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DYNAMICS OF BLOOD GLUCOSE DURING HIGHER INTENSITY PHYSICAL ACTIVITY BY BASKETBALL PLAYERS

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Abstract: The focus of the research is the dynamics of blood glucose before and after high intensity exercise by basketball team players, 16 years of age and 18 years of age. The aim is to define the biochemical changes in blood glucose levels after physical stress of a high intensity. The study encompassed 24 subjects, 12, 16 year olds and 12, 18 year olds. The testing of submaximal physical strains of basketball players was conducted in the laboratory under the control and supervision of a doctor of sports medicine. The basketball players were tested using the Nowacki test on a treadmill with the direct measurement of the functional parameters of metabolic testing. The measurement of blood glucose levels was performed by taking a portable analyzer of capillary blood from the fingers of respondents. A blood sample was taken before the start of testing, when the payers were idle, and three minutes after the stress test. The comparative statistical analysis of the results showed a statistically significant difference in blood glucose after the first and second measurements. Blood glucose levels after the exercise test was increased in all subjects. The average value of the increase in the blood glucose level was 1.15 mmol/l. The level of increase in blood glucose levels is proportional to the duration of the test which was no longer than 15 min. per subject. The T-test determined the statistical significance of $p = 0.00$ which confirmed the results of previous studies.

Keywords: *glucose, biochemistry, physical activity, basketball*

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INTRODUCTION

Successful participation in a basketball game involves the implementation of certain requirements in terms of morphological characteristics, and functional and motor abilities. From a physiological point of view, the game of basketball requires a synchronized operation of all functional, organic systems at a high level. The level of energy consumption, high stress on the body due to sudden changes in intensity and content of motion activities classifies basketball at the top of the sports complex in regard to the physiological reaction to physical strains which the organism is exposed to during a game.

Metabolic characteristics of an organism, as a prediction of functional abilities, encompass all processes in the human body that occur on the endogenous biochemical level in order to achieve homeostasis after completing physical activity. The base metabolic phenomenon describes and defines the way and type of generated energy which is necessary to achieve a high performance in sports in terms of the functional preparedness of basketball players. The production and consumption of energy is a crucial area in the metabolic system, which determines the functioning of all systems in the body. The metabolism is a complex set of chemical reactions, whose consequences lead to the development and functioning of organic systems (Stefanović, 2012).

Energy is the body's ability to perform work that is reflected in mastering the forces in a certain way (Jovašević et al., 2015). For sports, of fundamental importance is the production of energy for physical activity, and the ability to eliminate the negative products from the body after the completion of physical action. In sports, we find two modes, aerobic (with oxygen content) and anaerobic (oxygen-free). Realization of physical work has enabled several chemical processes that take place in three energy systems. The main carrier of the energy molecule is adenosine triphosphate (ATP), consisting of four elements, and adenosine triphosphate (Suzić et al., 2013). The body has little adenosine triphosphate, just enough for short and hard work. Constant resynthesis and replacing comes to restoring deposits of ATP. ATP is produced the most in the mitochondria, while the resynthesis is done with the help of glucose and fatty acids (Suzić et al., 2013). The limitation of ATP in the body (about 100g) can be replaced with other energy sources: creatine phosphate (CP), carbohydrates, fats and proteins (Stefanović, 2012). Creatine phosphate with ATP belongs to a group of phosphagenous energy. CP is available to cells and is rapidly activated by the creation of ATP. The amount of the CP enables about twenty seconds of maximum engagement of the musculature, which is a few seconds longer than when energy is released from ATP (Nikolić, 2011). Carbohydrates are placed in the muscles and liver, where they are degraded into glycogen in order to maintain the blood glucose levels, thus achieving the necessary energy for operation; carbohydrates release energy faster from fat (Đorđević Nikić, 2002). Fats have a multiple role in the organism, the energy from fat is expressed the slowest in muscles, but contains a greater amount of energy. One gram of fat contains 9 kcal, as compared to carbohydrates and proteins - per one gram administered is approximately 4 Kcal (Nikolić, 2003). The formed protein material consists of chains of various amino acids. The complex structure of the protein results in a slow degradation of energy and its transformation. The organism activates the protein energy upon high, long-term consumption due to the exhaustion of other energy sources (Karzoun and Obrenović, 2012).

