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Glucose Dynamics Can Evaluate State of Anaerobic Fitness in Wrestling?!

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A B S T R A C T

The aim of this study was to describe and explain wrestling fight lactate and glucose curves and establish the differences between wrestlers of different quality level. The study was conducted on a sample 60 young wrestlers, cadets (N=30, aged 15.5±0.5) and juniors (N=30, aged 18.6±1.2). Every subsample was divided in two quality classes (higher quality n=15, lower quality N=15), according to the national championship ranking. Every subject wrestled one match (3×2 minutes). Heart rate was recorded and blood samples were taken before the match, after each round, and after 5 minutes of sedentary rest. Obtained results clearly suggest that there were no differences in measured physiological parameters between cadets and juniors. Statistically significant difference was determined between the higher and lower quality wrestlers after second and third round and after 5 minutes of sedentary rest in lactate level ($p < 0.05$), and after rest in glucose level ($p < 0.001$). This study confirmed the thesis suggesting that anaerobic diagnostics in wrestling through lactate measuring is possible. This study also revealed that anaerobic diagnostics in wrestling can be done even more precise through glucose measuring.

Key words: *physiology, combat sport, lactate, cadets, juniors*

Introduction

Among the most important motor abilities in wrestling, as in other combat sports, are different types of muscular strength[1–3]. Regarding functional abilities, special attention has to be focused on development of wrestlers' anaerobic capacites[4]. Wrestling physiology is a frequent subject of scientific papers. Maximal and submaximal workload in wrestling causes stress and pathophysiological body response[5,6], and it is therefore interesting from the physiological point of view. The average number of actions during a wrestling match is 16 (3.1 s duration) for standup and parterre wrestling. The time between two actions is the time of tactical preparation for the next action. During that period, wrestler's activities are pushing, pulling or lifting an opponent[7]. Maximal and submaximal load operate interchangeably in a wrestling match, and under these conditions, anaerobic glycolytic pathway is the main energy source. This claim is supported by the fact that only 2 minutes of wrestling will increase the blood lactate level up to 8.6 mml/L – 11.6 mml/L[8]. Therefore lactates accumulate from the very beginning of the match. The anaerobic alactic energy system contributes to sudden, explosive throws, and the aerobic energy source contributes during the breaks between the rounds, or within the round[9]. Anaerobic fitness diagnostics is very important in wrestling, but these common diagnostics tests were constructed for other sports (Wingate test, Margarija stair climb test, Bosco anaerobic test, Shutle-run test), which they differ from the wrestling match for their structure of movement, muscle engagement, duration, load, even physiological response[10]. Many authors seem to agree that anaerobic fitness diagnostics has to be done through objective physiological parameters such as lactate measurement[11]. There are a lot of unresolved issues and controversies about anaerobic glycolytic energy pathways. Lactates can be produced from glucose breakdown under hypoxic conditions and under influence of adrenaline under conditions of normoxia. Lactates can also be produced by several organs during basal metabolism. Lactates have historically been blamed for the cause of acidosis during intense exercise, as well as for the subsequent muscle »burn« that accompanies vigorous exertion. Lactates are

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not a waste product, according to recent research[12]. A lactate is a useful metabolite during increased energy demand[13]. The aim of anaerobic diagnostics in wrestling is to determine the rate of lactate accumulation in particular periods of the match, and the rate of lactate disappearance during the recovery period. The major problem of such diagnostics is the lack of referent lactate and glucose values in particular periods of the wrestling fight for wrestlers of different age or quality class. Former studies of these metabolites in wrestling lean on sampling blood samples before and after the wrestling match, which is not sufficient to determine match glucose or lactate dynamics. Theoretically, if there is a sudden increase and then decrease, the two-point measurements would miss that phenomenon. Metabolite curve consisting of several measurements can give us a much better insight of the actual status. Wrestling match lactate curve differences between wrestlers of different quality level can answer the question of what the desirable lactate curve in wrestling would be. Glucose is the most important simple sugar in human metabolism and a primary energy source in the body. Glucose and lactate are parts of the same metabolism, thus a lactate produced by anaerobic glycolysis in the muscles moves to the liver and is converted to glucose (Cory cycle). The exercise intensity directly affects the glucose level[14]. The glucose level is lower in well trained persons, thus the glucose level depends on the body fitness. Well-trained athletes have higher glucose level during exercise. Hyperglycemia in trained subjects during intense exercise appears to be due to this lower rate of glucose utilization rather than a higher rate of glucose production[15]. There is an attempt in recent studies to connect some lactate and glucose states for purpose of sport diagnostics[16–19]. There are no studies with the attempt to connect glucose states with anaerobic fitness level in wrestling. Wrestling match duration is 2×3 minutes, and it is a relatively short activity predominated by maximal or submaximal load, and such activity extremely increases the glucose level[14]. Wrestling match glucose curve has never been described, as well as match glucose curves differences between wrestlers of different quality level. Glucose level diagnostics has many advantages over diagnostics by lactate level. For the purposes of diabetes patients, field glucose measuring methodology has been improved, and it is now more accurate and reliable than the equipment for field lactate measuring. The aim of this study is to describe and explain wrestling fight lactate and glucose curves and establish the differences between wrestlers of different quality level.

