Original article **UDC: 796.012.1**
doi:10.5633/amm.2013.0406

VALUES OF AEROBIC CAPACITY IN HANDBALL AND VOLLEYBALL PLAYERS

Vesko Milenković[1], Biljana Vitošević[1], Hadži Miloš Vidaković[1], Gorana Ranković Nedin[2], Jasmina Ranković[3]

Physical capacity of athletes is an important element of success in sports achievements. Aerobic capacity has been accepted as its major component. Maximal oxygen uptake (VO2max) has been regarded by majority of authors as the best indicator of aerobic capacity of an organism, and at the same time, the best indicator of an athlete's physical capacity. The aim of the investigation was to analyze the aerobic capacity as an indicator of physical capacity of athletes, differences in their aerobic capacity with regard to the kind of sport they are practicing, as well as the differences obtained when compared to physically inactive subjects. The investigation included the determination of absolute and relative VO2max in the total of 70 male examinees. The examinees were divided into two groups of active athletes (handball players (n=24) and volleyball players (n=20) of different profiles, while the third group of non-athletes served as control group. Maximal oxygen uptake was determined by performing the Astrand 6 minute cycle test. Peak values of VO2 max were recorded in the group of handball players (4,27±0,29 l/min), and they were statistically significantly higher ($p<0,001$) compared to other examined groups. In the group of volleyball players the oxygen uptake was 3,98±0,19 l/min, while statistically significantly lower values were reported in the group of non-athletes compared to the groups of athletes ($p<0,01$). A similar ratio of VO2 max values was also shown by the analysis of values expressed in relative units. Our results showed that peak values of VO2 max were obtained in handball players, and that handball as a sport requires higher degree of endurance compared to volleyball. Having considered the morphological and functional changes which are the consequence of the training process, it can be concluded that VO2 max values are statistically significantly higher in the groups of athletes compared to the group of non-athletes. *Acta Medica Medianae 2013;52(4):35-38.*

Key words: *athletes, maximal oxygen uptake, Astrand test*

University of Kosovska Mitrovica, Faculty of Sport and Physical Education, Department for Medical Subjects, Leposavić, Serbia[1]
University of Niš, Faculty of Medicine , Institute of Pharmacology, Niš, Serbia[2]
Health Centre, Niš, Serbia[3]

Contact: Vesko Milenković
University of Kosovska Mitrovica
Faculty of Sport and Physical Education
Dositeja Obradovića bb 38218 Leposavić, Serbia

Introduction

Physical capacity of athletes is an important element of success in sports achievements. It involves a huge number of different capacities, with aerobic capacity being its major component. Physiological basis of physical capacity of an organism incorporates the functional capacity of the organism to increase the level of metabolic processes in keeping with the requirement of physical effort being exposed to. The metabolic processes in this sense mean the transformation of chemical energy into mechanical one (1).

As energetic capacities of the human organism are certainly the most significant factors determining the limits of physical capacity, as well as practicing the sport, it is allowed to equate the physical capacity with the value of energetic capacity. Aerobic capacity denotes a general extent of metabolic processes occurring in the human organism, and stands for a larger portion of the total energetic capacity. Maximal oxygen uptake (VO2 max) refers to the intensity of aerobic processes, and actually represents the capacity of the organism to utilize at a certain moment the maximum amount of oxygen (2). However, as these two processes are highly interrelated, maximal oxygen uptake has been regarded by majority of authors as the best indicator of aerobic capacity of the organism, i.e. the functional capacities of cardiovascular and respiratory systems, as well as the capacity of tissues to utilize oxygen; at the same time, it is the best indicator of the athlete's physical capacity. Maximal oxygen uptake is defined as maximum amount of oxygen which the organism

consumes per unit of time while performing the exercise of growing intensity, and which cannot be further increased with further rise of exercise intensity. Maximal oxygen uptake as a measure of aerobic capacity has been determined as the international standard of physical capacity (3,4). The basic unit for measuring the maximal oxygen uptake is its absolute value expressed in liters or millilitres of oxygen per minute. However, the absolute value of VO2max is highly affected by body weight, and it is, therefore, more objective and generally accepted to express aerobic capacity in relative units - millilitres per kilogram of body mass per minute. Continuing estimation of athletes' physical capacity is one of the most important tasks of the physiology of sport. In that way, one can get insight into the momentary physical capability of athletes and efficiency of the training process (5). Determination of aerobic capacity is possible to perform with great precision by direct measuring of maximal oxygen uptake in laboratory tests on maximal physical effort. More or less accurately, it can be indirectly estimated by means of various submaximal laboratory and field tests. The current submaximal ergometric tests for the estimation of maximal oxygen uptake performed on a treadmill and bicycle ergometer meet the criteria according to which they could be classified as the group of ergometric tests; however, they are impractical for testing a large number of examinees as they require special conditions and relatively expensive equipment. When the test is to cover a larger number of examinees at the same time or in a short period of time in field conditions, a step bench is the ergometer of choice. Unfortunately, the majority of tests which are performed on the step bench (the so-called «step- tests») are non-standard as they do not meet the basic precondition of aerobic capacity indirect estimation - that field conditions for all examinees are the same (6). The aim of the investigation was to provide a valuable insight into aerobic capacity i.e. athlete's capability as an indicator of his physical capacity, difference in aerobic capacities of athletes with regard to the kind of sport they were practicing, as well as the differences obtained when compared with physically inactive subjects - the so-called non-athletes.

