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The Influence of Morphological Characteristics on the Ball Throwing Velocity in the Professional Handball Players

Influencia de las Características Morfológicas en la Velocidad de Lanzamiento del Balón en los Jugadores Profesionales de Balonmano

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SUMMARY: The aim of this study was to determine influence of upper limbs on the ball throwing velocity. A total of 10 professional handball players (25.74±4.84 years) participated in this study. All of them were playing in the top Montenegrin professional handball league. The results obtained in this study shows that upper limbs have high influence on ball throwing velocity. This study provides normative data and performance standards for professional handball. Coaches can use this information to determine the type of anthropometric characteristics that are needed for handball. Anthropometric parameters such as arm length, wrist diameter, hand length and arm span are the most relevant aspects related to ball throwing speed, given that these parameters cannot be changed through training, they should be taken into account when discovering talents.

KEY WORDS: Upper limbs; Kinetic and kinematic chain; Ball speed; Anthropometrics characteristics.

INTRODUCTION

Handball is an Olympic team sport that requires significant physical preparation in order to complete 60 minutes of competitive play to achieve a success. This game's movement patterns are characterized as intermittent and continuously changing responses to different offensive and defensive situations (Deng *et al*., 1990). Anthropometric factors, physiologic and morphological characteristics can influence the effectiveness of such responses, as has been observed in other team ball sports (Chaouachi *et al*., 2009). Therefore, anthropometric profiles may contribute to understanding a player's suitability, particularly at high standards of play. In fact, morphological characteristics of players have become a major field of interest for many trainers and sports scientists (Moncef *et al*., 2012).

Previous reports have shown that body structure and morphological characteristics are important determinants of performance in many sports and certain physical impressions such as body composition (body fat, body mass, muscle mass) and physique can significantly influence athletic performance (Coldwells *et al*., 1993). Some of these researchers have studied the relationship between morphological characteristics and physical performance in order to evaluate the effect of physical predisposition on the choice of sport and the influence of training on the morphological characteristics (Chaouachi *et al*., 2009).

One of the main factors that appears to distinguish a professional from an average male athlete is ball throwing velocity (Zapartidis *et al*., 2009b). Ball throwing velocity may be influenced by certain anthropometric characteristics (Zapartidis *et al*., 2009a), as well as physical fitness capacity and specific motor abilities, as shown in a study involving young female handball players (Zapartidis *et al*., 2009a). Throwing is considered as one of the most important technical skills in competitive team handball as it is a major determinant of all actions taken by the players. For a proper execution of a throw, the achievement of maximal voluntary velocity is necessary, depending on the sort of the throw, whilst accuracy is always a demand (Van Den Tillar & Ettema, 2004).

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These data told us that in practice there is still space for upgrading and improving the precision in the handball game. Since the very aim of the game sorts shooting among the most important elements of handball game that determine the success of the score, it is no coincidence that more and more authors base their research on the factors affecting the quality of shooting (Karisik *et al*., 2016). A positive impact of motor skills on the speed of the ball, especially the explosive strength, confirmed the investigation (Rogulj *et al*., 2007). Previous studies have shown that the technique of shooting, throw of the ball (Zvonarek *et al*., 1997), as well as the movement of the hand with a ball during the shoot (Jovanovic & Dukic, 2007) have high correlation with efficiency of the ball throw.

The aim of this study was to determine influence of upper limbs on the ball throwing velocity.

MATERIAL AND METHOD

Sample of participants. A total of 10 professional handball players (25.74±4.84 years) participated in this study. All of them were playing in the top Montenegrin professional handball league. This league comprised players who were part of the national Montenegrin teams participating at the junior and senior levels. During the year in which the study was carried out, this league was the number one in Montenegro. Physical characteristics of the players are shown in Table I.

Research Design

Anthropometry. The anthropometric variables of height (m), body mass (kg), body fat (%) were measured in each subject. Height and body mass measurement were made on a levelled platform scale (Ano Sayol, Barcelona, Spain) with an accuracy of 0.01 kg and 0.001 m, respectively. Body mass index (BMI) was calculated from body mass and body height. Percentage of body fat was calculated from measurements of skinfold thickness (Jackson & Pollock, 1978). To estimate the dimensions of the upper limbs, variables of arm length, wrist diameter, the length of the hand, planimetric parameter of the hand and arm span were used (Karisik *et al*., 2016). All anthropometric variables were measured according to standard procedures of the International Society for the Advancement of Kinanthropometry (ISAK) (Marfell-Jones *et al*., 2006).

