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Physiological predictors to lactate dynamics during a wrestling match

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Abstract

Background & Study Aim: Exercise testing is a gold standard in physiological assessment of an athletes. Previous research showed that in match physiology may play decisive role in wrestling. However there is no relation between results obtained in laboratory testing and real in match physiology. The objective of the present study was knowledge about the relationship of physiological variables measured during a laboratory exercise testing as a set of predictors of lactate levels during a wrestling match.

Material & Methods: Twelve elite level wrestles, completed a treadmill VO_{2max} exercise testing and simulated match. Blood lactates were measured before each bout and at the end of the simulated match. Using stepwise multiple regression the best set of predictors were obtained for each lactate measurement.

Results: The result indicated that the strongest predictor for lactate after all three bouts was VO_{2max} (β = –1.05, –0,81, –0,83, respectively). Respiratory frequency (Rf) had an increasing effect on lactates (β = 0.40, 0.91, 0.83) where effect of tidal volume (Tv) presented only in second and third bout (β = 0.65, 0.44 respectively).

Conclusions: The VO_{2max}, maximal respiratory frequency and tidal volume are key indicator in physiology and lactate dynamics of a wrestling match thus our findings change physiological approach to interpretation of exercise testing in wrestlers and its utilization in wrestling and similar anaerobic sports.

Key words: combat sport • respiratory frequency • tidal volume • VO_{2max} • ventilation

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Tidal volume – the volume of air that is inspired or expired in a single breath during regular breathing.

Respiratory frequency – the number of breaths per minute.

Ventilatory threshold – point during exercise training at which pulmonary ventilation becomes disproportionately high with respect to oxygen consumption; believed to reflect onset of anaerobic metabolism.

INTRODUCTION

During a wrestling match, wrestler utilizes both aerobic and anaerobic energy pathways to a various degree. Match consists of brief repeated bouts of high intensity characterized by repeated sudden, explosive attacks and counterattacks. While short, quick bursts of maximal power mostly utilize anaerobic energy pathways, the energy released from ATP-PCr and anaerobic glycolysis cannot last longer than 2 minutes or one wrestling bout. Lactate concentrations in athletes during intense training or competition have been used for assessing level of acidosis and muscle fatigue. Even though in the recent review of acidosis, Robergs [1] shows that there is no biochemical support for lactate production causing acidosis, increased lactate production remains a good indirect marker for cell metabolic conditions that induce metabolic acidosis [2]. High blood lactate concentrations, well above the steady state indicate that without continuous increase in blood lactate concentration, level of activity is unsustainable that in return forces the athlete to lower his physical activity. Several studies [3, 4] showed that lower lactate levels after intense workout or a match are good indirect indicator of higher athletes' proficiency.

Although the regulation of acid-base balance involves chemical buffers, kidney function and pulmonary ventilation, respiratory system plays a crucial role in rapid adjustment during and immediately after the exercise, therefore it is expected that ventilation will influence ability of a wrestler to compensate acidosis and thus tolerate higher lactate levels during a wrestling match.

Aerobic capacity is defined as a maximal oxygen uptake (or VO_{2max}) and it is regarded as the best single measurement of cardiorespiratory endurance [5]. Aerobic capacities of 50 to over 70 ml/kg/min have been observed in elite wrestlers [6]. These findings suggest that aerobic capacity plays a very important role during wrestling match.

Other studies show importance of aerobic or anaerobic capacity of wrestlers comparing them to endurance runners [6] or sprinters [7] but complete study of aerobic capacity and in match lactates has not yet been researched.

The objective of the present study was knowledge about the relationship of physiological variables measured during a laboratory exercise testing as a set of predictors of lactate levels during a wrestling match.