Material and Methods

Subjects

The study was conducted on a sample 60 young wrestlers from different Croatian wrestling clubs; which makes 50% of juniors and cadets who have participated in the 2011 national championship. The sample was divided in two age classes (according the FILA wrestling rules) cadets (N=30, aged 15.5±0.5) and juniors (N=30, aged 18.6±1.2). Every subsample was divided in two quality classes (higher quality N=15, lower quality N=15), according to the national championship ranking. National championship ranking from 1st to 5th place represents higher quality wrestlers and 6th to 10th place represents lower quality wrestlers. The testing was conducted immediately after the national championships, in order to avoid changes in fitness or quality level. Wrestlers who were ranked below 10th place were not considered for testing. There's a possibility that wrestlers below 10th place are wrestlers with less experience or without training habits, in which case, the obtained physiological parameters are not the result of the influence of wrestling training. Subjects participated voluntarily, giving a written informed consent to participate in the study, signed by each parent prior to commencement. The study protocol was approved by the ethical committee of the Faculty of Kinesiology in Split.

Sample of variables

Sample of variables included 10 physiological variables: blood lactate level (5 measurements) and blood glucose level (5 measurements). Blood samples were taken before the match (after warming up), after first, second and third round, and after 5 minutes of sedentary rest. Heart rate was recorded (for all measuring points) as a fight intensity indicator.

Protocol

The subjects were instructed to avoid intensive physical activity, medications, sport nutritional supplements and alcohol or caffeine consumption. Testing began at 10:00 am. The subjects were instructed to follow the fifteen-minute warm up protocol: 5 minutes of running, 5 minutes of general preparatory exercises and 5 minutes of specific pair exercises. After the warm up, every subject wrestled one match (3×2 minutes) according to the international (FILA) wrestling rules. A wrestling match can end before the end of the bout (fall or technical fall), but for the purpose of this research, they wrestled until the time expired. That was the only exception from the official rules. Special attention has been paid to matching appropriate pairs. To achieve high competitive matches with high intensity, every wrestler has to have an equal opponent, with great rivalry between the opponents. Expert team consisting of: national team coach for cadets, national team coach for juniors and head coach of national teams, has matched the pairs. Their task was to match the wrestlers who wrestled a very tight match in the last championship. Finger-prick blood samples were taken near the wrestling mat by medical technicians (Sports medicine laboratory »Diomed«, Split), and some sampling was conducted within the 30 seconds of stoppage time between the rounds. The last measuring was conducted after 5 minutes of sedentary rest. Lactate disappearance rate after exercise depends on intensity of the activity during the recovery period[20]. To avoid the differences caused by different activities during recovery, a model of sedentary rest was chosen.

Measuring equipment

For blood lactate measuring, the Accutrend lactate portable device was used (appropriate device for sport diagnostics[21]). For blood glucose measuring, Accu-Chek Active device was used (device with appropriate characteristics[22]). Heart rate was recorded with Polar PE3000 Heart Rate monitor (Polar Electro Oy, Kempele, Finland). Medical scale and Martin's anthropometer was used for measuring body mass and body height.