Material and methods

The investigation included the determination of absolute and relative VO2max in the total of 70 examinees of male sex. All investigations were undertaken at the Faculty of Sport and Physical Education University of Prishtina in Leposavić. The examinees were divided into two groups of active athletes of different profiles, while the third group of athletes served as control group. The investigated groups were divided into the following way:

1. handball players (n=24)
2. volleyball players (n=20)
3. non-athletes (n=26)

Peak values of oxygen uptake (VO2max) were determined by performing the Astrand 6 minute cycle test at 150 W. Thus obtained values expressed in ml/min represented the absolute values of oxygen uptake (VO2max). The obtained values were further divided by body weight values (expressed in kilograms), and represented the relative value of maximal oxygen uptake (ml/kg/min). Statistical processing of all parameters was done by calculating the mean values and standard deviation, while statistical significance was determined by Student's t-test.

Results

The values of maximal oxygen uptake are frequently compared to the degree of an athlete's physical work capacity, i.e. his physical capability. Therefore, the determination of maximal oxygen uptake plays the key role in sports functional diagnostics, and practically stands for physical capacity of athletes. As VO2 max values are highly affected by body weight of examinees, the values of maximal oxygen uptake are expressed both in absolute (l/min) and relative (ml/kg/min) values. Peak values of VO2 max, expressed in absolute units, were recorded in the group of handball players (4.27 l/min), and they were statistically significantly higher ($p<0,001$) compared to other investigated groups. The recorded oxygen uptake in the group of volleyball players was 3,95 l/min, while non-athletes had statistically significantly lower values (3,19 l/min) when compared to the groups of athletes ($p< 0,001$) (Table 1, Figure 1).

Table 1. Mean VO2 max values in the groups of athletes and non-athletes expressed in l/min

Examinees	VO_2max (l/min)	SD
Handball players	4,27*#	0,29
Volleyball players	3,98*	0,19
Non-athletes	3,19#	0,21

Data are presented as the mean ± SD.
* p<0,001 vs. non-athletes,
# p<0,001 vs. volleyball players

Table 2. Mean VO2 max values in the groups of athletes and non-athletes expressed in ml/kg/min

Examinees	VO_2max/BW (ml/kg/min)	SD
Handball players	51,90*#	1,14
Volleyball players	45,50*	1,67
Non-athletes	41,53#	1,14

Data are presented as the mean ± SD.
** p<0,001 vs. non-athletes*
 # p<0,001 vs. volleyball players

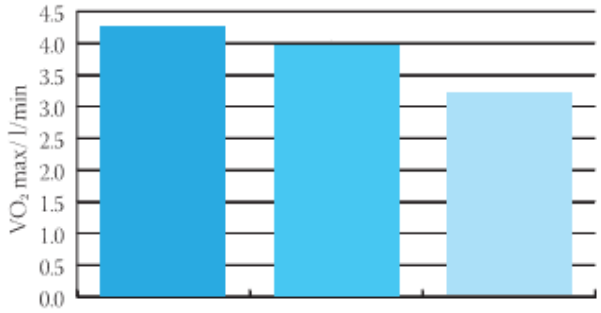

Figure 1. Mean VO_2max values in the investigated groups of athletes and non-athletes in l/min

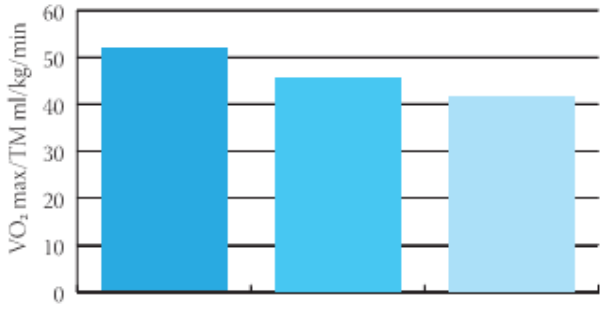

Figure 2. Mean VO_2max values in the investigated groups of athletes and non-athletes expressed in ml/kg/min

A similar ratio of VO2 max values was also recorded after the analysis of values expressed in relative units (Table 2, Figure 2). The best results were obtained again by handball players (51,90 ml/kg/min) with statistically significant differences when compared to the group of volleyball players ($p<0,001$), which emphasizes the importance of aerobic capacity for playing handball successfully. Somewhat lower values were recorded in the volleyball players (45,50 ml/kg/min), while the lowest values were obtained in non-athletes (41,53 ml/kg/min) whose VO2max/BW values were statistically significantly lower in comparison to both groups of athletes ($p<0,001$).