MATERIAL AND METHODS

Participants

Study was conducted on 12 elite level wrestles, members of Croatian national team. Six of those were medallist in either of Mediterranean, European and World championships during the period of 2006 to 2009. Descriptive data collected include age, body height, body mass, body mass index and years of training are given in Table 1. Each wrestler was introduced with the experimental procedure and they all gave informed consent to participate in the study. The study protocol was in accordance with the ethical standards and therefore was approved by research ethics comity of the Centre for sport medicine and rehabilitation “Diomed”, Split, Croatia. All procedures followed in this study were in accordance with the Helsinki Declaration of 1975, as revised in 2008.

Experimental design

Testing protocol consisted of control fights held according to international wrestling rules of World wrestling federation FILA in training camp in Split and laboratory testing conducted in Exercise testing laboratory of Diomed, Split, Croatia. Tests were conducted at the approximately same time of day with a day rest between them.

Control fights consisted of three 2 minutes bouts, with 30 seconds break between each round. The warm-up protocol conducted in controlled conditions consisted of 5 minute jogging at the constant heart rate between 60% and 70% of the expected maximum for the lifespan, followed by passive and dynamic 5 minutes stretching depending subject’s method of preparation, and active 2 to 3 minutes rest. In our testing, the fight was continued till the end of the round, differently from FILA rules where the winner of the round is proclaimed based on technical superiority (6-point advantage) or win by fall (after pin). The fight always lasted full three rounds even if the wrestler won in two rounds. Fights took place between wrestlers of same level and weight category. Blood samples were collected each time from a different finger at four intervals: before each bout and at the end of the match. Lactate concentrations were determined immediately after blood sample collection, using Accutrend Lactate Analyzer [8] (ROCHE, Germany).

Procedures and data analysis

Maximal exercise test was conducted in accordance with the guidelines issued by AHA [9, 10]. The participant was asked to run on the treadmill at starting speed of 6 km/h, 2% incline for 2 min, thereafter,

Table 1. Descriptive characteristics of wrestlers (n = 12).

Variables	Wrestlers (means, SD)
Age (years)	20.2 ±1.87
Body height (cm)	178.2 ±12.51
Body mass (kg)	78.7 ±11.86
BMI (kg/m^2)	25.34 ±3.27
Training experience (years)	10.5 ±1.9

Table 2. Blood lactate characteristics and lactate kinetics indicators during wrestling match.

Variables	Wrestlers (n = 12)
Lactate before fight (mmol/l)	2.68 ±0.59
Lactate after 1st bout (mmol/l)	**7.98** ±1.66 *
Lactate after 2nd bout (mmol/l)	**12.23** ±2.35 **
Lactate end of the fight (mmol/l)	12.95 ± 2.19

Values are mean ±SD; repeated measures ANOVA and LSD post hoc test were used to determine significant differences of match lactate concentrations of wrestlers;

* p<0.001 and significantly different between lactate before fight and lactate after 1st bout; ** p<0.001 and significantly different between lactate after 1st bout and lactate after 2nd bout.

the workload progressively increased in 1- minute stages by 1 km/h until volitional exhaustion. The subjects were encouraged to continue running to their personal maximum unless they experienced any exceptional symptoms (chest pain, dizziness, severe breathlessness, musculoskeletal pain). Gas exchange and heart rate were recorded continuously. The gas analysis system has been calibrated before each test. Expired gases were sampled breath-by-breath and measured using computerized respiratory gas analyser (Cosmed PFT4ergo, Italy). Ventilatory threshold was determined using a computerized V-slope method [11]. Blood sample was collected immediately before and after the test, lactate concentrations were determined using Accutrend Lactate Analyzer (ROCHE, Germany).

Statistical analysis

Kolmogorov-Smirnov statistic was used to quantifies empirical distribution function between our data collection indicators. Statistical method repeated measures ANOVA and LSD post hoc test, were used to determine lactate concentrations differences among wrestlers. Stepwise multiple regressions were used to determine key physiological variables: the oxygen uptake (VO_2), oxygen uptake body mass-normalized ($VO_{2(norm)}$); ventilation (VE); tidal volume (Tv) and respiratory frequency (Rf) measured at rest, point of ventilatory threshold (VT), point of maximum oxygen uptake (Max) during exercise. This tests were significant predictors of in match lactates.