Statistics

Statistical data analysis was carried out using the statistical package Statistica version 7.0. (Softsat, USA). For all variables, the basic descriptive parameters were computed: mean, standard deviation, sample minimum, and sample maximum. Normality of distribution of the variables was tested by means of Kolmogorov-Smirnov test. The distribution of the data was not different from the normal distribution. In order to determine the differences in lactate values between the groups and between the measures within the groups, ANOVA was used for repeated measurements, while in post-hoc analysis, Fisher's LSD test was used. Statistical significance was set at $p<0.05$.

Results

Heart rates were the same among the cadets and juniors. Increased average heart rates before the match was caused by the worming up and they were from 102.1 bpm to 109.0 bpm. All matches occurred in the submaximal and maximal load zone, according to the heart rates recorded after the rounds, from 183.2 bpm to 196.5 bpm.

The same fight lactate dynamics was established for higher quality wrestlers in both age classes. After the first and the second round, a statistically significant increase of the lactate level at $p<0.05$ was recorded, and after 5 minutes of sedentary rest, a statistically significant decrease of the lactate level at $p<0.001$. Lactate dynamics for higher level wrestlers is: La1 < La2 < La3 = La4 > La5 (Fisher LSD).

The same fight lactate dynamics was established for lower quality wrestlers in both age classes. After the first round, the lactate level increased statistically significant at $p<0.05$, and after 5 minutes of sedentary rest, the lactate level decreased statistically significant at $p<0.001$. Lactate dynamics for low level wrestlers was: La1 < La2 = La3 = La4 > La5 (Fisher LSD).

The same fight glucose dynamics was established for higher quality wrestlers in both age classes. After the second and the third round, and after 5 minutes of sedentary rest, the glucose level increase was statistically significant at $p<0.05$. Glucose dynamics for higher level wrestlers was: Gll=Gl2 < Gl3 < Gl4 < Gl5 (Fisher LSD).

The similar fight glucose dynamics was established for lower quality wrestlers in both age classes, and it was characterized by a lack of statistically significant increase, except after the second round in the cadets age group ($p<0.05$). Glucose dynamics for low level wrestlers is: cadets Gll<Gl2=Gl3=Gl4=Gl5, and juniors Gll= Gl2=Gl3=Gl4=Gl5 (Fisher LSD).

For the age classes of cadets, a statistically significant difference in the lactate level between higher and lower quality wrestlers was determined after the second round, the third round and after 5 minutes of sedentary rest for the cadets ($p<0.05$), and difference of the glucose level after 5 minutes of sedentary rest ($p<0.001$).

Exactly the same differences were determined in the junior age category. Statistically significant difference in lactate levels between higher and lower quality wrestlers was determined after the second round, the third round and after 5 minutes of sedentary rest ($p<0.05$), and difference of the glucose level after 5 minutes of sedentary rest ($p<0.001$).

Discussion

Obtained results clearly suggest that measured physiological parameters are similar for the cadets and juniors. Further discussions about quality will be conducted for both age classes together.

Recent studies have recorded wrestling match heart rates from 175 bpm to 188 bpm[23,24]. Slightly higher heart rates in this study from 183.2 bpm to 196.5 bpm are the

TABLE 1
DESCRIPTIVE STATISTICS (X±SD) OF: PHYSICAL CHARACTERISTICS, WRESTLING EXPERIENCE, PLACEMENT ON NATIONAL CHAMPIONSHIP

Variables	Cadets		Juniors	
	Higher quality (N=15)	Lower quality (N=15)	Higher quality (N=15)	Lower quality (N=15)
	X±SD	X±SD	X±SD	X±SD
Age (yrs)	15.5 ± 0.5	15.3 ± 0.5	18.6 ± 1.2	17.7 ± 0.9
Wrestling experience (yrs)	5.8 ± 2.0	2.9 ± 1.4	8.5 ± 1.9	3.8 ± 1.6
Body mass (kg)	65.6 ± 15.0	69.1 ± 11.8	80.3 ± 20.1	72.1 ± 8.3
Body height (cm)	173 ± 6	173 ± 10	177.5 ± 11.0	176.3 ± 4.0
Body mass index	21.7 ± 3.8	22.9 ± 2.7	25.5 ± 3.6	22.8 ± 2.2
Placement on national champ.	2.2 ± 1.1	7.5 ± 1.6	1.7 ± 0.8	7.2 ± 1.0