Discussion

New regulations and tough competition require an extraordinary aerobic capacity of each athlete on the field. Sports competition stands for a typical test of athlete's physical capacity. Aerobic capacity is an integral indicator of functional capacities of all systems involved in supply, transportation and energetic oxygen transformation (cardio-pulmonal capacity, functional muscle capacity to produce ATP in the presence of oxygen) (5). Functional impairment of any link in the chain can, to some extent, influence the decrease in the level of athlete's physical capacity (7). As maximum value of aerobic capacity of top athletes is achieved between 17 and 22 years of age, after which it linearly decreases with aging (8), we cannot expect some significant improvement in VO2 max in our handball and volleyball players. After the age of 22, a possible increase in VO2 max, which can be conditioned by a period of a training cycle (up to 10%), is still not enough to meet the world and European standards (8-10). Insufficient aerobic capacity precludes the maintenance of high level of aerobic exercise, and therewith the maximal performance in certain sports as it leads to progressive exhaustion, especially in the last 15 minutes of a match (11). High level of aerobic capacity is indispensable for achieving success in many sports; therefore, the determination of VO2max is of special importance as it plays the key role in professional sports - it is the reflexion of any athlete's physical capability.

Analyzing our results, it can be observed that maximal oxygen uptake was recorded in the group of handball players; it was expressed both in absolute (4,27 l/min) and relative units (51,90 ml/kg/min), which was the expected value having considered the prior facts. Handball, as a representative of sports games, requires an intermittent performance with intertwining the aerobic and anaerobic exercises. The player is thus required to have an efficient energetic system which would support all 90 min maintaining full strength. By comparing the relative values, it can be noted that there are statistically significant differences between the volleyball and handball players, which indicates that VO2 max values also depend on the kind of sport. The data presented by Živanić, related to physiological profile of handball players, show that the average distance made during the match by our first league handball players is 8-12 km, with aerobic/ anaerobic ratio 90% :io % (12). By measuring the maximal oxygen uptake, Diaz et al. obtained the value of 53,8 ml/kg/min, determining thus VO2max in the handball players of the First Mexican league. Based on such results, they emphasized the need to improve those values in order to achieve better results on the international level (7). Wisloff et al. have investigated two Norwegian teams from profe-ssional league, and obtained the value of 60 ml/ kg/min (8). The investigations of Cajasus have shown that the value of VO2max reached 66,4 ml/ kg/min in handball players of the Spanish first league (13). Therefore, based on the results obtained on maximal oxygen uptake, we can explain the success in the investigated sports teams, i.e. handball and volleyball players and their ranking during competitions. Having com-pared the functional parameters and levels of competition, it was determined that handball players of the Union of Serbia and Montenegro's first league had statistically significantly higher VO2max values (53,8 vs. 44,8 ml/kg/min) compared to amateur handball players (14). In our investigation, the volleyball players had lower VO2max values in comparison with the handball players (45,50 ml/kg/min), which can be explained by aerobic character of this sport. On average, the group of non-athletes had the poorest results (41,53 ml/kg/min), which was expected having considered the influence of training on aerobic capacity (15,16).

Conclusion

The investigation into the maximal oxygen uptake provides the relevant data on the health of players, planning and follow-up of the training effects, also being useful for early selection of athletes. For these reasons, the increase in VO2max values as indicators of physical capability of athletes is indispensable for achieving the top sports results. Our results show that the highest VO2max values were obtained in the handball players, and that handball as a sport requires higher degree of endurance compared to volleyball. Taking into consideration the morphological and functional changes as the consequence of the training process, it can be concluded that VO2max values are statistically significantly higher in the groups of athletes compared to the group of non-athletes.