Energy systems are processes in which the resynthesis of adenosine triphosphate is made possible. Depending on the intensity and duration of the physical activity, the corresponding energy system is activated (Suzić et al., 2013). Energy production in the body takes place through three energy systems.

The phosphagenous system enables work at a high intensity of up to 15 seconds, also referred to as the ATP and CP system (Nikolić, 2003). The phosphagenous system has a small capacity with a big potential for production of ATP. After the utilization of phosphagenous resources, the body relies on the following energy system to produce enough energy for physical activity.

Glycolysis is an extremely dominant energy system in sports games, providing energy for the duration of activity from 30 seconds to 2 minutes. Deposits of it have a lower capacity and a high energy potential. ATP, due to glycolysis, is received by resynthesizing carbohydrates, glucose and glycogen (Nikolić, 2003). Glycolysis is a complex biochemical process by which glucose is converted into pyruvic acid due to resulting ATP (Voet et al., 2011). Glucose is a monosaccharide which is most common in nature. It has a sweet taste, and a high energy content which contributes to the maintenance of vital functions and the realization of physical activity (Schenck, 2006).

The aerobic system provides energy for activities that last for several hours. The aerobic system has a high capacity but a lot of low potential; aerobic ATP resynthesis is extremely slow in terms of complex chemical processes involving oxygen, glucose, glycogen, and fat (Nikolić, 2011).

The object of the research is to determine glucose levels in basketball players 16 years of age and 18 years of age, before and after the exercise test on a treadmill. The subjects' capillary blood was taken from the finger before and after a brief submaximal strain. Assessment of glucose was carried out using a manually portable analyzer that provides fast response times.

The hypothesis of the paper is based on the fact that there will be an increase in blood glucose levels after intense physical activity. Adaptation of the organism to experiencing stress involves the launch of metabolic processes which stimulate the concentration of glucose, an important energy source of the organism, thus being increased in the bloodstream.

The aim of the paper is aimed at defining the physiological processes that occur in the body during intense physical activity with an emphasis on monitoring glucose levels as a fundamental factor in achieving the energy necessary for physical work.

METHODOLOGY

The study included 24 subjects, basketball players, all male. The sample consists of two groups of players 12 aged 16 ± 6 months and those aged 18 ± 6 months, in the same basketball club. Both teams have equal conditions for training. Both age groups participated in the final tournament of the Quality League, organized by the Basketball Association of Belgrade in the 2015/2016 season. The study evaluated four of the variables, the level of glucose alone G1 (mmol/l), glucose level after the test stress G2 (mmol/l), the heart rate at rest FSM (n/min) and the maximum frequency of the heart during the performance of an exercise test MFS (n/min).

Data collection research involved the use of testing techniques, functional diagnostics, using devices with a high degree of sensitivity. The used for data collection are standardized aptitude tests, of high measurement performance.

From statistical analysis procedures applied were descriptive and comparative methods in the analysis of the results obtained. Descriptive methods include determination of the distribution of frequencies. For continuous series, representative central and dispersive parameters were determined: number of subjects (N), the mean (M), standard deviation (SD), standard error (SG), the range of (O), the maximum value (MAX) and minimum value (MIN). The comparative analysis included the T-test. To process the obtained data statistical method of description and comparison were used with the use of the specialized statistical IBM SPSS Statistics 19 software package.

