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Original research article

PHYSICAL PERFORMANCE MODELING AMONG YOUNG BASKETBALL AND HANDBALL PLAYERS

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Abstract. *The aim of the present study was to define a model of the physical performance of fourteen-year-old quality basketball and handball players. Forty-four boys took part in this study: 20 basketball players (average age 14.4 ± .31) and 24 handball players (average age 14.5 ± .41). In order to assess the morphological status of the athletes we applied four, and for motor status assessment, 10 variables. The Yo-Yo test was used to estimate athletes' functional status. By arithmetic means, we presented a model of the desirable physical performances of basketball and handball players. The t-test for independent samples was used to determine the significance of the differences between the two groups of athletes. The basketball players had better results on all 15 tests, although the difference is statistically significant in 11 tests. The difference in quality was explained by the fact that basketball is three times more popular among children than handball, and the lack of sports halls in Bosnia and Herzegovina with a proper size for a handball court.*

Key words: *puberty, training, testing, selection*

INTRODUCTION

Children and youths develop at a different pace. The coaches should consider individual maturation of each athlete, and therefore, adjust the training plan and program as well as any competition activities (Bompa, 2000). Growth and development is a turbulent and complex phenomenon, but a regular process where many principles can be defined. The individuality of the rate of change raises particular interest, especially in

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regards to demands that sports training exerts on the body (Komeš, Pavlov, Štefanić & Smiljanec, 2005). Individual differences in the dynamics of growth are a significant source of form variability, functions, and capabilities of the human body. During growth, a child or adolescent's body goes through a period of high intenstiy, when important physiological changes occur and the body bears physical effort differently. Sports training, if it is well selected, designed, and quantified, can be a stimulating factor in development, but excessive and age-inappropriate training could have negative effects (Mišigoj-Duraković & Matković, 2007). The beginning of the adolescent growth spurt and the year of the biggest height growth are indicators of a child's maturation. Children who enter puberty earlier than average child are called accelerants. Opposite to them there are children who enter puberty later than the average child does. This is very important because accelerants, at that time, have more developed motor and functional abilities than their peers, thus they have a potential advantage in the selection process (Vučković, Kukrić, Petrović & Dobraš, 2013). Knowledge about an athlete's physical, mental, and social characteristics in the initial phase, sport-shaping phase, and during specialization provides better guidance in training that can improve their development and lead to top-level results. Basic anthropological characteristics are elemental human capacities that enable the optimal functioning of athlete's organs and systems of organs, as well as the abilities and features that have a significant influence on success and quality performance in sport. During one's sports career, they develop under the influence of the biological determinants of growth and development, and the process of sports preparations. Programmed training easily influences most of them, in accordance with their genetic basis. However, it means that some of them cannot be influenced from the outside (height, bone diameters). Other characteristics can be influenced to some extent (personality traits, speed). The rest of the anthropological characteristics are prone to major changes under the influence of other factors during a sports career (Milanović, 2010). The significance of an athlete's body height and length of their other body parts for performance is commonly recognized in sports games (Alexander, 1976). Training can have an impact on muscle mass, the development or reduction of subcutaneous fatty tissue, while some morphological features, like longitudinal and transversal bone measures cannot be altered by training (Milanović, 2010). The most intensive growth in boys occurs from the ages of 14 to 17. The development of the movement apparatus is variable due to the faster growth of arms and legs, which causes characteristic disproportions typical for youths of that age (Cvijan, 2006). The risk of injury increases during the most intense period of growth, which is usually around the age of 14 (Baechle & Earle, 2000). Potential risk factors are relative bone weakness, muscular intermittency of the flexors and extensors, and the shortening of tendons.