All results were expressed as mean (±SD), Statistical significance was considered to be indicated at the 5% critical level (p<0.05) for all the analysis.

RESULTS

Blood lactate during a match

Mean values of blood lactate concentrations after the warm-up and after each bout are shown in Table 2. As expected lactates after the warm up were slightly higher than normal resting values (2.68 ± 0.59 mmol/l). Significant increase in lactates was after the first and second bout (7.98 ± 1.66 mmol/l and 12.23 ± 2.35 mmol/l respectively). Though highest lactate levels were after the third bout (12.95 ± 2.19 mmol/l), no significant increase was found.

Cardiorespiratory responses during treadmill exercise testing

During exercise testing VO_2, $VO_{2(norm)}$, VE, Tv, Rf and HR were recorded at three key points: rest, VT and Max as shown in Table 3. Intriguingly although VO_{2max} and $VO_{2(norm)max}$ are very similar in the group, breathing patterns differ in much greater percentage.

Using stepwise multiple regressions the best set of predictors from variables recorded at key points were obtained for each lactate measurement and shown in Table 4. There are no significant predictor variables for the lactate concentrations after the warm up. After the first bout lactates are highly determined (R^2=0.73, p<0.01) by VO_{2max} (β=–1.05; p<0.05) and Rf_{max} (β=0.4; p<0.05), while after the second bout lactate are even better determined (R^2=0.9; p<0.001) by VO_{2max} (β=–0.81; p<0.001), Rf_{max} (β=0.91; p<0.001) and Tv_{max} (β=0.65; p<0.05). Third bout measurement lactate levels show the best model that almost completely determines the in match lactate dynamics (R^2=0.92; p<0.001) with highest influence of VO_{2max} (β=–1.05; p<0.05) and Rf_{max} and lesser influence of Tv_{max} (β=0.44; p<0.05). Variables at VT showed no significant influence as predictors on resting or in match lactates.

DISCUSSION

this study determines relationship of key physiological variables measured during an exercise testing as a set of predictors of lactate levels during a wrestling match. Although many studies suggest influence of laboratory measured maximal oxygen uptake on athletes lactate levels and influence of breathing patterns on aerobic and anaerobic sports, no direct correlation was determined. Our results suggest that VO_{2max} obtained during laboratory exercise testing has the greatest influence on lactate levels during all bouts while "breathing patterns" have growing influence through the match.

Previous research has shown a significant influence of VT on endurance and energy expenditure in athletes [12, 13]. The higher VT the higher intensity workload is needed to induce rapid blood lactate accumulation so it would be expected that variables measured at VT have influence on lactates during a wrestling match. In this study no correlation between variables at VT and lactate levels during the match was found. The latter has support in similar research in boxing [14] where authors found that in the beginning of the match primary energy source is anaerobic glycolysis with workload well above VT, and as the match progresses the energy obtained by aerobic energy pathways increase. Furthermore previous research [3] found that in elite wrestlers' anaerobic glycolysis and PCr are primary energy source in first two bouts where after the second bout primary source becomes aerobically produced energy. As the lactates have significant increase in the first and second bout workload is much higher than of steady state so influence of VT on total lactate production can be neglected. Considering there is no significant increase in third bout lactates no VT influence on lactates can be found.

Resting lactates have no significant predictor which is expected as warm-up protocol included 5 minutes of personalized active and dynamic stretching.

The strongest predictor for lactate after all bouts was VO_{2max}. Regression coefficient is negative after all tree bouts. The influence of VO_{2max} is the highest after the first bout (β = –1.05) and diminishes in the second and third bout (β = –0.81, –0.83, respectively). Although other research shows that first bout is mainly anaerobic strong effect of VO_{2max} on lactate

Table 3. Wrestlers cardiorespiratory responses during treadmill exercise testing.

