

Anaerobic capacities and blood lactate responses to wingate tests in male greco-roman wrestlers

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Summary

Introduction. This study aimed to compare LA peak magnitude and its time of appearance after 30s Wingate test performed by arms and legs in elite Polish male wrestlers.

Material and methods. 13 male senior wrestles of Greco-Roman style performed 30s Wingate tests by arms and legs on two successive days in a randomized order. Capillary blood was sampled from earlobe at 8 time points (T): after warm-up (0 min) and then after the tests at +3, +7, +9, +11, +13 and +30 minute. Blood specimens were analyzed for lactate levels. The obtained data were analyzed using two-way ANOVA (limb*time point). Mean and individual functions $LA=f(T)$ were determined, and times of LA peaks were identified solving the equations $d f(T)/dT = 0$

Result. Legs showed significantly higher mean relative peak power output (11.87 ± 0.92 Watt/kg) and work output (263.67 ± 17.48 J/kg) than arms, 9.13 ± 0.64 Watt/kg, 216.70 ± 13.41 J/kg. For both tests on the interval [0, +13 min] the functions of LA(T) were represented by the parabolas, while on the interval [+13, +30 min] by the linear regressions. Mean LA peak appeared itself near +9min after Wingate tests, but individual LA peaks were varied and ranged from +7.3 to +11.8min.

Conclusions. During short term post arm-crank and leg-cycle Wingate recoveries changes in LA were represented by U-converted curves with their maximal values appeared near +9 min. Mean power output and work output were higher for the test of legs. and lactic acidosis is higher after higher muscle masses i.e legs, involved in the maximal effort.

Introduction

Wingate tests are the most frequently exercise tests used to evaluate their anaerobic capacity in relation to the metabolic changes, sexes, tested extremities and training status. Short tests durations (10-30 sec), pre test warm-up and loud verbal encouragement from a researcher ensure, that examined individuals do not use pacing strategy but engage their maximal physical abilities from the start to the end of the effort. An advanced technology of power measurements online with very high frequency (1000 Hz) allow to explore various internal and external circumstances affecting levels of the performance parameters, like power output, work output and accumulating fatigue during the test, that expresses itself as decrease of the power, especially at the end of an exertion. Peak power (PP) recorded during Wingate tests showed diagnostic value for predicting of strength, power levels and performances of other exertions. Changes in PP levels induced by period of strength and power ballistic exercises were related to performance of the other tests like high jumps and shot put throws [1]. It was found, that PP during bench throw ex-

plained 87% and 72% of the variances in arm crank Wingate peak power in men and woman respectively [2]. Another variable recorded during Wingate, which diagnostic value seems to be not appreciated is a time to PP attain (TA). When starting an anaerobic exercise test, an examined individual has to overcome not only braking force but also wheel inertia, thus, maximal rate of revolutions he/she usually achieves at 2-4 seconds after the start. Obviously, the higher rate of force development, the shorter the TA, and this relationship explains, why rate of force development (so called explosive strength) affects performance of the various athletic exertions for instance a high jump [3].

As the completing of the Wingate test engages anaerobic sources of energy, we may observe high rise of lactate level in blood after termination of that type of effort. Generally, the higher the LA the more intensive the effort. The main issue of the study on a post effort acidosis is to find the time point, when LA reaches its peak. The behaviours of LA responses to short-lasting anaerobic efforts have been often studied in athletes. It was shown that immediately after a judo struggle lasting from 2 to 5 minutes LA peak appears at the time from

+5.7 to +7.7 min and the time of peak depends on struggle duration [4]. Markedly more delayed LA peak, at near +9 min was found after completing of more intensive and continuous efforts [5]. The above mentioned studies used the equation of a parabola, which well represents the behaviour of LA during post-effort recovery. The other authors used various bi-exponential functions, which represent a rate of LA disappearance from blood. A magnitude of this process is the resultant value between rate of LA flow from muscles to blood and rate of LA elimination from blood.

The researcher analyzed the lactate disappearance starting directly after termination of the test and ending short term recovery lasting 30 minutes. These studies, in which blood was sampled very frequent, revealed that after both efforts, leg cycle or arm crank Wingate test LA showed biphasic changes, the rise to the maximal values and next almost linear rate of decrease up to +30 minute of the recovery [6-9]. The mentioned studies omitted the issue whether magnitudes of peak lactate and power output generating by exercising limbs are linked to the time of peak LA.

