capacity. The biomechanical parameters of work and power recorded during the test is combined frequently with blood lactate (LA) determination throughout post-test recovery. The objectives of this experiment was to examine an effect of 4-month training period on anaerobic capacity and LA response to the effort.

Material and methods. Eight Polish senior judokas were enrolled to the study. The examination was carried out twice, the first one after 1-month detraining period (January) and the second after 4-month training, prior to main competition (May). In both terms resting plasma cortisol (C) and testosterone (T) were determined, capillary blood was sampled for determination of lactate over post-Wingate (30s) passive recovery as follows: +1, +3, +5, +7, +9, +11 and +30 minutes. Biomechanical parameters were recorded online during the efforts.

Results. The training resulted a little, non significant (by 7%) improvement of biomechanical features. In both trials the shape of curve representing LA time course was almost the same and there were no term-related differences separately for each of the seven time points LA. However, when the aggregated data, i.e concurrently the all LA observations (2 terms*56 measurements), were taken into calculation, difference between two terms was significantly (p<0.02), lower in May. Mean T level was significantly higher in May.

Conclusions. In conclusion (i) the training period elicited an increase of contribution of aerobic energetic processes during Wingate test, (ii) aggregated results from multiple LA measurements gave better information about post-exercise lactic acidosis.

Introduction

The best way for rating of effectiveness of training period is the examination of a post training changes in physical fitness using standardized exercise test performed on ergometer, motorized treadmill or the others equipped with system for reliable determination of biomechanical parameters. For determination of anaerobic capacity, the most frequently utilized type of maximal bout performed by lower- (legs cycling), and upper body limbs (arms cranking) are Wingate tests lasting from 10 to 30 seconds. These exertions are of high diagnostic value, and their performance are related to the other physical abilities like maximal bench press, which performance level is related to a high extent with Wingate peak power [1].

During high intensity exertion predominant source of energy originates from anaerobic processes, that is confirmed by rise of blood lactate level (LA).

However, as has been shown, LA peak did not appeared directly after short anaerobic exertion. Studies on LA time course following judo match showed bi-phase changes (rise-drop), and that dynamics within the period from +1 to +15 minutes is the best fitted by an equation of the parabola [2], but for longer recovery period (0.5h) that way of approximation is not adequate. The LA behavior in blood were recorded after various supra-maximal exertions including classic Wingate (30s) test [3-11]. An alternative to parabola approximation non-linear curves was proposed by other authors. It is bi-exponential 3- or four-parameter functions describing the compartmental model.
of rate of appearance and disappearance LA in circulation [12-15]. The earliest simple formula demonstrating well compliance of calculated and observed results of LA after running with maximal speed on the distance of 100, 200, and 400m has been proposed by Fujitsuka et al. [16] as follows:

$$La(t) = A_i + K_1 t + A_d - K_2 t + La\ at\ rest,$$

where $A_i$ and $A_d$ are the components describing rates of increase and decrease of LA in blood respectively. The above LA behavior was in agreement with that observed at 1-minute intervals up to +7min of post-exercise recovery, and longer time intervals over the later recovery. Because of between-subject variations in the post-effort dynamic of LA, more informative data regarding lactic acidosis are provided by aggregated results, however, it needs more frequent blood sampling.

Beside of examination of LA responses to Wingate and on-line observations of several biomechanical parameters during the effort like maximal and mean power output, total work output, time to peak power, time to attain of maximal power, time to its sustain and so-called fatigue index calculated from power drop occurring during an exertion, in addition a diagnostic value have of plasma cortisol and testosterone levels at rest condition. From 1986 these hormones are the most frequent used parameters for examination of adaptation of exercise metabolism to increased physical activity in athletes [17-20].

The purpose of this study was to examination effects of long-term training period on anaerobic capacity, dynamic of lactate response to Wingate test and plasma resting hormonal status, cortisol (C) and testosterone (T) in male senior judokas.

### Material and methods

Eight Polish male senior judoists (international level) of various body weight category, excluding heavy weight category, were subjected to the study twice, after 1-month detraining period, in January, and subsequently after 4-month training period at the beginning of May. In both terms subjects performed Wingate test (30s) in laboratory of Department of Physiology with standardized and controlled environmental condition (ambient temperature and humidity). The same verbal encourage was provided be the same researcher in both terms. All the examinations were carried out forenoon, and in both terms the same resistance on a wheel of ergometer (breaking force was 0.075% of body mass) was set. The trial was preceded by the same anaerobic warm-up. Blood was sampled to a glass capillary tubes from earlobe at time points as follows: +1, +3, +5, +7, +9, +11 and +30 minute of post test recovery. Lactate levels (LA) were determined with use of DR LANGE kit (GERMANY) with assay precision of 6.8%. Resting (8:00 pm) plasma cortisol (C) and testosterone (T) were determined using the commercial kits (ELISA, DRG-GERMANY). Power output were recorded with frequency of 1000 Hz. Two-way analysis of variance with repeated measures (2 term x 7 measures with post-hoc Tukey test was used for comparison means of LA, and Wilcoxon test for comparison cortisol and testosterone in both examination. (STATISTICA version 10). The study was approved by the Ethical Commission at Institute of Sport.