Throwing Velocity test. Throwing velocity was assessed with a radar gun (StalkerPro Inc., Plano, TX, USA), with 100-Hz frequency of record and with 0.045-ms sensitivity, placed behind the goal post and in a direction perpendicular to the player. This test has been shown to have a very good test-retest reliability intraclass correlation coefficient (ICC) of 0.96 and a coefficient of variation (CV) of 2.4 % (Dauty *et al*., 2005). Before the throwing velocity assessment, subjects' performeda15-minute warm-up focused on overhead throwing. After applying resin as desired, the subjects performed protocols of throw. Protocol, the subjects threw a standard handball as fast as possible toward a standard goal, using a single hand and their personal technique. The sequence of throwing was as follows: A throw from just behind the 7-m penalty mark, a throw from just behind the 9-m line, a 3-step dribbling and throw from the 9-m line, and a 3-step passing the ball and throw from the 9-m line. Three throws of each type were performed, and the best trial was used for further analysis (Vila *et al*., 2012). Only throws sent to the goal post were used for analysis. For motivational purposes, the players were immediately informed of their performance. A 3-minute rest elapsed between throws to avoid fatigue.

Statistical analysis. The data were processed using the Statistical Package for Social Sciences SPSS (v26.0, SPSS Inc., Chicago, IL, USA). In the first step, descriptive parameters and distribution of variables were determined. For all the tests, central and dispersive param-eters were calculated: arithmetic mean (Mean), standard deviation (SD) and Confidence interval for mean (Lower and Upper). The normality of the distribution of the variables was derived through two procedures: the asymmetries of the Skewness results and the homogeneity of the Kurtosis results. Linear regression analysis was applied to determine the influence of upper limbs on the throwing velocity. The statistical significance of the results was $p < 0.05$.

RESULTS

Table II shows descriptive parameters of anthropometrics characteristics and ball throwing velocity in professional handball players. The results of Skewness and Kurtosis showed that there is a symmetry and homogeneity of the results. The distribution of the result was normal.

Table I. Physical characteristics of professional handball players.

	Height (cm)	Body mass (kg)	BMI (kg/m^2)	BF (%)
Professional handball players (n=10)	186.56±5.25	86.87±14.88	24.85±3.92	15.03±5.39

Results are mean (± SD)

Table III shows influence of anthropometrics characteristics to ball throwing velocity in professional handball players. Analyzing the results in Table III in the 7 meters ball throwing velocity test, it is noticeable that the high coefficient of multiple correlation R=.867 indicates a statistically significant influence of morphological characteristics on ball throwing velocity. The greatest statistically significant influence is the length of the hand B = -1,495, $p \leq 0.03$. In the 9 meters ball throwing velocity test, a high coefficient of multiple correlation R = .884 is noticeable. The greatest statistically significant influence is noticeable in the variable arm length B = 5.306, $p \leq 0.04$. In the 9 meters with 3-step dribbling test, a high coefficient of multiple correlation R = .884 is noticeable. The greatest statistical impact was recorded in the variables arm length B = 4.677, $p \leq 0.04$ and planimetric parameter of the hand B = 1.243, $p \leq 0.05$. In the 9 meters with 3-step passing the ball test, a high coefficient of multiple correlation R = .963 was recorded. A statistically significant influence was recorded in all variables of morphological characteristics: arm length B =5.810, $p \leq 0.004$; wrist dynameter B = .520, $p \leq 0.03$; the length of the hand B = -.840, $p \leq 0.03$; planimetric parameter of the hand B = 1.462, $p \leq 0.006$ and arm spam B = -5.181, $p \leq 0.004$.

Table II. Anthropometrics characteristics and ball throwing velocity of handball players.

Variables	mean ± SD	95% CI
		Lower - Upper
Arm length (cm)	81.42±3.41	78.98 – 83.86
Wrist diameter (cm)	5.60±0.33	5.35 – 5.84
The length of the hand (cm)	18.70±1.25	17.79 – 19.60
Planimetric parameter of the hand (cm)	22.32±0.87	21.69 – 22.94
Arm spam (cm)	186.42±7.32	181.18 – 191.65
7 meters ball throwing velocity (km/h)	76.74±5.25	72.98 – 80.50
9 meters ball throwing velocity (km/h)	78.01±6.68	73.22 – 82.79
9 meters with 3-step dribbling (km/h)	86.13±7.64	80.66 – 91.59
9 meters with 3-step and passing (km/h)	85.79±6.73	80.96 – 90.61

Table III. Influence of anthropometrics characteristics to ball throwing velocity.