This study was undertaken to examine biomechanical parameters of arms and legs performing 30s Wingate tests and the behaviour of LA following completing these two efforts in the same group of wrestler players.

Material and methods

The group (n=13) of senior male wrestlers practising Greco-Roman style were subjected to the study for examination of anaerobic capacity of upper and lower body extremities and determination of blood lactate changes during post test recovery. Their body mass ranged from 57 to 120 kg and age from 23 to 28 y. Wingate tests, arms cranking and legs cycling were undertaken forenoon in a randomized order on two successive days. Cycling was performed against resistance of 7.5% of body mass on Monark 824E bicycle ergometer. Cranking test was performed at standing position against 5.5% of body mass with the use of cycle ergometer adapted for arm cranking. The efforts were preceded by a standardized 5-minute warm-up with 60rpm and low breaking force. A verbal encouragement was provided during the tests by the

same researcher. Capillary blood was sampled after warm-up and then at seven time points of post-test recovery, +3, +5, +7, +9, +11, +13 min and +30min. Blood lactate level was determined with the use of LANGE kit (GERMANY). The obtained data were analyzed using two-way ANOVA (test*time). Using the first derivatives of the functions given by the LA (time) curves, the times of LA peaks and its magnitudes were calculated. This study was approved by the Ethical Commission at Institute of Sport.

Results

Means and SD values of LA recorded after warm up and at 7 time points after arm cranking and leg cycling tests of are displayed in Table 1. Table 2 showed the differences for LA during Wingate tests between time points and limbs. Figures 1 and 2 present the graphs of LA curves for the time interval from 0 min to +13min.

We assumed that shape of the curve representing changes in LA on the entire time interval [0, +30 min] is consisted from two functions $LA = f(T)$. Hence, it was assumed that LA(T) curve will be the best represented by a spline function consisted of parabola on the interval [0, +13 min], and linear regression on the interval [+13, +30 min] respectively. The graphs of LA(T) curves on the interval [0,+13 min] were presented in Figure 1 and 2 for arm cranking and leg cycling respectively.

Analysis of the variance showed significantly higher LA levels for leg cycle Wingate test when the data comprised all eight time points of blood sampling (n= 13*8 measurements). However, comparison of the data obtained from the time points separately (n=13 pairs of the observations, there were no significant LA differences between the exercising limbs. To locate maximum value of the function LA(T) i.e. peak of LA on the interval [0 - +13 min], the derivative of that function was used to solve the following general equation: $d LA(T)/dT = 0$, hence, the specific equations for LA after leg-cycle and arm-crank Wingate tests take the form: $2.763-0.1539*T=0$ and $2.699-0.1493*T=0$ respectively. The calculations revealed mean LA peak at + 9.04 min after completion of arms-cranking test, while after the leg-cycling test LA peak appeared itself at

Table 1. Descriptive statistics for the changes in LA in mmol/L following arm cranking and leg cycling Wingate tests in male Greco-Roman wrestlers

Situations	Day 1	Day 2
VE-HGS	51.3±6.0	52.8±6.1
No-HGS	52.1±5.6	53.4±5.0

Table 2. Results of statistical analysis (two-way ANOVA) for post Wingate LA changes in 13 male wrestlers

Source of variance	F-value	p-value	η^2
VE	0.220	0.642	0.005
Day	0.742	0.394	0.017
VE*Day	0.004	0.952	0.000

+8.98 min. At these points mean maximal LA levels reached the values of 14.51 and 15.02 mmol/L after arms and legs tests respectively, and that difference was not significant. The same procedure was used to find time points for individual LA peaks and the magnitudes of LA peaks. For both types of the

tests the majority of individual LA peaks were near +9.00 min, but some (n=3) of them appeared at near +7 min and the other (n=2) at near +11 min. In Figures 1 and 2 we can see huge between-subject differences in LA at various time points, but the individual LA peaks appeared at almost the same moment.