### Results

There were significant differences in means LA levels recorded at the 7 time points in January and May. The shape of curves representing changes in LA during the recovery was similar in both terms. Instead of clear and significant mean peak LA from +5 to +11 minute of the recovery we observed the relative LA plateau covering the mentioned interval. Within that time mean LA levels did not change significantly, and each within-subject variation was very little, hence, it may be omitted. However, one can noted the slightly increased of LA from +5 min to +9 min, by 6.2% , and subsequently its decrease from +9 to +11min, by 5.6%. That change may point out 9th minute of recovery as the moment, when majority of individuals reached their maximum levels of LA. When comparing results from the same time point separately between two terms, there were no significant differences, but comparison for overall results (aggregated data: 8 subjects x 7 time points) revealed significant between-trial difference. Overall mean LA in January-MLAJ (n=56, 13.6±4.2 mmol/L) was significantly higher (p<0.02 F=3.47, df=104) than that in May-MLAM (n=56, 12.8±4.0 mmol/L). Surprisingly, that significantly lower lactic acidosis in May (by6.3%) occurred despite of somewhat higher (by 7%) relative mean work output on May-MWOM (268±10 kJ/kg) than mean work output on January-MWOJ (255±25 KJ/kg) and mean peak power (12.43±0.94 vs. 11.57±1.4 Watt/kg), however, that biomechanical improvement was not significant (p<0.07). Considering the new modified variable representing relative con-

<table>
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<th>+1min</th>
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<th>+5min</th>
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<tr>
<td>May n=8</td>
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<td>15.1±2</td>
<td>15.7±2</td>
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<td>Total n=16</td>
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<td>6.0±0</td>
<td>3.62(105)</td>
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*AD - mean values significantly differ (p<0.05) from the all others

F-value of the F-function, df=degree of freedom

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Table 1 Blood lactate levels (mmol/L) determined at 7 time points of post Wingate recovery at the beginning of retraining (January) and after 5-month period of physical exercises, prior to main competition.
distribution of aerobic processes and expressed as mean work output/mean LA ratio (kJ/mmol/L), we found: in January MWOJ/MLAM (255/ 13.6=18.8) the lower value than that in May MWOM/MLAM (268/ 12.8=20.9). The hormonal analysis showed non-significant (p=0.208) higher mean C level in May compared to its value in January (503±95 nmol/L vs 456±58 nmol/L). Mean T level was significantly (p=0.030) higher in May (25.1±3.1 nmol/L) than in January (22.0±3.5 nmol/L).

**Discussion**

The main finding of this study is that mean LA exhibited almost steady state within the time interval 5th-11th minute of post Wingate test. Obviously, as regards to other anaerobic efforts continuous or non continuous, a proper time of maximal blood lactate and its value depend on their intensity, duration and modality, as was shown in earlier studies [2,21]. It is worth to note, that in comparative studies on Wingate performance and anaerobic capacity, standardized protocol of examination play an important role in reliable and correct interpretation of the results. When designing studies on differen days, the authors have to remember that: there is time-of-day effect of daytime on Wingate performance which is paralleled to circadian rhythm of body temperature [2,22]. Finally, the similar environmental conditions (ambient temperature and humidity) are recommended, that needs a room equipped with air-condition, however, that is demanded rather during longer exercise-tests. As to blood analysis of any parameters including LA levels, it is important to establish the levels of between- and within errors, to differentiate the recorded between-trial variations derived both from an assay errors and the physiological fluctuations of the parameter. In addition, some authors recommend estimation of post exercise plasma volume shift, when examined blood indices demonstrate relative low change. In these cases “corrected” results of examined parameters allow for proper interpretation of recorded results. However, single Wingate test causes mean decrease of plasma volume by 17.4±2.6% [24]. Considering that post Wingate LA levels are 10-15-fold higher than those at rest, hence, the effect of plasma changes may be omitted.

In comparative exercise studies resistance established on a wheel of cyclo-ergometer also should not be differ across trials, since at same power output the lower resistance brings about higher cadence, and that in turn may induce stronger lactate response to an exertion with lower mechanical efficiency, as was reported by Ferguson [25]. The protocol of our experiment met all those criteria, therefore, the results are reliable. As to between trial changes in biomechanical measures and mean value by subject and sampling (7 x 8) it was shown slight improvement in total work output and maximal power output at somewhat lower LA in May. More distinct differences appear when we compare the indexes calculated as ratio of mean absolute power output to mean LA. In January and May those indexes were as follows 18.75 and 20.94 Watt/mmol/L. We may speculate that that improvements may be caused by higher contribution in aerobic processes during Wingate test in May, probably due to increases in general aerobic capacity, or the other factors like increase of mechanical efficiency. Unfortunately, lack of VO2max determination cannot support any thesis. It is known, however, that aerobic metabolism contribute in a various extent to anaerobic exertion. Beneke and co-worker [26] found that energy for Wingate test derive from mixed metabolic sources, aerobic (18.6%), anaerobic alactic (31.1%) and lactic glycolysis (50.3%). Moreover, athletes of higher aerobic capacity, like middle distance runners demonstrate lower then sprinters lactate during Wingate test [27]. Interestingly, aerobic contribution to Wingate test performance increases from morning to evening together with body temperature and mechanical efficiency at the same lactate levels [28]. Based on above we may speculate, that including measurements of fast-component of post-Wingate VO2 and calculation of anaerobic energy from net lactate appearance provide information on post-training changes in aerobic capacity.