TABLE 2
DESCRIPTIVE STATISTICS (X±SD) OF: LACTATE, GLUCOSE AND HEART RATE WITH DIFFERENCES BETWEEN THE MEASURES INSIDE QUALITY GROUPS (FISHER LSD TEST)

Variables		Cadets		Juniors	
		Higher quality (N=15)	Lower quality (N=15)	Higher quality (N=15)	Lower quality (N=15)
		X±SD	X±SD	X±SD	X±SD
La 1 (mml/L)	warm up	2.6 ± 0.6	3.0 ± 0.8	2.7 ± 0.8	3.1 ± 0.6
La 2 (mml/L)	round 1	9.1 ± 2.2*	8.7 ± 1.9*	8.8 ± 2.2*	7.8 ± 2.0*
La 3 (mml/L)	round 2	11.6 ± 1.6*	9.5 ± 2.4	11.7 ± 2.7*	9.5 ± 1.5
La 4 (mml/L)	round 3	12.2 ± 1.8	9.7 ± 2.3	12.4 ± 2.6	10.0 ± 2.5
La 5 (mml/L)	5 min rest	10.2 ± 2.6**	6.3 ± 2.1**	10.5 ± 2.1**	7.9 ± 2.4**
Gl 1 (mml/L)	warm up	4.9 ± 1.1	5.6 ± 1.1	5.6 ± 0.9	5.9 ± 1.1
Gl 2 (mml/L)	round 1	5.5 ± 1.1	6.4 ± 1.3*	5.7 ± 0.9	6.3 ± 1.5
Gl 3 (mml/L)	round 2	6.5 ± 1.0*	7.0 ± 1.6	7.1 ± 1.1*	7.1 ± 1.3
Gl 4 (mml/L)	round 3	7.9 ± 1.2*	7.4 ± 1.6	8.4 ± 1.0*	7.5 ± 1.1
Gl 5 (mml/L)	5 min rest	9.2 ± 2.0*	7.6 ± 1.4	10.2 ± 1.5*	7.9 ± 1.2
Hr 1 (bpm)	warm up	107.4 ± 11.7	109.0 ± 14.5	102.1 ± 12.4	103.9 ± 13.6
Hr 2 (bpm)	round 1	193.3 ± 7.8	183.2 ± 6.4	186.9 ± 9.2	186.4 ± 7.5
Hr 3 (bpm)	round 2	195.2 ± 5.7	188.4 ± 6.4	188.2 ± 8.3	186.1 ± 5.0
Hr 4 (bpm)	round 3	196.5 ± 7.0	189.1 ± 9.0	185.9 ± 6.6	186.1 ± 5.2
Hr 5 (bpm)	5 min rest	121.0 ± 5.6	124.6 ± 6.9	122.1 ± 9.8	122.3 ± 7.9

* significant increase at $p<0.05$, ** significant decrease at $p<0.001$

confirmation of the high motivation of wrestlers and high match intensity. Slightly higher heart rates were recorded among higher quality wrestlers, which are contrary to the records in tae kwon do[25]. After 5 minutes of sedentary rest, the average heart rates were significantly lower and they were 121.0 bpm to 124.6 bpm.