Basketball and handball are very popular sports in Bosnia and Herzegovina. The national basketball team took part in almost every European Championship and the handball team participated in the World Championship in 2015. The Republic of Srpska (RS, an autonomous political unit in Bosnia and Herzegovina with a population of around 1.2 million) has contributed to the quality of basketball and handball national teams in senior, as well as in junior selections, for years. On the other hand, basketball and handball are dynamic sports that incorporate intermittent skill-demanding activities as a combination of individual and team skills (Jakovljević, Pajić, Gardašević, & Višnjić, 2010). Success in these sports games depends on numerous factors: the player's technical, tactical, psychological, etc. characteristics and capabilities. Modern basketball

requires many well-developed, complex anthropological features where agility, speed, and explosive strength are the basis for the performance of various movement structures in competition (Ivković & Kardum, 2007). Running speed and jumping ability develop after the age of 13. Strength and other motor abilities improve significantly after mid-childhood and adolescence (Malina, Bouchard & Bar-Or, 2004). Basketball players run around 4500 – 5000 m during a game, which lasts 40 minutes. They move in different ways: running, dribbling, defense movements, and jumping (Crisafulli et al., 2002). From the structural biomechanical analysis point of view, jumps are especially important (to win ball possession, to score, and prevent opponents to score), speed (transition into attack – defense), and agility (change of movement directions, defense movements, etc.). Regarding the development of movement abilities Trunić (2007) quotes: "Motor development, as well as that of the whole body, develops intermittently. Motor abilities do build up periodically, and respectively there are periods when certain motor abilities rapidly develop, followed by periods of slower development or even stagnation". That problem is more pronounced in basketball where a wide range of body height exists within same competitive and age category. Within same age category in basketball, it is possible to have a range of 30 to 40 cm in players' body height. When differences in chronological and biological age are added to this problem, the concept of training planning for the development of all motor abilities becomes very complex in terms of thinking and practical execution. The creation of a top-level basketball players training plan and program and its operationalization in every developmental phase of young basketball players, requires knowledge when a specific motor ability should be targeted, and when we could expect an optimal increase and performance improvement. The modern game of basketball is characterized by high intensity during almost all 40 minutes. Explosive strength, needed for the start, fast and short sprint, defensive and offensive rebound, dominates the energy demands during a game. Apart from that, there is coordination in performing specific motor tasks, agility in solving new situations efficiently, speed of the neuromuscular reaction, and speed of movements itself. High aerobic ability provides the slower appearance of fatigue and faster recovery during short breaks within a game. Anaerobic ability is responsible for sustaining high-intensity repetitive activities.

Determining anthropometric characteristics is one of the three most frequently measured and tested dimensions of an athlete (Milanović, 2005). Just like in basketball, monitoring anthropometric measurements of handball players is an important step in the process of efficient modeling of the training process, and in selection. Morphological characteristics are important for sports success in handball because motor abilities and handball-specific sport technique knowledge, for the most part, depend on the handball players' morphological characteristics (Cvijan, 2006). In that respect, an organized, planned and well-established training process in handball is one of the external factors that can significantly influence the development of the quantity and quality of morphological dimensions, which are not genetically determined. Morphological characteristics and motor abilities are the basic factors of sports mastery in handball. Thus, handball is a game that requires a high level of different motor abilities. Based on the current analyses of modern handball and testing of a large number of players of different quality levels and ages, it could be claimed that this sport demands high levels of: absolute and explosive strength, repetitive strength of the trunk, speed endurance, leg speed, shooting accuracy, and speed endurance of the lactate type (Galipidis, 2002). The

adequate development of these abilities, needed for a good handball player, the objective and proper planning of the training process is essential, and could be achieved by the use of scientific and empirical achievements (Cvijan, 2006). A handball player's activity is predominantly characterized by constant movements with or without a ball, fast and sudden sprints, various high and deep jumps, landings and collisions with opponents, all with one purpose – scoring as many goals as possible. It is obvious that a handball player must acquire a large number of handball specific structural elements and successfully use them in the game conditions. In modern handball, these values are relatively high, but they do tend to change according to the periodization of the training process. Basketball and handball are full of jumps, changes of movement direction, and one-on-one plays that are one of the basic elements of the game. That is challenging for the child's locomotor system during the period of accelerated growth, so injuries of the spine or knee joints are not uncommon. The highest content of bone minerals in boys is reached between the ages of 13 and 15 (Kraemer & Fleck, 2005). In developmental terms, handball and basketball players of different ages (from 13 to 19) need to meet certain reference values in motor ability tests. The results in all of the motor abilities must improve in each coming year. During childhood, fundamental motor abilities develop at a natural pace (Jakovljević, Pajić, Gardašević & Višnjić, 2010). Strength and other motor abilities are subject to improvement, especially during mid-childhood and adolescence (Malina, Bouchard & Bar-Or, 2004).