Variables	Rest	VT	max
VO_2 (l/min)	0.69 ± 0.25	3.06 ± 0.45	4.22 ± 0.43
$VO_{2(norm)}$ (ml/kg/min)	8.64 ± 2.40	37.63 ± 5.51	53.58 ± 4.75
VE (l/min)	19.17 ± 5.40	68.65 ± 9.37	121.40 ± 19.29
Rf (beets/min)	20.62 ± 2.93	35.87 ± 6.47	51.82 ± 8.72
Tv (l)	0.93 ± 0.21	1.94 ± 0.40	2.34 ± 0.46
HR (beets/min)	87.60 ± 6.86	155.60 ± 3.86	182.30 ± 7.93

Values are mean ± SD; VT-ventilatory treshold; max-point of maximal oxygen uptake

Table 4. Stepwise multiple regressions for best set of predictors in match lactates.

Variables	Lactate 1 B	Lactate 2 β	Lactate 3 β	Lactate 4 β
VO_{2max}	-	–1.05 *	–0.81 ***	–0.83 ***
Rf_{max}	-	0.40 *	0.91 ***	0.75 ***
Tv_{max}	-	-	0.65 *	0.44 *
R	-	0.89 **	0.96 ***	0.97 ***
R^2	-	0.73 **	0.90 ***	0.92 ***

R-multiple correlation coefficient; R^2-adjusted coefficient of determination;

β-regression coefficient; * p<0.05; **p<0.01; *** p<0.001

levels suggest that either the higher the maximum oxygen consumption the lesser need is for anaerobic glycolysis or that ability to utilize more oxygen results in faster lactate oxidation to pyruvate or conversion to glucose via gluconeogenesis.

Although one could expect that body mass-normalized $VO_{2(norm)max}$ would be a better predictor that VO_{2max}, the lack of correlation has support in the fact that blood lactate levels are dynamical process of creation, accumulation and lactate oxidation. Normalizing VO_2 to body mass includes tissues that do not play the role in this process and as such are useless in lactate level assessment therefore render variable useless.

Inspiratory muscle fatigue may play a major role in limiting athletes performance [15, 16] Higher respiratory frequency followed by increase in tidal volume increases load on respiratory muscles and may leads to diaphragmatic fatigue [17]. Furthermore increased work of breathing and inspiratory muscle fatigue can significantly increase blood lactates [18] even after few minutes of high intensity work [19]. Therefore it is expected that best predictors of lactate levels in match should be Rf and Tv instead of VE. In this study we found that Rf has an increasing effect on lactates after all three bouts (0.4, 0.9, 0.8) where effect of Tv present in second and third bout (0.65, 0.44).

Dynamics of the match forces maximal energy utilization from the start, thus lactate levels depend on athlete's ability to oxidize lactates in order to minimize lactate production in all working muscles. This is accomplished by increasing oxygen consumption rather than utilizing it by raising VT point. Thus, lactate increase during a wrestling match does not depend on ability of an athlete to postpone anaerobic glycolysis As ventilation regulates body homeostasis, which is disrupted by high lactate increase, respiratory muscles, if not trained properly will increase breathing workload leaving the athlete to rely solely on aerobic energy. Therefore although not as widely studied as in aerobic sports, respiratory muscles training may play crucial role in anaerobic sports not only for its role to regulate ABS but also to leave more energy for the rest of the body.

At the point when anaerobic energy reserves are depleted all of the work must come from aerobic energy and therefore higher VT could be crucial for winning a match.

Specific energetic of sports like boxing, judo, karate often guide athletes and their trainers to ignore VO_{2max}, an essential part of preparation. Therefore our findings can be important in changing physiological approach to these and similar sports.

CONCLUSIONS

The VO_{2max} maximal respiratory frequency and tidal volume are key indicator in physiology and lactate dynamics of a wrestling match thus our findings change physiological approach to interpretation of exercise testing in wrestlers and its utilization in wrestling and similar anaerobic sports.

COMPETING INTERESTS

Authors have declared that no competing interest exists.

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