Lactate

By comparing the lactate curves among the cadets and juniors (Figure 1), it is obvious that there are no differences. Recent studies suggest that curve is the same in the age group of seniors[26]. Lactate metabolism age differences can be found in prepuberty, because of the development of the anaerobic pathway. The decline in anaerobic capacity is significant after the age of 60[27]. Lactate level as well as lactate dynamics can distinguish wrestlers by quality[8]. This study confirms those theses (Figure 1, 2). Higher quality wrestlers can elevate the lactate level much more; they have the ability to adapt to the high intensity exercise conditions[28–30]. The most significant difference between quality groups is one after the second round. A poorly trained wrestler can wrestle one high intensity round, but his energy supply for the second round is insufficient, so he is forced to reduce intensity, consequently reducing the lactate level. Therefore, the lactate level of higher quality wrestlers is significantly higher. After the third round, the lactate increase was not statistically significant for either quality group, bat there was a statistically significant difference in the lactate level between quality groups (as a consequence of the differences which occurred after the second round). Former investigations of wrestling fight lactate level were 13 to 15 mml/L, and sometimes even 20 mml/L[31] (after the match for the sample of seniors). After 5 minutes of sedentary rest, a statistically significant lactate decrease has been recorded. Some former investigations suggest that after 5 minutes of rest (after intense exercise), peak lactate level can be recorded[32]. Perennial anaerobic training influence caused adaptive changes in both quality groups. Higher and lower quality wrestlers have the ability of fast lactate oxidation and thus of fast recovery. Blood lactate level decreases for several reasons, lactates have the ability of shuttling between cell compartments, cells, tissues and organs very fast. Lactate shuttles from active to inactive muscle mass, but there is a very small amount of inactive muscle mass in wrestling. Therefore, lactate shuttles from active to inactive muscle mass are not a reason of lactate decrease in wrestling. Lactate decrease could be a consequence of lactate oxidation. Although the lactate decrease is significant for both groups, lactate level is still significantly lower in lower quality group. It is possible that it is still a consequence of differences which have occurred after the second round. Lactate differences between higher and lower quality wrestlers are similar as lactate differences between the wrestlers before and after the competition period[26]. At the end of the competition period, after numerous fights and competitions, anaerobic energy reserves are low, and wrestlers cannot elevate the lactate level high. This similarity confirms that the energy status of wrestlers can be explained by lactate dynamics.

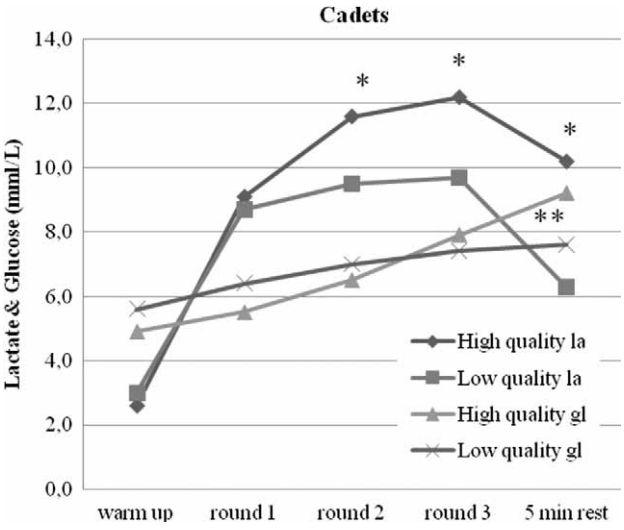

*Fig. 1. Lactate and glucose curves for cadets with differences between the quality groups (Fisher LSD test). *Differences between lactate level significant at p<0.05. ** Differences between glucose level significant at p<0.05.*

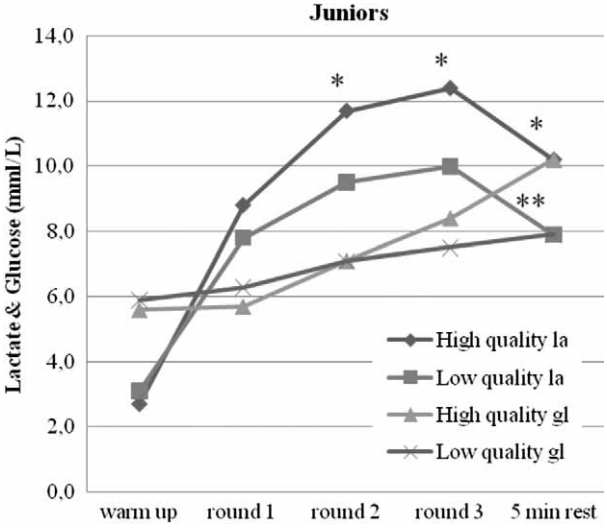

*Fig. 2. Lactate and glucose curves for juniors with differences between the quality groups (fisher LSD test). *Differences between lactate level significant at p<0.05. **Differences between glucose level significant at p<0.05.*