The aim of this study was to define the physical profile of quality fourteen-year-old basketball and handball players. Based on the proposed model, coaches that train younger selections for a year or two could plan and program their own training sessions. Having in mind the three times bigger "basketball population" (according to the data of the Regional Basketball Association and Regional Handball Association of the Republic of Srpska) in regions where the study was conducted, it was assumed that young basketball players would be physically dominant compared to their handball peers.

METHOD

Participants

Forty-four boys born in the same year participated in this study. The first group of participants consisted of 20 basketball players; aged 14.4 ± .31. They are members of the first rotation of the best four teams of the Republic of Srpska (RS). On average, their basketball experience was 6.4 years ± .55, four one-hour training sessions per week. They play about 20 official games per year. The second group of participants consisted of 24 handball players; aged 14.5 ± .41. They are members of the first teams from the top-four teams of RS (notice: goalkeepers were not part of this study). On average, they had handball experience of 5.5 years ± .45, four one-hour training sessions per week. They play about 20 official games per year too. All of the participants took part in the final tournaments in RS for children (four best teams in each sport). All of the participants gave their consent to be part of this study. Prior to the testing procedures, they underwent a medical checkup and provided their parents' consent, as well as consent from their clubs.

Measuring instruments

We used variables from morphological, motor, and functional space. The variables from morphological space were: body height (BH), body mass (BM), body mass index (BMI) and fat tissue percentage (FTP). The variables from motor space included variables for speed assessment: the 10 m sprint (SP10 m) and 30 m sprint (SP30 m). The agility tests included: the agility test 5 x 10 m (AG5x10) and envelope test (ENT). The coordination tests included: the polygon backward (POB) and coordination with a baton (COB). The vertical explosiveness test was the maximal squat jump (MSJ). The flexibility test was the sit and reach (SAR). Muscular endurance tests included maximal push-ups (MPU) and maximal sit-ups (MSU). Functional abilities were assessed by the Yo-Yo intermittent test level 2 (YOYO 2). All of the measurements and tests were recommended by Reiman & Manske (2009) and Sudarov (2007).

All of the measurements and testing were performed using the following machines and apparatuses: the body composition analyzer (model TANITA BC 418-MA), photocells (Globus ergo System) and field jumping platform (Globus ergo system). The Yo-Yo intermittent endurance test level 2 was performed with a sound signal and measures drawn on the gymnasium floor.

Procedure

All of the measurements and testing were performed in the sports hall in the morning, with the same apparatuses and the same timekeepers. The participants received instruction on the testing protocol and execution of the tests before the start. Each group of participants had two days to measure the morphological characteristics and two days to test the motor skills. The Yo-Yo test was performed as the last test. The participants were tested at the end of the competition season.

Descriptive statistics were calculated for all the variables and the Kolmogorov-Smirnov test was used to check their normality. Differences between the means of two groups of participants were analyzed applying the t-test for independent samples. The effect size was applied in order to determine the significance of the differences between the two groups of athletes. Analyses were performed using the statistical software SPSS 20 (SPSS Inc., Chicago, IL, USA).Research results

RESULTS

The results of this study are summarized in two tables with four morphological, eight motor and one functional variable. The Kolmogorov-Smirnov test showed that all the variables had normal distribution, except for the variables COB and MSU. A logarithmic transformation was applied for these variables.

