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Review article

IMPORTANCE OF CARDIORESPIRATORY ENDURANCE IN MALE HANDBALL PLAYERS

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Abstract. *Handball is a complex game which requires a series of different abilities while the fact that different players' positions in the field require different characteristics and abilities hinders the defining of the morphofunctional model of ideal handball player. Unlike the anthropomorphological profile, the functional model of a handball player is not even close to being clearly defined. The basis for assessing the optimal level of cardiorespiratory endurance in handball players is the definition of the duration of certain levels of load during a handball match, including the physiological requirements that the player needs to fulfill. The level of cardiorespiratory (aerobic) endurance plays an important role in inducing and controlling the desirable physiological adaptations during a training process. Previous scientific results indicate that cardiorespiratory endurance does not represent a limiting factor for high performance of handball players during a competition. However, a good aerobic preparation allows an efficient process of recovery during the period between high intensity activities. Knowing the individual cardiorespiratory endurance of handball players is the foundation for enhancing their abilities and competition results by means of sports training.*

Key words: *handball, cardiorespiratory endurance, adaptation, training.*

INTRODUCTION

Cardiorespiratory or so-called aerobic endurance represents the main defense of athletes against exhaustion. A low endurance capacity leads to fatigue, even in terms of sports and activities with lower dynamics levels. Regardless of the type of sport or activity, fatigue is a major obstacle to optimal performance for any athlete. Even minor fatigue may hinder the overall achievement of athletes because of decreased muscle strength, extended reaction time and movement, reduced agility and neuromuscular

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coordination, reduced speed of the whole body and reduced concentration and dexterity (Radovanovic, 2013). Knowing the individual cardiorespiratory (aerobic) endurance of athletes is the foundation for training skills and competition results enhancement. This can be achieved through continuous maintenance in terms of increasing competition capacities, while avoiding detraining because of under-dosed training or the occurrence of the overtraining syndrome and/or possible injuries in case of excessive training loads (Radovanovic, 2013).

Even though the first records of any game similar to that of handball originate from medieval France, a game that later in 1898 originated in Denmark is considered to be the ancestor of today's handball. During the 20^{th} century, original handball has suffered many modifications, and today's sports hall version of the game (European handball) became the constituent part of the Olympic Games program in Munich in 1972.

Success in practicing a certain sport depends on the specific morphological, motor, functional, cognitive, conative and sociological characteristics of an individual. Handball is a complex game that requires a whole range of different abilities, and defining a morphofunctional model of an ideal game of handball is aggravated by the fact that different playing positions require different features and skills. Nevertheless, regardless of the position of a player, the anthropomorphological profile of contemporary handball player particularly distinguishes the body height and body weight, followed by the arm span and the size of the hand. The average height of elite handball players at the World Cup in 2007 was 186.4 cm (190 cm on average in the top-three teams), while at the Junior World Cup in the same year it totaled 187.5 cm (191.3 cm on average in the top-three teams) (Táborský, 2007). The data from the last World Cup held in 2013 indicate that the average height of the players in the four most successful teams was 193.2 cm, and their average weight amounted to 95.74 kg (Ghobadi, Rajabi, Farzad, Bayati, & Jeffreys, 2013). This information confirms the claim that morphological evolution in this sport takes place in the direction of the increase in bodily dimensions and that the somatic requirements of top-level team handball refer to body heights of over 190 cm, body weights between 90 kg and 100 kg (with the least possible percentage of body fat), and depending on the playing position, the mesomorphic to ectomorphic body type. Additionally, it is preferable to have longer upper limbs that contribute to maximizing the speed of the throw, as well as a larger arm span, and also hands that allow better control of the ball in terms of the passing, receiving, dribbling and throwing. Unlike their anthropomorphological profile, the functional model of handball players is not nearly as clearly defined.

CARDIORESPIRATORY ENDURANCE OF HANDBALL PLAYERS

Handball is a complex game which requires a high level of motor and metabolic potentials of the participants. This intermittent sport is characterized by aerobic movements at different speeds accompanied by a variety of highly intense (anaerobic) movements, such as throwing, accelerating, turning, jumping, pushing and holding during mutual matchups, all of which require a high level of both general and specific fitness. The basis for assessing the optimal level of cardiorespiratory endurance of handball players is defining the duration of the specific load level during a handball match and the physiological requirements that a player should meet.