	7 meters ball throwing velocity				9 meters ball throwing velocity			
	r	Part-r	B	p	r	Part-r	B	p
Arm length (cm)	-.179	.267	1.897	.34	-.039	.747	5.306	.04
Wrist diameter (cm)	.229	.522	.635	.10	.076	.473	.575	.15
The length of the hand (cm)	-.503	-.768	-1.495	.03	-.288	-.465	-.905	.15
Planimetric parameter of the hand (cm)	.051	.327	.652	.20	-.040	.622	1.242	.08
Arm spam (cm)	-.183	-.135	-.886	.61	-.149	-.678	-4.445	.06
	R=.867	R^2=.751	F=2.419		R=.884	R^2=.713	F=1.983	
	9 meters with 3-step dribbling				9 meters with 3-step passing the ball			
	r	Part-r	B	p	r	Part-r	B	p
Arm length (cm)	-.348	.659	4.677	.04	-.310	.819	5.810	.004
Wrist diameter (cm)	-.238	.246	.299	.35	-.085	.428	.520	.03
The length of the hand (cm)	-.572	-.512	-.996	.09	-.471	-.432	-.840	.03
Planimetric parameter of the hand (cm)	.114	.623	1.243	.05	.130	.733	1.462	.006
Arm spam (cm)	-.448	-.602	-3.947	.06	-.423	-.790	-5.181	.004
	R=.884	R^2=.781	F=2.854		R=.963	R^2=.928	F=10.241	

DISCUSSION

The aim of this study was to determine influence of upper limbs on the ball throwing velocity. The results obtained in this study shows that upper limbs have high influence on ball throwing velocity. Throwing velocity of the ball is an important skill in handball and a very important aspect for success. The velocity of a handball throw is not only dependent on the muscular strength but also on other aspects such as body segments, coordination and technical skills. This velocity is an important aspect for success, because the faster the ball is thrown at the goal, the less time defenders and goalkeeper have to save the shot (Vila *et al*., 2012). According to studies, when an athlete has increased segmental measurements of body length, he/she can throw the ball with a higher velocity. The combination of a longer humerus and a higher angular velocity results in a higher linear velocity of the ball (Fleising *et al*., 1999).

Mechanically, an increase in the radius of gyration should cause a proportional increase in the force applied to the ball, and therefore an increase in the linear velocity of the ball. During an overhand throw, the axis of rotation of the movement consists of the longitudinal axis of the arm (Winter, 1990). Reasonably, an overall longer limb has a positive effect on ball release speed. This is supported by the fact that the main factor affecting ball velocity is the effective energy transition from the ground to the lower limbs and through the kinematic chain to the throwing arm (Jöris *et al*., 1985). Ball throwing velocity may also be attributed to the type of muscle fibers as in high velocity movements like throwing; fast motor units are preferentially recruited (Hoff & Almasbakk, 1995). It has been demonstrated that in sprinters, jumpers and throwers that the size of the glycolytic fibers (IIx type) is approximately three times the size of the oxidative glycolytic fibers (IIa type), despite the fact that the overall distribution of the slow and fast twitch fibers is proportional in the muscles of the lower and upper limbs (Zapartidis *et al*., 2011).

Ball speed depends on the length of the route in which the body has an effect on the ball during the throwing movement; it depends on the amount of the involved musculature, as well as the speed and consistency of contraction and relaxation of muscles that are used in the release of the ball. Therefore, the player who operates the ball with strength for a longer period will give it a greater amount of kinetic energy. It is obvious that players with longer lever or the players who achieve greater amplitude of throwing movement will be able to accomplish a longer traveling of the ball. It is this conclusion that confirms the result obtained from this research, that the players, who had longer upper limbs, achieved significant results in the length of the throwing of the ball. Throwing of the ball in handball is characterized as an open successive kinetic chain. In the basic throws from the ground, that produces the maximum speed of the ball, the longest kinetic chain is engaged and it begins with a foothold, it is transmitted through the hip and torso, and ends with the longest lever of the arm and the throwing movement of the hand. It is very important to emphasize that in successive schemes of kinetic chain, the movement begins at a joint of one end of the kinetic chain, and then the adjacent joints start joining, until the entire chain is in motion (Karisik *et al*., 2016).

In handball throwing, the hip, trunk, shoulder, upper arm, fore arm and hand generate maximum linear mechanical energy around the ball release events for all segments between the start and end of the action. Key moments are the segment-to-segment momentum transfer ratio. When absolute momentum values are sufficiently large, the transfer ratio appears as an additional important factor in the assessment of the handball throwing technique. Role of the hip is to initiate the movement of the upper body part, to generate a large value of the momentum and to transfer the momentum from the lower limbs to the trunk during the counter-movement. It should be emphasized that the hip plays an essential role in the throw performance since it provides, in the moment of arresting the movement, a solid base of support for upper body during the standing throw (Wit & Eliasz, 1998). In the handball jargon, as well as professional, this scheme is called "whip" technique of throwing the ball, because, like in the movement of a whip, in the direction of the movement, the segments with the backing are the first to move, then the adjacent segments, until in the end the last segment moves, which is, in our case, the hand with the ball (Karisik *et al*., 2016).