Table 1 shows the descriptive parameters of the applied variables. The mean values show that the basketball players were taller while the handball players had a higher BMI, fatty tissue percentage (FTP) and body mass (BM). These parameters are quite variable considering the participants' age, but still they can be a determining factor in the performance of motor abilities. Analyzing the descriptive data of motor and functional abilities, it is evident that basketball players have better results in all the variables.

Table 1 Descriptive statistics of the physical characteristics and performances of basketball and handball players

	Sport	N	Mean	Std. Dev	Std. Err. Mean
BH (cm)	Basketball	20	176.98	11.12	2.48
	Handball	24	170.20	9.66	1.97
BM (kg)	Basketball	20	62.61	12.67	2.83
	Handball	24	63.12	13.68	2.79
BMI	Basketball	20	19.71	2.31	.517
	Handball	24	21.59	3.44	.702
FTP (%)	Basketball	20	15.43	3.05	.683
	Handball	24	17.28	4.31	.881
SP10m (s)	Basketball	20	2.46	.11	.025
	Handball	24	2.51	.10	.021
SP30m (s)	Basketball	20	5.25	.25	.056
	Handball	24	5.58	.38	.077
AG5x10 (s)	Basketball	20	12.89	.50	.113
	Handball	24	13.89	.96	.196
ENT (s)	Basketball	20	7.16	.34	.078
	Handball	24	7.58	.41	.085
POB (s)	Basketball	20	13.33	2.86	.640
	Handball	24	15.41	3.75	.766
COB (cm)	Basketball	20	6.04	.83	.187
	Handball	24	8.78	3.14	.641
MSJ (m)	Basketball	20	.40	.06	.015
	Handball	24	.33	.03	.008
SAR (cm)	Basketball	20	17.70	7.02	1.571
	Handball	24	20.12	8.70	1.777
MPU	Basketball	20	14.80	6.46	1.446
	Handball	24	9.70	5.34	1.090
MSU	Basketball	20	66.50	32.23	7.208
	Handball	24	51.25	34.36	7.013
YOYO2 (m)	Basketball	20	1116.00	370.24	82.788
	Handball	24	871.58	288.20	58.828

The significance of the differences between basketball and handball players in physical performances is shown in Table 2. The results of the t-test for morphological characteristics showed a significant difference in the variables of body height (BH) and body mass index (BMI), where the basketball players had higher values. There was no significant difference in the other two morphological variables. Considering motor abilities, a statistically significant difference was noted in almost all the motor and functional abilities, in favour of the basketball players. The only exceptions are the variables the 10 m sprint (SP10 m) and the sit and reach (SAR), where no differences were recorded. The results of the Effect size method showed a significant difference in tests AG5x10, COB and MSU ($d>1.2$). A moderate difference was recorded in the following variables: BH, BMI, SP30m, ENT, POB, MPU and YO-YO2 ($d=0.6$-1.2).

Table 2 Differences between basketball and handball players in terms of physical performances

	F	Sig	t	df	Sig.	Mean Diff	Effect size (Cohen's d)
BH (cm)	.142	.708	2.160	42	.037	6.771	0.65
BM (kg)	.039	.844	-.128	42	.899	-.514	0.04
BMI	1.269	.266	-2.077	42	.044	-1.876	0.64
FTP (%)	2.512	.120	-1.611	42	.115	-1.852	0.50
SP10m (s)	.001	.973	-1.457	42	.152	-.048	0.44
SP30m (s)	4.360	.043	-3.221	42	.002	-.321	0.99
AG5x10 (s)	7.614	.009	-4.204	42	.000	-1.006	1.31
ENT (s)	2.086	.156	-3.580	42	.001	-.421	1.09
POB (s)	3.466	.070	-2.033	42	.048	-2.080	0.62
COB (cm)	10.367	.002	-3.783	42	.000	-2.739	1.22
MSJ (m)	7.988	.007	4.134	42	.000	.068	0.31
SAR (cm)	1.000	.323	-1.002	42	.322	-2.425	0.36
MPU	.849	.362	2.860	42	.007	5.091	0.65
MSU	.054	.748	-3.724	42	.000	15.250	1.46
YOYO2 (m)	5.616	.022	2.462	42	.018	244.416	0.74

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DISCUSSION

The aim of the present study was to determine the advantageous physical performances of quality basketball and handball players. Based on them, coaches could design the model of optimal physical performances for boys aged 14 in both sports (Table 1: Mean).