In a study conducted by Gorostiaga, Granados, Ibanez, Gonzales-Badillo, & Izquierdo (2006) in an official handball match, handball players spent an average of 25 to 30 minutes, covering a distance between 1.1 km to 3 km and consuming up to 800 calories. The effective duration of a handball match is approximately 40 minutes and during that time approximately 50 defenses and attacks take place, which usually last 20 to 35 seconds each (Boraczyński & Urniaż, 2008). A time-motion analysis of matches at the Men's World Team Handball Cup in 2007 revealed that handball players, according to their playing positions, covered an average of 2 km to 3.7 km, wherein 34.3% of the total distance covered consisted of walking, 44.7% of jogging, 17.9% of fast running and 3.0% of sprinting (Ziv & Lidor, 2009). In the research of Povoas, Seabra, Ascensao, Magalhaes, Soares, & Rebelo (2012) a time-motion analysis of 10 official matches was conducted, in which the average movement of players amounted to 4.37 km, whereas sprinting made up a mere 0.4% of the total movement.

In one of the first targeted studies of the physiological demands of the game of handball, Delamarche, Gratas, Beillot, Dassonville, Rochcongar, & Lessard (1987) monitored the production of lactate in seven young handball players during a friendly match, taking blood samples every 5 minutes. The maximum observed heart rate was 190 beats·min^{-1} and the level of lactate was 7.5 mmol·L^{-1}. These handball players were running from 20 to 30 min with lactate levels higher than 4 mmol·L^{-1}.

In the research conducted by Povoas, Seabra, Ascensao, Magalhaes, Soares, & Rebelo (2012), the heart rate frequency of handball players during matches was monitored by means of two indicators, due to many changes that the rules of the game permit. Effective heart rate frequency indicated the average heart rate frequency during the time the handball players spent on the field, whereas the total heart rate frequency indicated the average frequency during the entire match. In the research in question, the values of effective frequency were 157 beats ·min^{-1}, which equaled 82% of the maximum estimated frequency, whereas the value of the total frequency was 139 beats·min^{-1}. The 10% difference between the average effective and the total frequency, the authors explained with higher values of heart frequency on the court compared to the time spent on the bench. Despite the fact that the analysis of movement during the match showed that the players spent more than half of the effective duration of the match (approximately 53%) in low intensity activities, only during approximately 7% of the total duration of the match did the players have a hear rate frequency lower than 60% of the value of maximum estimated heart rate frequency. These results indicate that muscle contractions during physical contact, one-on-one technical and tactical requirements set by the coach directly influence the increase in the heart rate frequency of the players. Physiological variables may significantly differ with regard to players' positions, just like anthropometric and physical characteristics. On the other hand, the results of the latest studies show that there are differences in anaerobic capacity parameters among players of different competition levels (average strength during anaerobic tests) and explosive force tests (Nikolaidis & Ingebrigtsen, 2013).

The research which was directed towards cardiorespiratory endurance in male handball players of different competition levels, while running at the speed of 10,12,14 and 16 km ·h^{-1}, did not find any differences concerning the value of lactate concentration in the blood or the average value of heart frequency between top team and amateur male handball players (Gorostiaga et al., 2005). In a similar study, the average values of running speed and heart rate frequency, which caused the production of lactate concentration in the blood of a value of 3.0 $mmol \cdot l^{-1}$, were similar in elite and amateur male handball players, which confirms that cardiorespiratory endurance, as a separate physiological characteristic, cannot be used for the evaluation of the competition level in male handball players. Moreover, the authors determined that in elite players, during the season, no significant changes occur in terms of cardiorespiratory endurance when running at the speed of 10, 12, 14 and 16 $km \cdot h^{-1}$ (Gorostiaga, Granados, Ibanez, Gonzales-Badillo, & Izquierdo, 2006).

In a detailed research, Ziv & Lidor, (2009) revealed data stating that the value of maximum oxygen consumption – VO_{2max} in male handball players is very similar to the one in male basketball players (50–60 $ml \cdot kg^{-1} \cdot min^{-1}$), which is insignificantly less than the values in men between the ages of 20 and 29, which are used as a general standard for physically active individuals (Whaley, Brubaker, & Otto, 2006). The stated values indicate that these physiological characteristics cannot be used to differentiate between elite male handball players and those who are not. Similar data related to VO_{2max} (an average of 58 $ml \cdot kg^{-1} \cdot min^{-1}$) were revealed in the research of Sporiš, Vuleta, Vuleta, & Milanovic, (2010). Apart from that, the researchers established a significant difference between wing players and pivots players which they explained with a far greater distance that wing players cross during an average match, especially when it comes to quick changes between attack and defense plays. Although recent studies reveal that VO_{2max}, that is cardiorespiratory endurance, is not very significant in achieving success in team sports with a ball (Gorostagia et al., 2006; Ziv & Lidor, 2009), a weak aerobic component could be a limiting factor in the process of achieving maximum results. High VO_{2max} does not ensure success in repeated sprints and duels, but VO_{2max} must optimally be developed so as to ensure the maintenance of the high level of activity during the entire match, without showing excessive exhaustion.

