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THE RELATIONSHIP BETWEEN AEROBIC CAPACITY AND MATCH PERFORMANCE IN TEAM-HANDBALL

ODNOS MED AEROBNO SPOSOBNOSTJO IN USPEŠNOSTJO NA TEKMI V EKIPNEM ROKOMETU

ABSTRACT

The aim of this research was to determine the relationship between aerobic capacity and match performance of elite handball players. A total of 12 male handball players who competed in the male super league had participated in the study as volunteers. The participants' mean age was 25.25±2.76 years, height was 188.3±4.8 cm and weight was 90.00±6.22. All participants had a training experience over 7 years. For measuring aerobic capacity, the Cooper 12-minute run-walk test was performed. To determine the match performance of players, *"Performance Appraisal Inventory in Handball"* developed by Ulrich was used. Study results show that there was a relationship between aerobic capacity and match performance of participating handball players. Our findings indicated that athletes with high positive score have higher match performance and aerobic capacity. As a result, aerobic capacity may use as a predictor of the match performance in team-handball.

Keywords: sport, handball, aerobic capacity, performance

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IZVLEČEK

Cilj te raziskave je bil opredeliti odnos med aerobno sposobnostjo in uspešnostjo na tekmi pri vrhunskih rokometaših. V raziskavi je prostovoljno sodelovalo skupno 12 rokometašev, ki so tekmovali v moški superligi. Povprečna starost merjencev je bila 25,25 ± 2,76 let, višina 188,3 ± 4,8 cm, teža pa 90,00 ± 6,22 kg. Vsi merjenci so trenirali več kot sedem let. Za merjenje aerobne sposobnosti smo izvedli Cooperjev 12-minutni test teka in hoje. Uspešnost igralcev na tekmi smo določili s pomočjo vprašalnika za ocenjevanje uspešnosti v rokometu »*Performance Appraisal Inventory in Handball*«, ki ga je razvil Ulrich. Rezultati študije so pokazali, da je pri sodelujočih rokometaših obstajal odnos med njihovo aerobno sposobnostjo in uspešnostjo na tekmi. Naši izsledki so pokazali, da so športniki z visokim pozitivnim rezultatom bolj uspešni na tekmi in imajo večjo aerobno sposobnost. Iz tega sledi, da se lahko v ekipnem rokometu aerobna sposobnost igralca uporabi kot element napovedi njegove uspešnosti na tekmi.

Ključne besede: šport, rokomet, aerobna sposobnost, uspešnost

INTRODUCTION

Team-handball is a dynamic team sport that played at high speed and incorporates elements physical, mental, technical and tactical. It requires a high-level athletic performance to be successful (Eler and Bereket, 2001). Athletic performance is affected by many factors such as; strength, speed, endurance, and mobility. These basic motoric features must be at an optimal level to carried out at the highest level of athletic performance. (Bompa, 1994; Günay, 1998). Match duration in team-handball is typically 60 min and can increase. Because of the long duration of the game, endurance plays an important role for successful performance. Therefore, cardiorespiratory and muscular endurance are necessary for the high-level athletic performance. Aerobic capacity is considered an important determinant of endurance performance during prolonged and sub-maximal exercise (Astrand and Rodahl, 1977; Günay 1998; Koç, 2010).

Aerobic capacity is defined as the cardiac functional capacity and the amount of oxygen consumed in one minute during maximal exercise. The terms of maximal aerobic capacity, cardiorespiratory endurance, oxygen uptake and oxygen consumption (VO_{2max}) are used synonymously in sports sciences (Baker, Rambsbottom and Hazeldine, 1993; McManus, Armstrong, and Williams, 1993). VO_{2max} has been defined as the maximum amount of oxygen consumed per kilogram of the body mass per minute (ml/kg/min) (Hartung, 1995). High-level performance in team-handball depends on athletes' energy capacity. Athletes' energy demands were met through the anaerobic and aerobic energy pathway. To compete at a high level, players must have high aerobic power (VO_{2max}). Aerobic power is highly effective on the athletic performance in the team-handball that requires the prolonged physical activities executed at a sub-maximal intensity such as; walking, jogging and moderate running. It is considered one of the basic factors for high-level physical performance in team-handball (Clanton and Dwight, 1996; Barth and Nowak, 2009; Wagner, Finkenzeller, Würth, and von Duvillard, 2014). However, several previous studies in the team-handball have mostly focused on the influence of anaerobic capacity on athletic performance (Bhadu and Singh, 2016; Karadenizli, 2016; Nikolaidis and Povoas, 2013). A few studies indicated that team-handball players with higher aerobic capacity generally have a lower fatigue index. Obviously, fatigue has a negative impact on the dribbling, holding, throwing, passing and catching performance or accuracy besides running in a team-handball game (Balasubramaniana and Chittibabu, 2014). For this reason, the relationship between AC and performance is an important issue that should be investigated.