The results showed that basketball players have superior physical qualities when compared to handball players. Basketball players are significantly taller ($p<.05$). The difference in height (and some other parameters) can be mainly attributed to selection conditions (Milanović, 2010). Considering variable Body mass, it is notable that there is no significant difference between basketball and handball players. The body mass index (BMI) was lower in basketball players ($p<.05$). Basketball players had a lower percentage of fatty tissue (although not statistically significant). Fatty tissue percentage is genetically determined to some degree. In regards to this, Milanović (2010) proposes that the training process and a quality diet can influence adipose (fatty) tissue and increase in muscle mass. On the 10 and 30 meter speed tests, basketball players had somewhat better results.

The difference was statistically significant at the .01 level only in the 30 m sprint test, meaning that basketball players have a higher speed of movement frequency, but not reaction speed. The speed is very important for both sports and it is difficult to speak about differences in the training process because this ability is genetically highly determined. Marković & Bradić (2008), and Issurin (2008) propose sensitive periods (age) for the development of the ability of maximal running speed – from 5 to 8; reaction time – 9 and 10; speed of movement frequency – 11 and 12. Certainly, these periods are very important and should be fully exploited because the overall margin for improvement is limited. Both agility tests showed a significant difference between basketball and handball players ($p<.01$). As previously mentioned, handball players had a significantly higher fatty tissue percentage and the body mass index that negatively affected their mobility. Agility tests require rapid change of movement directions, and considering that basketball players are notably taller, the results of these tests are somewhat surprising. The reason for the handball players' weaker results can be found in their movement patterns during a game and training session, where there are not too many zigzag movements as in basketball. The coordination test revealed statistically significant differences in favor of the basketball players. Possible reasons for that might be found in different adaptations to the test and motivation, for this test is uncomfortable and demanding. However, it seems that different morphological characteristics largely affected the outcome of the test itself. The test of explosive strength, the Squat jump, confirmed the higher quality of basketball players in vertical jumping. Certainly, morphological characteristics contributed to this result, as well as sport-specific features. Namely, vertical jumps are much more frequent in basketball than in handball. The sit and reach test (SAR) did not show a significant difference between basketball and handball players. Muscular endurance tests (MPU and MSU) revealed better results for the basketball players at the .01 level. During this period, strength develops in children and this motor skill is increasingly used as the game demands increase. Handball players had lower results than basketball players on the endurance test (YO-YO, $p<.05$). The age of 14 is when young athletes are introduced to a program of aerobic-anaerobic training, and it can be assumed that handball players did not have this type of training. Furthermore, a higher body mass index and fatty tissue percentage of handball players are aggravating factors.

Numerous quality studies explored the physical performances of adult basketball players (Apostolidis, Nassis, Bolatoglou & Geladas, 2004; Ostojić, Mazić & Dikić, 2006; Pearson, Naughton & Torode, 2006; Ziv & Lidor, 2009; Torres-Unda et al., 2013). Moreover, adult handball players were subjects in a number of studies Buchheit, Leblond, Renaud, Kuhnle & Ahmaidi, 2008; Živković, Goranović, Marković & Branković, 2010; Dane & Erzurumluoglu, 2003; Bresciani, Cuevas & Garatachea, 2010; Loffing & Hagemann, 2014). However, rather few studies included the population of fourteen-year-old basketball and handball players. The results of our study is consistent with the results of a previous study conducted by Živković et al. (2010). Based on the results of the canonical correlation analysis, they found a significant canonical factor with a high correlation between morphological dimensions and explosive strength. Granić & Krstić (2006) compared fourteen-year-old non-athlete students with basketball players and found significant difference in the standing broad jump test in favor of the basketball players. That is in accordance with our study because we claim that basketball develops the vertical jump and the standing broad jump ability. Jumping ability is very important for basketball, as shown in our results. Considering its importance, it is clear that it takes a special place in the concept of basketball training. Castagna,