Testing was carried out within two days, in the morning according to a predetermined protocol. The course of studies was conducted according to the following procedures:

1. The day before the test, subjects had no training, in order to rest for testing. The training micro cycle after the competition had a recuperating character. Before the test, subjects consumed a meal rich in carbohydrates, three hours prior to testing.
2. Upon arrival for testing, players were subjected to medical examination. Evaluation involves assessing the health status of basic biological parameters in order to determine the level of competence for the implementation of testing.
3. Basketball players prior to testing received instructions on how the test is performed. Also, the motivation of participants was performed. Immediately before the test, the subjects' blood was taken from a finger in order to determine the level of glucose prior to physical exertion.
4. Provocation of the submaximal strain on the athletes is caused by ergospirometric testing on the Treadmill T1 50-MED COSMED. The analysis of gas was performed with the help of gas analyzer

QUARK CPET COSMED. Parallel with the analysis of the gas, cardiovascular parameters were analyzed, FSM and MFS by using electrocardiography. Measuring blood sugar, G1 and G2 was done on the basis of the results obtained by the portable analyzer GlucoSure autocode. Ergospirometry values were obtained from the Nowacki test on a treadmill protocol which involved a continuously increasing inclination of the running belt (running deck) at a constant speed. The subjects went through three phases. The first phase is the resting phase and lasts for 3 minutes, without increasing the inclination and speed. After 3 minutes, the second phase, the phase of warming up lasts for 2 minutes - in the first minute the level of the slope is not increased and the speed is 5 km/h, in the second minute of warm-up the subject is moving at 6 km/h in the first 30 seconds and speed is 7 km/h with a gradient of 2%. The third phase is the continuous increase in stress, each stretch is 2 minutes, the initial speed is 9 km/h and it is constant while the slope increases every 2 minutes by 2%. The test was stopped when the subject was not able to continue testing (Reilly et al., 1988).

5. Upon completion of the test, after three minutes, capillary blood is taken from the finger and again the glucose values obtained after physical exertion are measured, thus completing the research process for each individual. Basketball players are advised to head for the changing room and rest.

RESULTS

Descriptive analysis and processing of the data obtained are presented in the underlying variable size for the two age groups of subjects. Table 1 presents the results of the descriptive analysis of 16 year olds. Table 2 presents the results of analysis of 18 year olds.

Table 1. *Results of descriptive statistics for cadets*

Cadets	N	M	SD	SG	O	MIN.	MAX.
FSM	12	58.08	6.81	1.96	25.00	43.00	68.00
MFS	12	193.91	3.98	1.15	12.00	190.00	202.00
G1	12	5.51	0.27	0.07	1.00	4.80	5.80
G2	12	6.60	0.63	0.18	1.90	5.50	7.40

N - number of subjects; **M** - mean; **SD** - standard deviation; **O** - range; **MIN** - minimum value; **Max** - maximum value; **FSM** - heart rate at rest; **MFS** - maximal heart rate during the test; **G1** - blood glucose level at rest; **G2** - glucose levels after the stress test.

Based on the obtained data of the descriptive statistics (Table 1) it can be concluded that the average value of the maximum heart rate during the test (MSF) is extremely high, which implies that subjects have been exposed to a high intensity of stress which meets the condition for the further examination of blood glucose level in athletes. It is notable that variables G1 and G2 indicate the existence of the difference between the two measurements, both before and after the exercise test with elevated blood glucose levels after a test.

Table 2. *Results of descriptive statistics for juniors*

Juniors	N	M	SD	SG	O	MIN.	MAX.
FSM	12	53.83	3.37	0.97	11.00	47.00	58.00
MFS	12	194.66	2.64	0.76	8.00	190.00	198.00
G1	12	5.40	0.31	0.09	1.10	4.90	6.00
G2	12	6.27	0.43	0.12	1.20	5.80	7.00

N - number of subjects; **M** - mean; **SD** - standard deviation; **O** - range; **MIN** - minimum value; **Max** - maximum value; **FSM** - heart rate at rest; **MFS** - maximal heart rate during the test; **G1** - blood glucose level at rest; **G2** - glucose levels after the stress test.

Table 2 shows the results of the descriptive statistics of the basketball players' stress test. It indicates the existence of the difference between the size of the obtained blood glucose levels before and after the exercise test.