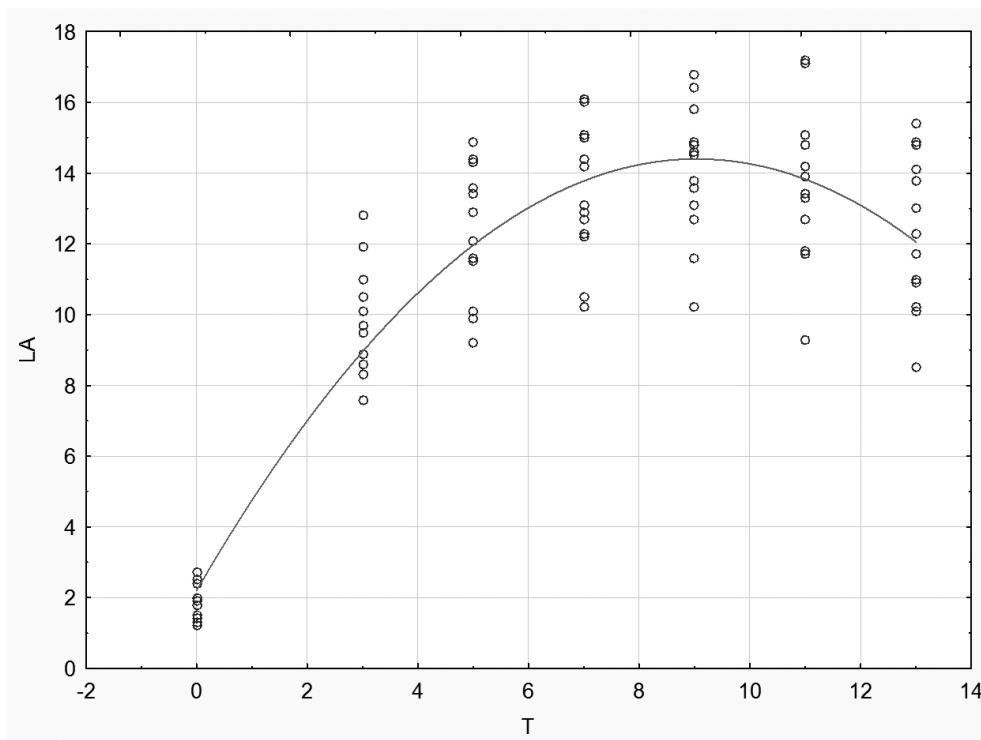


Figure 1. The graph of LA(T) function on the interval [0, +13 min] after post crank-arm test. Parabola: $LA=2.2033+2.699T-0.1493T^2$

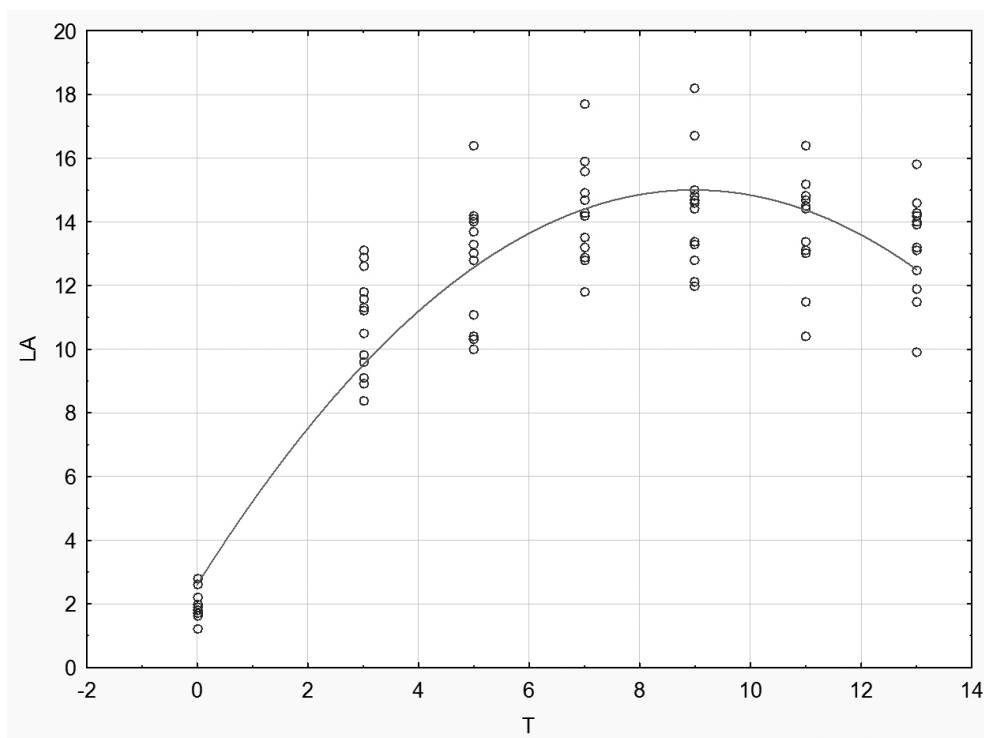


Figure 2. The Graph of LA(T) on the interval [0,+13 min] after post leg-cycle test. Parabola: $LA=2.6069+2.763T-0.1539T^2$