CARDIORESPIRATORY ENDURANCE AND OXIDATIVE STRESS IN HANDBALL

Team sports played with a ball, such as handball, basketball and football are characterized by aerobic phases, which include intermittent movements and running at different speeds, as well as by anaerobic phases which include sprints and jumps, and so require both aerobic and anaerobic sources of energy. There are not many studies that focus on oxidative stress caused by this kind of training and competition physical load. In spite of the fact that the effects of physical exercise on oxidative stress have been extensively studied for more than three decades, there is still not enough scientific information related to oxidative stress, especially the one caused by aerobic-anaerobic sports such as handball (Djordjevic et al., 2011; Stankovic & Radovanovic, 2012). Previous studies have shown that simultaneous cardiorespiratory endurance and muscle strength training leads to an increase of the maximum oxygen consumption and anaerobic capacity, but causes a disbalance between the reactive types of oxygen and anti-oxidative systems in the body (Radovanovic et al., 2009). Recently published studies show that male handball players, when not active, have higher levels of superoxide-dismutase (Djordjevic et al., 2011; Djordjevic et al., 2012a), higher levels of reduced glutathione and nitric oxide and lower levels of lipid peroxidation in comparison to those who do not practice sports (Djordjevic et al., 2012a), whereas the levels of catalase activity in one study were lower in athletes (Djordjevic et al., 2011), while in another one higher values in comparison to non-athletes were recorded (Djordjevic et al., 2012a). In one study, nonspecific intensive activity, such as the maximum progressive ergocycle test, induced oxidative stress in young male handball players (Djordjevic et al., 2012b). The usual individual handball training led to the decrease in the level of superoxide-dismutase activity, whereas there were no changes in the level of other endogenic antioxidants, or in the oxidative stress parameters, which suggests that the first line of anti-oxidative defense was sufficient to prevent the onset of oxidative stress (Djordjevic et al., 2012b). The joint conclusion of both studies including young male handball players is that the overall period of time they spent training does not influence the morpho-functional characteristics and redox balance of young athletes; however, the other two elements of the training status – training load structure and the cardiorespiratory endurance level play an important role in the process of inducing and controlling the desired physiological adaptations. Moreover, the aimed studies showed that an individual handball match (Marin, dos Santos, Bolin, Guerra, Hatanaka, & Otton, 2011), as well as creatinine supplementation in combination with specific training endurance (Percário et al., 2012), induce oxidative stress in male handball players. During the monitoring of male handball players in one season, in the period of the most intensive training and competitions, the increase in the oxidative stress parameters in blood plasma was recorded, whereas a decrease was noted in the erythrocytes (Marin, Bolin, Campoio, Guerra, & Otton, 2013).

CONCLUSION

Scientific discoveries have so far lead to the conclusion that cardiorespiratory endurance is not a limiting factor in the competition performance of male handball players. However, the level of cardiorespiratory endurance plays an important role in inducing and controlling the desired physiological adaptations during the training process. Future studies should be directed towards the precise determination of minimum cardiorespiratory endurance values which the players should reach and maintain, as an important prerequisite for an optimal competition level. Taking into consideration the intermittent change in low and high intensity activities, it can be concluded that it is of the utmost importance that players produce greater muscle strength in a short period of time, which emphasizes the significance and importance of anaerobic capacity. In addition, a good aerobic preparation enables an effective recovery process during periods between high intensity activities.

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ZNAČAJ KARDIOREPIRATORNE IZDRŽLJIVOSTI KOD RUKOMETAŠA

Rukomet je složena igra koja zahteva čitav niz različitih sposobnosti, a definisanje morfo-funkcionalnog modela idealnog rukometaša otežano je činjenicom da različite igračke pozicije zahtevaju različite karakteristike i sposobnosti. Za razliku od antropomorfološkog profila, funkcionalni model rukometaša nije ni približno jasno definisan. Osnova za procenu optimalnog nivoa kardiorespiratorne izdržljivosti rukometaša je definisanje trajanja određenih nivoa opterećenja tokom rukometnog meča i fizioloških zahteva koje igrač treba da ispuni. Nivo kardiorespiratorne (aerobne) izdržljivosti igra značajnu ulogu u indukovanju i kontroli poželjnih fizioloških adaptacija tokom trenažnog procesa. Dosadašnja naučna saznanja upućuju na zaključak da kardiorespiratorna izdržljivost nije limitirajući faktor za visoki takmičarski učinak rukometaša. Međutim, dobra aerobna pripremljenost omogućava efikasan proces oporavka tokom perioda između aktivnosti visokog intenziteta. Poznavanje individualne kardiorespiratorne izdržljivosti rukometaša je osnova da se treningom unaprede sposobnosti i takmičarski rezultati.

Ključne reči: *rukomet, kardiorespiratorna izdržljivost, adaptacija, trening*.