Using comparative statistics, the T-test results were obtained by a comparison between variable G1 and G2 in both groups of subjects together.

Table 3. *The results of T-test glucose levels at rest and after the exercise test for both groups of subjects*

BASKETBALL CADETS AND JUNIORS		
Number of examinees	**24**	
Variables	G1	G2
Arithmetic mean	5.60	6.75
Variance	0.04	0.25
p-value	**0.00**	

The obtained results of comparative statistics for variables G1 and G2 confirm the difference with the statistical significance p=0.00 level, which is evidence that the level of glucose in blood during submaximal physical exertion increased by an average of 1.15 mmol/l in this study.

DISCUSSION

In this and previous research studies, it has been shown that the glucose level increases due to intense physical stress, regardless of the given sport. Blood glucose levels at rest in subjects who regularly train and those who show no differences until after the test. Thus, a greater increase in the blood glucose is noticed in subjects who do not train regularly. The research has shown that the intensity of the strain affects the increase in blood glucose levels, as during higher levels of strain the level of glucose increases.

Examining the different categories and age groups of judo athletes, it has been confirmed that blood glucose level increases after each step of the execution of a special judo test (Karninčić et al., 2013, p. 557; Karninčić et al., 2013 p. 125; Kuvačić et al., 2014, p. 229). Blood glucose levels in these studies were measured after situational stress, a judo fight, thereby proving that in competitive conditions the transfer of more glucose into the blood stream is also performed not only in laboratory tests, by using enforcement agencies of the treadmill or a bicycle ergometer.

The study, which included 10 top water polo players and 10 male subjects who are not physically active, found that there has been an increase in blood glucose levels at the end of the exercise test in 30 recovery minutes (Jeremić et al., 2012, p. 74). The results of this study indicate that blood glucose levels in elite athletes had a lower level of increase as compared to the level of increase in blood glucose in inactive subjects. The trend of increasing blood glucose level after the stress test in individuals who are not physically active has a tendency to increase, which indicates the fact that regular physical activity of a higher intensity adapts the metabolic processes in the stress conditions which are manifested by the economic use of energy resources such as glucose.

Dynamics of glucose in the blood is determined by the intensity and extent of the strain (Wahren et al., 1971, p. 2715). This study included 25 subjects of a healthy and physically active population, which were divided into three groups. Each group during the test had a different level of strain on a cycle ergometer. The blood glucose level in all three groups was measured at rest, at the fifth, tenth, twentieth, thirtieth and fortieth minutes of the test. The group of respondents who had a maximum strain of about 200 W had the largest increase in blood glucose levels during the measurement of each section. The obtained results of this study demonstrated that the intensity of the strain causes the blood glucose level.

Based on the results obtained and the theoretical framework, the hypothesis, during physical exertion of submaximal intensity is that the level of glucose increases in the blood stream. This can only be measured in capillary blood from the finger plucked from subjects. The statistical significance of the hypothesis with a value of $p=0.00$ thus confirms the current biochemical research in the field of sport which is assessed by the dynamics of glucose before and after physical exertion.

Based on heart frequency when resting, before the start of testing and the maximum of the heart rate that was achieved during the test, it can be concluded that the Nowacki test on a treadmill was adequately achieved in a stressful situation that caused the blood glucose level to be raised in basketball players aged 16 and 18 years of age. The average value of the heart rate at rest with 16 year olds was 58.08 beats per minute while with 18 year olds, this value was 53.83 beats. This data shows that tested players trained regularly. A lower resting heart rate defines the quality of the heart and is reflected in the functional capacity of the body. Athletes whose resting heart rate was lower enabled the postponing of their peak performance during the competition, which improved the functional performance.