During a match of team-handball, players demonstrate a variety of physical performance characteristics for the specific movements patterns; checking, catching, passing, throwing, blocking e.g. and basic movement patterns; running, jumping, pushing, change of direction (Michalsik, Madsen and Aagaard, 2012; Povoas et al., 2012). Therefore, it can be difficult to observe these movement patterns in team-handball. Recent years, computerized video analysis methods (CVAM) have been used to analyze the movement patterns and performance of players during a match. This method has been successfully used to detect numerous skills and movements patterns quickly and objectively. In this way, CVAM provides feedback and data for evaluating the match performance of players. These data are valuable both coach and players for further performance improvement (Barris and Button, 2008; Chelly et al., 2011; Tallie et al., 2003).

In the literature, previous studies revealed that both aerobic and anaerobic capacity had a critical role in the handball players' performance (Bhadu and Singh, 2016; Balasubramaniana and Chittibabu, 2014). However, there is a need for additional studies to understand how these factors

effects on the players' performance during a match-play. To make an accurate inference, it is more important the evaluating handball players' specific and basic movement patterns within the context of the game, rather than evaluating their performance outside the game. To this end, we investigated the relationship between aerobic capacity and match performance of elite team-handball players.

METHODS

Participants

The study sample was composed of 12 male team-handball players who compete in Turkish Male Super Handball League had participated in the study as volunteers. Goalkeepers were excluded from the study. Characteristics of participants are described in Table 1. The mean age of participants was 25.25±2.76 years, mean height was 188.3±4.8 cm and means weight was 90.00±6.22.

Table 1. Characteristics of the players.

Variables	n	Min.	Max.	Mean	SD
Age (year)	12	22.00	32.00	25.25	2.76
Height (cm)	12	180.00	198.00	188.08	4.88
Weight (kg)	12	80.00	102.00	90.00	6.22

Study procedure

This study was carried out during the 2014-15 season in Turkish Male Super Handball League. All procedures were conducted in accordance with the Declaration of Helsinki. All anthropometric measurements were taken using standardized techniques and calibrated equipment. Body height was measured using a stadiometer (Seca 214, Germany) calibrated in millimeters and weight was obtained using a balance beam scale (Seca 700, Germany). Aerobic capacity was tested using Cooper 12 min run/walk test. The test was performed on a 400 m tartan athletics track, under the same environmental conditions (at air temperature 22°C and with 55% relative humidity) in the morning. Prior to tests, the all players warmed up for 10 minutes. Participants' running distance was determined at the end of 12 min running, and aerobic capacity was derived from the Formula of Balke [VO_{2max} = 33.3 + (X* - 150) x 0.178)].

The competition performance data in this study have been taken directly from analysis of the video records. Video recordings were collected using two professional cameras (HXR MC2500; Sony, Tokyo, Japan). The game activities of players were monitored from video tapes for the analysis of the match performance according to CVAM. Competition performance was analysed using were "Performance Appraisal Inventory in Handball" This inventory was developed to evaluate the in-game performance of players during a match by Ulrich (1998). In the inventory is calculated the in-game performance score of players based on the positive and negative scores according to handball-special tasks. The inventory forms were filled by two experts and coaches who watching video tapes. The experts had experience in the use of CVAM and coaches had a minimum of 10 years' experience as a team-handball. The video tapes were reanalysed and re-scored 20 days following the initial analysis to assess intra- and inter-observer variation. Detailed information about the task variables and scores in the inventory form are presented in Table 2.