Hand grip strength is essential in order to place and throw the ball in different sports, but is especially important considering the dominant hand of a handball player (Koley & Singh, 2009). It is noticeable that hand width and length cannot be modified by training. Nevertheless, top elite players showed greater hand length and hand width than the elite ones, and, logically, it was not due to training. The ability to grasp the ball is essential in handball, and it is associated with hand size. A good grasp has a positive influence on the ball'sthrowing velocity (Srhoj *et al*., 2002;Visnapuu & Jurimae, 2007), a relationship that has been confirmed in this study. Accordingly, the size, length and width of the hand are undoubtedly crucial to become a top elite player, because a greater value of hand length and hand width provides a greater hand surface in order to grasp the ball. This could improve handling of the ball and there by enhance the speed and precision of the ball throw during the game (Ferragut *et al*., 2018). Firm hand grip is not only important for firm holding of the ball with distal ends of the metacarpal bones, but it also provides fast hand flexion in the terminal phase of the throw-out which gives final ball acceleration and provides kinematic efficiency of the throw-out. Considering previously explained hand length importance on ball speed, it can be assumed that distinguishable hand longitudinal dimensionality contributes also to the hand grip strength because examinees with longer hand, due to biomechanical reasons, need to produce proportionally shorter affecting path to the instrument than the students with shorter hand. Also, longer tendons contribute to more efficient grip. In fact, examinees with longer hand have to extend hand less in initial grip of the instrument and therefore they have better initial base for forearm muscles contraction. Time-spatial synchronisation, time liness and successiveness of the various muscle groups and joints inclusion in kinetic chain as well as optimal relations and angles between levers are necessary premises for maximal generation of force impulse in throw-out movement. Therefore, the speed of

distal end of kinematic chain in the moment of throw-out, besides on the lever lengths responsible for achieving as longer trajectory as possible, greatly depends on technical characteristics of the throw-out movement, i.e. it depends on motor knowledge quality because it ensures that motor and morphological components are optimally utilized (Srhoj *et al*., 2002).

PRACTICAL IMPLICATIONS. This study provides normative data and performance standards for professional handball. Coaches can use this information to determine the type of anthropometric characteristics that are needed for handball. Finally, trainers should take into account some anthropometric characteristics during handball talent selection because they tend to be a requirement for future high-level performance. A database including such information from different teams and competitive levels would allow training professionals to compare their own data with those of other teams and better assess the effectiveness of their routines in improving the performance of their players.

CONCLUSION

Anthropometric parameters such as an arm length, wrist diameter, the length of the hand and an arm spam, are the most relevant aspects related to ball throwing velocity, given that these parameters cannot be changed through training, they should be taken into account when discovering talents. Since handball players are able to maintain a high level of passing accuracy at high speeds, training should always be performed at high speed. Regardless of the training routine, most players successfully improve ball throwing velocity in training situations, so more physical planning is needed to develop ball throwing velocity.

GORANOVIC, K.; PETKOVIC, J.; JOKSIMOVIC, M.; KARISIK, S. & ELER, N. Influencia de las características morfológicas en la velocidad de lanzamiento del balón en los jugadores profesionales de balonmano. *Int. J. Morphol., 41(6)*:1881-1886, 2023.

RESUMEN: El objetivo de este estudio fue determinar la influencia de los miembros superiores sobre la velocidad de lanzamiento de la pelota. En el estudio participaron un total de 10 jugadores profesionales de balonmano (25,74±4,84 años). Todos ellos jugaban en la principal liga profesional de balonmano de Montenegro. Los resultados obtenidos mostraron que los miembros superiores tienen una alta influencia en la velocidad de lanzamiento de la pelota. Este estudio proporciona datos normativos y estándares de rendimiento para el balonmano profesional. Los entrenadores pueden utilizar esta información para determinar el tipo de características antropométricas necesarias para el balonmano. Los parámetros antropométricos como la longitud del brazo, el diámetro de la muñeca, la longitud de la mano y la envergadura del brazo son los aspectos más relevantes relacionados con la velocidad de lanzamiento de la pelota, dado que estos parámetros no se pueden cambiar mediante el entrenamiento, deben tenerse en consideración a la hora de descubrir talentos.

PALABRAS CLAVE: Miembros superiores; Cadena cinética y cinemática; Velocidad de la pelota; Características antropométricas.

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