References

1. Bowers RW, Fox EL. Sports Physiology. 3rd ed. Boston: McGraw-Hill; 1988.
2. Živanić S, Životić VM, Mijić R, Dragojević R. Aerobna sposobnost i njena procena Astrandovim testom opterećenja na bicikl-ergometru. Beograd (Serbia): Udruženje za medicinu sporta Srbije; 1999.
3. Fletcher GF, Balady G, Froelicher VF, Hartley LH, Haskell WL, Pollock ML. Exercise standards. A statement for healthcare professionals from the American Heart Association. Writing Group. Circulation. 1995; 91(2): 580-615. [CrossRef] [PubMed]
4. Ponorac N, Matavulj A, Grujić N, Rajkovača N, Kovačević P. Maksimalna potrošnja kiseonika (VO2max) kao pokazatelj fizičke sposobnosti sportiste. Acta Medica Medianae. 2005; 44(4): 17-20.
5. Wilmore HJ, Costill LD. Physiology of sport and exercise. 2nd ed. Champaign IL: Human Kinetics; 1999.
6. Shephard RJ. Biology and medicine of soccer: an update. J Sports Sci. 1999; 17(10): 757-86. [CrossRef] [PubMed]
7. Reilly T, Bangsbo J, Franks A. Anthropometric and physiological predispositions for elite soccer. J Sports Sci. 2000; 18(9): 669-83. [CrossRef] [PubMed]
8. Melo RS. Qualidades Fisicas e Psicologicas e Exeraaos Tecnicos do Atleta e Handebol. Rio de Janeiro: Sprint; 1997.
9. Živanić S, Životić VM, Malićević S, Mijić R, Ostojić S, Bogdanović S. Morfofunkcionalne karakteristike prvoligaških rukometaša u SCG [abstract]. Prvi srpski kongres sportskih nauka i medicine sporta. 2003; Beograd (Serbia). 2003. Serbian
10. Casajús JA. Seasonal variation in fitness variables in professional soccer players. J Sports Med Phys Fitness. 2001; 41(4): 463-9. [PubMed]
11. Ostojić S, Mazić S, Dikić N, Velkovski S. Physio logical profile of elite serbian handball players [abstract]. Risk factors and health: From molecule to the scientific basis of prevention. 2003; Zrenjanin (Serbia). 2003.
12. Chamari K, Hachana Y, Kaouech F, Jeddi R, Moussa-Chamari I, Wisløff U. Endurance training and testing with the ball in young elite soccer players. Br J Sports Med. 2005; 39(1): 24-8. [CrossRef] [PubMed]
13. Cheng YJ, Macera CA, Addy CL, Sy FS, Wieland D, Blair SN. Effects of physical activity on exercise tests and respiratory function. Br J Sports Med. 2003; 37(6): 521-8. [CrossRef] [PubMed]

VREDNOSTI AEROBNOG KAPACITETA KOD RUKOMETAŠA I ODBOJKAŠA

Vesko Milenković, Biljana Vitošević, Hadži Miloš Vidaković, Gorana Ranković-Nedin, Jasmina Ranković

Fizički kapacitet sportista je važan element uspeha u sportskim dostignućima. Aerobni kapacitet je prihvaćen kao njegova glavna komponenta. Većina autora smatra da je maksimalna potrošnja kiseonika (VO2max) najbolji pokazatelj aerobnog kapaciteta organizma, a istovremeno i najbolji pokazatelj fizičke sposobnosti sportiste. Cilj istraživanja bio je da se analizira aerobni kapacitet kao pokazatelj fizičke sposobnosti, razlike u njihovim aerobnim kapacitetima u zavisnosti od sporta kojim se bave, kao i razlike dobijene kada ih uporedimo sa fizički neaktivnim osobama. Ispitivanjem je obuhvaćeno određivanje apsolutnog i relativnog VO2max kod ukupno 70 ispitanika muškog pola. Ispitanici su bili podeljeni u dve grupe aktivnih sportista (rukometaši n=24 i odbojkaši n=20) različitih profila, dok je treća grupa nesportista služila kao kontrolna grupa. Maksimalna potrošnja kiseonika određivana je izvođenjem Astrandovog šestominutnog testa vožnje bicikla. Najviše vrednosti VO2max zabeležene su kod grupe rukometaša (4,27±0,29 l/min) i one su bile statistički značajno veće ($p<0,001$) u poređenju sa drugim grupama. U grupi odbojkaša maksimalna potrošnja kiseonika bila je 39,8±0,19 l/min, dok su statistički niže vrednosti zabeležene u grupi nesportista u odnosu na grupe sportista $p<0,01$. Sličan odnos VO2max vrednosti takođe je prikazan i analizom vrednosti izražene u relativnim jedinicama. Naši rezultati su pokazali da su najviše vrednosti VO2max postignute kod rukometaša i da rukomet kao sport zahteva veći stepen izdržljivosti u odnosu na odbojku. Razmotrivši morfološke i funkcionalne promene koje su posledice treninga, može se zaključiti da su VO2max vrednosti statistički značajno veće kod grupe sportista u poređenju sa grupom nesportista. *Acta Medica Medianae 2013;52(4):35-38.*

Ključne reči: *sportisti, maximalna potrošnja kiseonika, Astrand test*