Table 2. Positive and negative task scores according to performance appraisal inventory in handball.

Positive Task	Score	Negative Task	Score
Playmaker goal	1.0	Failed block	-0.4
Ignored 2 min penalty	0.7	Turnovers	-0.4
Close range goal	0.6	Back shot of wasted space	-0.4
Help with prevent goals	0.5	Wasted castle close shot	-0.6
Shot from close range that led to the castle assists	0.4	Yellow cards that 2 minutes time penalty	-0.8
Successful blocks	0.4	Binary combat loss	-0.8
Taken 7m penalty shot	0.4	Incorrect turnovers that led to the shooting castle	-0.8
winning ball	0.2	Not leading to 7m shots	-0.8
Gaining shot 7m	0.2		

According to "Performance Appraisal Inventory in Handball", performance index scores were calculated by using the Taborsky formula "Vi = □ Pi + (1/2 Mi) + □ Ni" (Taborsky, 2007).

"***Vi;*** *Competition Performance Score,* □***Pi;*** *Total of the positive score,* ***(½Mi);*** *Played half the time,* □ ***Ni;*** *Total of the negative score"*

Statistical analysis

Statistical analyses were performed using the SPSS software. Measurement results were presented in mean (M) and standard deviation (S_D). The Shapiro-Wilk test was used to determine if dependent variables were normally distributed. The relationship between the aerobic capacity and the competition performance was determined by the Pearson correlation coefficient. The Pearson correlation coefficients were classified into three levels: high correlation (>0.50), medium correlation (>0.30 – 0.49), and low correlation (≤0.30). Intra- and inter- observer agreement were evaluated using Cohen's κ statistic (κ). Significance level $p<0.05$ was used in all statistical analyses.

RESULTS

In order to validate the observations, it was calculated Cohen's κ statistic. The κ statistic for performance appraisal inventory in handball demonstrated a very good level of agreement for intra and inter observer reliability ranged from 0.86 to 0.91 (Table 3).

Table 3. Intra- and inter- observer agreement in the performance appraisal inventory

Kappa Score (κ)	
Intra-observer agreement (1. observer group)	0.90
Intra-observer agreement (2. observer group)	0.91
Inter-observer agreement	0.86

Note. κ ≤ 0.40 poor, κ = >0.40 to ≤ 0.60 moderate, κ > 0.60 to ≤ 0.80 good agreement, κ > 0.80 very good agreement.

According to the data from Table 4, it was seen that players' the mean of the positive score were higher than negative scores. The mean of players' played time was 28.08±3.9 min (ranged 15-40

min) and competition performance score was 16.3±6.59. Our statistical analysis indicated that the mean maximum aerobic capacity (VO_{2max}) of the players was 45.9±4.21 $ml.kg^{-1}.min^{-1}$.

Table 4. The game performance data of players.

Variables	n	Min.	Max.	Mean	SD
Positive score (□Pi)	12	2.10	12.30	6.95	2.90
Negative score (□Ni)	12	1.80	9.80	4.69	2.79
Played time (min)	12	16.00	40.00	28.08	3.90
Competition performance score (Vi)	12	-3.70	20.50	16.3	6.59
VO_{2max} (ml.kg-1.min-1)	12	39.23	51.10	45.90	4.21

Table 5 indicates the Pearson correlation coefficient between aerobic capacity and competition performances of players. Aerobic capacity has relative strong correlation with negative performance scores *(r = -0.732, p = .007)* and Vi *(r = 0.726, p = .008).* As shown in Table, Vİ has the highest correlation coefficients Σ*Ni (r = -0.914, p = .0001),* 1/2Mi *(r = -0.839, p = .001)* and ΣPi *(r = -0.827, p = .001)* respectively.

Table 5. Pearson correlation coefficient analysis of aerobic and competition performance parameters.