The glucose value at the beginning of the measurements in both groups of subjects ranged in the upper limits of the reference frame, between 4.8 mmol/l and 6.0 mmol/l. In the subsequent measurement of glucose levels, three minutes after completion of the test, the border shifted in the range from 5.5 mmol/l to 7.4 mmol/l. The increase in glucose due to physical stress is the result of the body's need for energy, which is necessary for physical work. The system of regulation of glucose in the body pulls all available reserves and transports them into the bloodstream in order to ensure optimal energy in all units of skeletal muscle. By achieving a stable condition after recovery, blood glucose returns to normal. People who are in the system of regular and adequate training have optimal use of energy resources that are mobilized under the influence of metabolic processes.

CONCLUSION

Research conducted over two groups of 16 and 18 year old basketball players has contributed to the understanding of metabolic processes before and after physical exertion of a higher intensity. The results of this study have the same statistical significance as well as the results of the previous research that confirmed an increase in blood glucose levels during intense physical involvement of the organism. By processing the data obtained, it can be concluded that there is a statistically significant difference between the first and second measurements, where the level of glucose after a test strain was higher, which shows that blood glucose levels are aligned with the physical activity of an athlete.

Further studies of biochemical processes in sport should be directed towards a comparison of different scales and intensities of the load and the level of accumulation of glucose in the blood and the recovery time. Scientific practice in further research should include monitoring of metabolic processes occurring in the situation, training or competitive conditions in order to define the real dynamics of blood glucose during the daily activities of athletes.

REFERENCES

1. Đorđević-Nikić, M. (2002). *Ishrana sportista*, Beograd: Todra.
2. Jeremić, R., Bjelić, A. & Skorupan, N. (2012). Metabolički odgovor na test fizičkog opterećenja kod fizički aktivnih i neaktivnih ispitanika. *Medicinski podmladak*, 63 (1-2), 74-77.
3. Jovašević, Lj., Bajin, Z. i Nurković, J. (2015). *Biomehanika*, Beograd: Beoštampa.
4. Karninčić, H., Strize, I., Drašinac, G. & Dumplančić, D. (2013). *Razlike u određenim fiziološkim parametrima između nekih elementarnih oblika hrvanja kod studenata kineziologije*. Šesti međunarodni kongres "Ekologija, zdravlje, rad, sport", 557.
5. Karninčić, H., Gamulin, T. & Nurkić, M. (2013). Lactate and glucose dynamics during a wrestling match - differences between boys, cadets and juniors. *Facta universitatis, Physical Education and Sport*, 11 (2), 125.
6. Karzoun, D. i Obrenović, M. (2012). *Osnove anatomije i fiziologije sporta*, Beograd: DTA.
7. Kuvačić, G, Krstulović, S. & Miletić, A. (2014). *Dinamika laktata i glukoze pri izvođenju specifičnog judo testa*. 22. Ljetna škola kineziologa Republike Hrvatske, 229.
8. Nikolić, D. (2011). *Biohemija i fiziologija u aktivnom sportu i rekreaciji*, Zaječar: Sportski savez "Zaječar".
9. Nikolić, Z. (2003). F*iziologija fizičke aktivnosti,* Beograd: Fakultet sporta i fizičkog vaspitanja.
10. Reilly, T., Lees, A., Davids, K. & Murphy, W. J. (1988). *Science and Football*, London: E. & F. N. Spon Ltd.
11. Schenck, F. (2006). Glucose and glucose-containing syrups. *Ullmann's Encyclopedia of Industrial Chemistry*, Weinheim: Wiley-VCH.
12. Stefanović, N. (2012). *Anatomija čoveka: za studente Fakulteta sporta i fizičkog vaspitanja*, Niš: Fakultet sporta i fizičkog vaspitanja.
13. Suzić, S., Mazić, S. i Suzić-Lazić, J. (2013). *Osnovi fiziologije fizičke aktivnosti*, Beograd: Visoka sportska i zdravstvena škola.
14. Voet, D. & Voet, G. J. (2011). *Biochemistry*, 4th Edition. New Jersey: Wiley.
15. Wahren, J., Felig, P., Ahlborg, G. & Jorfeldt, L. (1971). Glucose metabolism during leg exercise in man. *Journal of Clinical Investigation*, 50 (12), 2715.