Glucose

There is a significant difference in fight glucose dynamics between higher and lower quality wrestlers. Glucose level increase is statistically significant after the second round, the third round and after 5 minutes of sedentary rest for higher quality wrestlers. The rate of increase is higher in every subsequent measurement (Figure 1, 2). There is no significant increase in glucose level for lower quality wrestlers, and even the rate of increase is declining. Increase trends are opposite for higher and lower quality wrestlers (Figure 1, 2). Training has an influence on muscle glycogen reserves. Well trained wrestlers have a great muscle glycogen reserve. Utilization of plasma glucose is lower in trained subjects during high-intensity exercise[15], and muscle anaerobic glycolysis is dependent on muscle glycogen rather than on blood glucose[33]. During high intensity exercise, body mobilizes large amounts of glucose from liver glycogen stores[34], meanwhile, glycolysis uses the muscle glycogen. Therefore, the bloodstream glucose accumulates and well trained wrestlers have higher glucose levels. Training elevates the muscle protein GLUT 4 concentration for 66%[29]. Transmembrane transport of glucose is mediated by glucose transporter (GLUT 4), and it is responsible for the uptake of glucose in skeletal muscle. Higher blood glucose level, as well as higher GLUT4 concentration in higher quality wrestlers allows them faster muscle glycogen repletion. In short, well-trained athletes use muscle glycogen, accumulate blood glucose, and have a faster muscle glycogen repletion[35]. The opposite glucose dynamics in lower quality wrestlers suggest that body uses a higher amount of blood glucose release from the liver into the bloodstream. A lower level of glucose in the recovery period could indicate slower muscle glycogen repletion. Body glucose level increases one hour after exercise[36], during which period the body restores spent energy reserves. Until the final match, a wrestler has between 4 and 5 matches in a tournament; pauses between matches can be less than an hour, sometimes insufficient for energy restores. Faster restoring energy reserves could mean a better chance of winning the tournament. The most important question is why glycolysis is dependent on muscle glycogen rather than on blood glucose during high-intensity exercise[33]. Hypothetically, homeostatic regulatory mechanism strives to maintain reference ranges of blood glucose during high energy consumption. There are three levels of that mechanism: hexokinase inhibits blood glucose, liver releases new glucose and muscle glycogen breaks down. But if a working muscle doesn't have enough glycogen stores, the muscle will use glucose from the bloodstream. Blood glucose curve during a wrestling match of a higher quality wrestler could be the reference range for anaerobic testing. This fifteen-minute physiological test can be used for testing regularly, or periodically before important competitions.

Conclusion

The aim of this study was to describe and explain wrestling fight lactate and glucose curves and establish the differences between wrestlers of different quality level. Wrestling fight lactate and glucose dynamics for higher and lower quality cadets and juniors was established. Differences were obtained between higher and lower quality wrestlers and they were the same in both age classes. Lactate dynamics as the objective indicator of the state of anaerobic fitness, can distinguish well trained from poorly trained wrestlers. Glucose dynamics can distinguish well trained from poorly trained wrestlers even more precisely then the lactate level. Advantages of glucose measuring provide new opportunities in wrestling functional diagnostics.

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KRIVULJOM GLUKOZE MOŽEMO PROCJENITI STANJE ANAEROBNIH KAPACITETA U HRVANJU?!

SAŽETAK

Istraživanje je provedeno sa ciljem da sa utvrde i opišu krivulje laktata i glukoze u hrvačkoj borbi za uzraste kadeti i juniori te da se utvrde razlike u navedenim krivuljama s obzirom na kvalitetu hrvača. Uzorak ispitanika sastojao se od 60 mladih hrvača, 30 juniora i 30 kadeta. Svaka dobna skupina podijeljena je na subuzorke, hrvače višeg razreda kvalitete (N=15) i hrvače nižeg razreda kvalitete (N=15). Svi ispitanici su hrvali jednu borbu (3×2 min). Srčana frekvencija, razina laktata u krvi i razina glukoze u krvi zabilježeni su prije borbe, nakon svake runde i nakon pet minuta sedentarnog oporavka. Nema razlika u izmjerenim fiziološkim parametrima između hrvača juniorskog i kadetskog uzrasta. Postoje značajne razlike obrascima kretanja laktata i glukoze kod hrvača različitog razreda kvalitete kao i statistički značajne razlike među tim skupinama nakon druge i treće runde u razini laktata ($p<0,05$) te nakon pet minuta sedentarnog odmora u razini laktata ($p<0,05$) i u razini glukoze ($p<0,001$). Ovo istraživanje je potvrdilo da se u hrvanju može raditi dijagnostika anaerobnih kapaciteta putem uzorkovanja laktata, ali i novost da se to može raditi još preciznije promatranjem dinamike glukoze u borbi.