Impellizzeri, Chamari, Carlomagno & Rampinini (2006) concluded that the explosive strength of the legs is closely related to the performance on the Yo-Yo test in quality football players, but not elite ones. In our study, the basketball players scored significantly better results than the handball players on the Yo-Yo test too, and they had notably better results on the vertical jump (MSJ). Children have significantly lower values of anaerobic capacity than adults have, irrespective of which way the results are standardized (the Margaria test, the Wingate test). Children have smaller glycogen reserves in their muscles, and as a result, lower amounts of the enzyme phosphofructokinase and lactate dehydrogenase. Therefore, their possibilities of glycolysis are significantly lower (Mišigoj-Duraković et al., 2007). Consequently, a comparison of fourteen-year-old and adult athletes in their anaerobic capacity was not justified, so we did not consider it. Body composition may play a role in the performance of predominantly aerobic activities with alternating periods of high and low intensity (Krustrup et al., 2006). Alongside endurance (aerobic and anaerobic), explosive and maximal strength are equally valuable for success in basketball and handball.

Authors of the present study propose several explanations for the fact that young basketball players have better physical performances than young handball players do. Firstly, basketball is a more popular game in Bosnia and Herzegovina and more children prefer basketball to handball. Hence, the selection base is larger for basketball. Secondly, there is a significantly smaller number of sports halls with handball courts. Basketball has no problem with that. Thirdly, it is well known that biologically mature children have more advanced physical performances. It is quite possible that among basketball players there are several accelerants who, in a fairly small sample, contribute to the difference in the basketball players' favor. However, it seems that the main reason for physical superiority of the basketball players lies in the larger number of young players (3:1) in the aforementioned territory. This probably outlines certain limitations of this study. If the number of basketball and handball players were equal, more reliable conclusions could be drawn.

CONCLUSION

It is well known, in modern sports practice, which physical performances are important for basketball and handball players. Young athletes and their coaches try to improve them as much as possible with training. For that reason, it is crucial to follow young athletes' improvement closely, and to have a relevant model that young players could be compared to. This study confirmed that the basketball players were better in all the tested variables. The quality difference was mainly attributed to the larger base from where basketball players have been recruited (the ratio of children that train basketball and handball in the studied region is 3:1 in favor of the basketball players). These results could be useful to basketball and handball coaches working with players from junior categories. The suggested "model of physical performances" will enable coaches to compare their players with the performances of quality basketball and handball players from this model.

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MODEL FIZIČKIH PERFORMANSI MEĐU KOŠARKAŠIMA I RUKOMETAŠIMA MLAĐEG UZRASTA

Cilj ovog istraživanja bio je da se definiše model fizičkih performansi četrnaestogodišnjih vrhunskih košarkaša i rukometaša. Ukupno je 44 dečaka učestvovalo u ovom istraživanju: 20 košarkaša (prosečne starosti 14.4 ± .31) i 24 rukometaša (prosečne starosti 14.5 ± .41). Kako bi se procenio morfološki status ovih sportista, primenjeno je četiri testova za procenu motoričkog statusa, i 10 varijabli. Yo-Yo test primenjen je kako bi se procenio funkcionalni status sportista. Na osnovu aritmetičkih vrednosti, prikazan je model poželjnih fizičkih performansi košarkaša i rukometaša. T-test za nezavisne uzorke primenjen je kako bi se ustanovio značaj razlika između ove dve grupe sportista. Košarkaši su pokazali bolje rezultate na svih 15 testova, iako razlike nisu bile statistički značajne na 11 testova. Razlika u kvalitetu objašnjena je činjenicom da je košarka tri puta popularnija među decom od rukometa, ali i nedostatkom sportskih hala u Bosni i Hercegovini gde bi deca u propisanim uslovima mogla da treniraju rukomet.

Ključne reči: *pubertet, trening, testiranje, selekcija.*