LA values recorded at two time points, +13 and +30min were used for determination of a linear regression, being the second part of the spline functions. For arm cranking and leg cycling these regressions are given by the following equations: $LA(T)=16.891-0.3485*T$ and $LA(T)=17.149-0.3511*T$. It should be noticed, that these functions showed average pattern of LA behavior. In fact, as mentioned, individual maximal LA appeared at various time points, from +7 min to +11min, and individual maximal LA varied from 10.8 to 16.2 mmol/L after arm cranking and from 12.6 to 17.2 mmol/L after leg cycling.

There were significant differences in biomechanical properties of legs and arms. During leg cycle Wingate test mean peak power output was 11.87 ± 0.92 Watt/kg, work output was 263.67 ± 17.48 J/kg and these values were significantly higher than those during arm cranking Wingate (9.13 ± 0.64 Watt/kg, 216.70 ± 13.41 J/kg). During arm cranking mean time to PP attain (TA) was 2.50 ± 1.62 s, mean time sustain of maximal power (TS) was 2.20 ± 1.60 s. For legs cycling these parameters were as follows: TA= 2.63 ± 1.73 and TS= 2.94 ± 1.91 s.

Discussion

Many of the earlier studies of physical fitness revealed that elite athletes show higher strength and power than those non-elite ones. The same rule applies to wrestling [10,11]. It is worth to note, that comparing the mean results of the studies on anaerobic power or explosive strength parameters reported by the researchers, it should be taken into consideration various circumstances affecting performance of these trials such as daytime of the examination [12-14] or type pre-test warm-up [15-17]. Moreover, some authors expressed the results adjusted to total body mass, the others, to free fat mass only, therefore, we decided to compile the results peaks power of arms as percentage of those recorded for legs cycling. Analysis of peak power output in athletes of different body mass showed, that body mass is the main determinant of absolute power, therefore, rating of anaerobic capacity in a such group should be allometrically scaled to BM or even to free fat mass when analysing differences between sexes [18]. In Greco-Roman wrestlers absolute peak power during arm-crank Wingate test as well as isometric grip force increase with body mass, from light to heavy weight category but the differences disappeared when biomechanical parameters were adjusted to body mass [19].

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The results of our study are in agreement with the others, which showed that in male wrestlers, regardless the practising style, biomechanical possibilities of legs were higher than those of arms. Study by Horswill et al [20] revealed relative PP in arm crank W-test amounting 73% of that reached during leg cycling. Somewhat higher the percentage of PP in male wrestlers was reported by Hubner-Woźniak et al, 84.2% and 84.8% when peaks of power were adjusted to whole body mass and free fat mass respectively [21]. Surprisingly different results were found by Demirkan E et al who examined PP for arms and legs in both wrestling styles [22]. In that study Greco-Roman wrestlers had significantly higher mean relative PP for arms as compared to that value in Free-style athletes, while PP for legs were almost the same. If that phenomenon would be confirmed in large samples of the similar skill level athletes one may suggest higher engagements of upper limbs during Greco-Roman wrestling struggles.

In our study arms-to-legs ratio of anaerobic performance (0.77) was similar to the results reported by Demirkan E [22]. As to magnitude of peak LA, our results of the both tests were higher than those showed by López-Gullon [19]. The main important finding of our study is that LA peak appeared near nine minutes after termination of both Wingate tests. Moreover, the time of its appearance suggests lack of marked effect of body mass or magnitude of LA peak. That allows to establish the one standardized time point for blood sampling to determine maximal LA.

Conclusions

1. Dynamics of LA during 0.5h post Wingate recovery may be approximated the best by a spline function, within the time interval from 0 to +13 min by a parabola and within the interval from +13 to +30 min by a linear regression respectively.
2. Integrated data for LA over the entire recovery period (n=104) showed higher acidosis after leg cycling, but there were no differences between limbs noted at any time points taken separately.
3. Mean maximal LA after tests performed by legs and arms appears near 9 minutes after completing of the efforts. All individual LA peaks were included in the interval [+7min, +11 min].
4. The magnitudes of biomechanical variables, power and work output were significantly higher for lower extremities.

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