Variables		□Pi	ΣNi	1/2Mi	Vi	AC
□Ni	r	**-.583***	-	-	-	-
	p	**0.047**	-	-	-	-
1/2Mi	r	0,471	**-0,791****	-	-	-
	p	0,122	**0,002**	-	-	-
Vi	r	**0,827*****	**-0,914*****	**0,839*****	-	-
	p	**0,001**	**0,000**	**0,001**	-	-
VO2max	r	0.575	**-0.732****	0.549	**0.726****	-
	p	0.051	**0.007**	0.065	**0.008**	-

Note. * = p ≤ .05, **= p ≤ .01, ***= p ≤ .001. n = 12 for all analyses.

DISCUSSION & CONCLUSION

In this study, we examined the relationship between match performance and aerobic capacity of team-handball players. It is a prerequisite for success in the modern team-handball for the elite player to have high-level endurance. This means players must possess high anaerobic and aerobic endurance fitness. Several previous studies have suggested that success in team-handball appears to include not only anaerobic capacity but also high aerobic capacity (Ilic, Ranisavljev, Stefanovic, Ivanovic and Mrdakovic, 2015; Pavlović and Radovanović, 2014). VO_2max is one of the most important indicators of aerobic endurance fitness (Clanton and Dwight 1996). Previous similar research usually used VO_2max as an indicator of the aerobic capacity of team-handball players (Balasubramaniana and Chittibabub 2014; Singh, Bhagat and Singh, 2016). The mean VO_2max of elite team-handball players is normally reported to be between 40 and 60 $ml.kg^{-1}.min^{-1}$ (Ilic et al., 2015; Singh et al., 2016; Wagner et al., 2014). When our results are compared with reference values, the mean VO_2max of our sample (55.9±4.21 $ml.kg^{-1}.min^{-1}$) is between reference range. This is an expected result because our sample was comprised of elite players.

In this study, the main hypothesis was whether there is a relationship between aerobic capacity and match performance of players. Our findings indicated that there was a strong positive correlation (r = 0.726) between these variables. Players with high positive score have higher competition performance score and aerobic capacity (VO_2max). Some research reported that the energy requirements of handball players were provided by anaerobic (%80) and aerobic (20%) system metabolism (Bompa, 1994; CASN, 2017). According to this knowledge, anaerobic system is the dominant energy system, but handball is an intermittent sports discipline and both aerobic and anaerobic capacity is important for successful performance in team handball. Elite handball players must have high-level aerobic capacity being another component of endurance (Clanton and Dwight, 1996; Koc, 2010; Michalsik, Madsen and Aagaard, 2015). Previous studies revealed that the low aerobic capacity promotes the fatigue for handball players. The high fatigue and low aerobic endurance can negatively impact on the mental and physical performance of players over time in a team-handball match. Therefore, the dribbling, holding, throwing, passing and catching performance or accuracy rate of players who had a low aerobic capacity comes down (Balasubramaniana and Chittibabu, 2014; Chittibabu, 2013; Ronglan et al., 2006). Futhermore, Pavlović and Radovanović (2014) reported that individual aerobic endurance of handball players plays a key role in enhancing their abilities and match results by means of sports training. In this context, the finding of this study accordance with the previous scientific reports.

The present study had been concluded that the increased level of aerobic fitness is associated with increased match performance in team-handball. Aerobic capacity may use as a predictor of the match performance in team handball. It is possible to conclude that if handball players can increase their aerobic capacity, they would show a higher level of match performance. Similar studies would be helpful to coaches and players both in perfecting technical–tactical skills and in optimizing techniques and training to maintain optimum performance during a game. We believe our findings contribute meaningfully to the literature, but there are limitations of our study. First, our sample associated with this investigation was small and relatively homogenous. A larger number of samples are needed to analysis according to the playing positions of the handball players and other variables. Second, as in other research using the notational analysis method, our findings may be influenced by expectations and motivations of observers. Lastly, the match performance of the players is influenced by many factors such as tactic, motivation, team performance, and ambiance. Therefore, it should be examined in the different variables other than the variables of the performance appraisal inventory in handball. Future studies should include a larger sample and should examine the relationship between the match performance and aerobic capacity of players according to the playing position.

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