In our study examined athletes demonstrated relatively very low improvement of power output after training period (by 7%). That low post training changes in anaerobic capacity is in agreement with results of the previous study conducted on elite male fencers examined also twice (Wingate 10s) before and after training period [29]. Since so, one may put the question, what is the sense to undertake such type of trainings which do not bring expected beneficial effects? We may speculate, that elite athletes, who reached previously very high level of physical fitness cannot improve their abilities markedly. In such cases any changes in fitness is related to the initial, pre-training state, and training period is utilized only to sustain that, what have been already achieved. Anaerobic capacity seems to be a factor playing role in general fitness in successful judo players. That assumption is supported by the facts, that examined by us judo players demonstrated an international level of judo skills, their mean peak power that was comparable with that demonstrated by Italian Olympic judo players (12.1±2.4 W/kg) [30]. Also Brazilian international judo medalists performed better in repeated Wingate tests then those athletes of lower competitive levels [31]. Likewise, among Polish male wrestlers, group of medalists demonstrated significantly higher legs and arms anaerobic power together with higher aerobic capacity in comparison with the values recorded in the group of less successful counterparts [32]. Obviously, the higher technical skill expressed as a greater number of throwing techniques with various directions of attacks provides greater number of spectacular wins [33].

As the study on the reproducibility (test-retest procedure) of some variables like peak LA, mean power output, peak power output, heart rate and plasma volume shift showed an excellent repeatability [34,35], all the differences recorded by us between the 1st and the 2nd examination should be ex-
plained as an effect of 4-month training period. Hence, significantly lower lactic acidosis after training period at the similar total work output after training period may suggest higher contribution to anaerobic metabolism as a source of energy. The question whether the 4-month training period resulted in improvement of general aerobic capacity (higher VO\textsubscript{max}) and its higher contribution to lowered post Wingate lactate is to be determined in a further studies. The above supposition is supported by the study that revealed association between aerobic capacity and type of training judo [36,37].

Based on obtained results and the opinion by Favier [38] we may assume that beneficial effects of 4-month training period involving endurance exercises, expressed itself as with a little bit reduced lactate production during anaerobic exercise and/or somewhat better its removal and improved performance of Wingate test. Hence, standardized laboratory anaerobic bouts with blood LA assessment throughout 30 min post test recovery seems to be is useful tool for evaluation of effectiveness of training period. However, it is worth to note some limitations of described procedure. As was shown significant effect of impact of training period on lower lactate response to Wingate appeared only then, when the aggregated data (i.e. the area under curve) from post-exertion recovery have been taken into account, while there were no between-trial differences at any time points separately. Interestingly, more expressive relationship, higher correlations, has been found between aggregated data of various unstable variables has been shown by other authors, who examined concurrently hormonal and psychological parameters [39,40]. That requires, however, several blood sampling over studying period when one wants to reveal more subtle changes in the post training adaptation. Another limitation is ignoring in our study such important factors as unknown but important post Wingate drop of total blood volumes, that could be various during the first and second examination. Moreover, strongly between-subject diversified post-Wingate plasma volume shifts and their time-dependent values have been reported by Zouhal [41], who found almost 20% decrease of plasma volume in exercising sprinters. The highest hemoconcentration was found directly after the test, and was normalizing across the recovery period. Thus, it seems to be more correctly to take into account amount of circulating lactate as a marker of its production, instead of its concentration.

Resting hormonal study showed little rise of C, but significantly elevation of T in plasma. These results are contradictory to those reported by Garatachea [42], who found lack of change in T but elevation of C. The above may be elucidated by various psycho-physical load preceded the examination Polish and Hispanic judoists. In our study judo players were in phase of taper period prior to the second examination, thus, they were able to normalize their hormones, while the Hispanic contestants were studied over competitive period, and being under repeated stress conditions showed higher level of their stress-related hormone.

Conclusions

1. 4-month training period resulted in slightly higher biomechanical abilities examined with Wingate test and significantly lower post Wingate lactic acidosis, that may be elucidated by a higher contribution of aerobic metabolism after training period. Between-examination difference in LA, however, was able to elicit only due to multiple blood sampling throughout post Wingate recovery.

2. 4-month training period resulted in resting plasma non significant increase of cortisol and significant increase of testosterone.

References


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