

Relationship among Anthropometric Characteristics, Handgrip Strength and Throwing Velocity in Adolescent Handball Players

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Abstract

Objectives: was to investigate the relationship among maximal isometric handgrip strength, ball throwing velocity and dribble as well as the influence of basic anthropometric characteristics on these parameters in adolescents male and female handball players. **Methods:** The sample consisted of 119 subjects (75 boys and 44 girls) adolescent handball players aged 13.44 ± 0.35 years with 2.77 ± 0.91 yrs training experience. Variables included height; body mass, BMI, arm span, hand length, hand span, maximal isometric handgrip strength, and throwing velocity. Statistics included a) Pearson correlation analysis to evaluate the relationship among the measured variables, b) stepwise regression analysis for the predictability control of selected anthropometric characteristics and handgrip strength against ball throwing velocity as well as between anthropometric characteristics and handgrip strength and c) independent sample t – test to compare sex differences in ball velocity and maximal isometric handgrip strength. **Results:** Ball throwing velocity was found to be moderately correlated to all anthropometric measures. Handgrip strength showed a higher correlation with ball velocity, and moderate correlation with hand length, arm span and body height, while 30-m speed dribble time showed a low correlation with ball velocity respectively. Stepwise regression analyses revealed that two of the independent variables (handgrip strength and arm span) contribute significantly to the prediction of ball velocity. Male athletes outperform significantly in ball velocity and hand grip strength.

Keywords: Ball velocity, youth, sex differences, isometric strength

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1. Introduction

European handball is a team sport which requires a great exertion. Motor abilities such as agility, jumping, sprinting, throwing, passing, gripping the ball, pushing and holding the opponent are frequent and necessary for a remarkable performance. In addition to anthropometric characteristics, motor abilities, technical and tactical skills, muscle strength and power and ball throwing velocity have been shown as very important factors that discriminate elite from sub elite young and adult's players. (Palamas et al., 2015; Zapartidis et al., 2009b).

Furthermore, ball throwing is considered as one of the most important competitive skill that contributes to the performance of the team. The importance of ball velocity during the athlete's effort to beat defense and goalkeeper is proven by the fact that trainers and players are exploring ways to improve this element. In sport game like handball, maximal hand grip strength is essential for the holding and throwing the ball, in addition, the handgrip is an important measurement of general health and is used as an estimator of the normal function as it is referred to as one of the most accurate clinical methods of estimating children's strength. Concerning ball throwing velocity in adolescents, there are not many references in the literature.

Previous studies concerning Greek adolescent players mention ball throwing velocity from a standing position varies from 48 to 89 km/h for males and from 50 to 60 km/h for females according to age and play position. (Palamas et al., 2015; Zapartidis et al., 2011a; Zapartidis et al., 2011b; Zapartidis et al., 2009c) Normal values of general adolescent population for maximal grip strength of the dominant hand seems to varies from 12 to 51 kg for boys aged 12 to 14 years old and from 12 to 38 kg for girls at the same ages. (Häger-Ross & Rösblad, 2002) Basketball and handball male athletes aged 12 to 15 years, have been showed to perform handgrip strength between 26 and 43 kg. (Vinsapuu & Jürimäe, 2007) Several researchers have suggested that basic anthropometric characteristics influence ball throwing velocity and isometric hand grip strength in children and adolescents, to our knowledge, there are no studies to examine the combination of hand grip strength, ball throwing velocity and basic anthropometric characteristics of male and female adolescents' handball players. Thus, the aim of this study was to investigate the relationship between maximal isometric handgrip strength and ball throwing velocity as well as the influence of basic anthropometric characteristics on these two parameters in adolescents male and female handball players.

2. Materials and methods

2.1. Subjects

The total sample consisted of 121 male (79) and female (42) adolescent handball players aged 13.44 ± 0.35 years with 2.77 ± 0.91 years training experience. All subjects had a frequency of 3 training sessions per week, 1.5h per session. Both players and their parents were informed about the procedures of the measurement provided their written consent for participating according to the research policy of the National University of Athens and they could drop out any time they wanted to.

2.2 Measurements

Anthropometric characteristics: Six variables were measured for each subject, that is, height, body mass, body mass index (BMI), arm span, hand spread and hand length. All length characteristics were measured to the nearest 0.1 cm and mass characteristics were measured in kg. BMI was computed as the ratio of body mass to the squared standing height ($\text{Kg}\cdot\text{m}^{-2}$).

Fitness and skill tests: Ball throwing velocity, 30-m slalom dribble, and maximal isometric handgrip strength of the dominant hand were measured. Ball velocity was measured using a radar gun (Sports Radar 3300, Sport Electronics Inc., USA) from a standing position. The height of the gun radar was adjusted to the height of each athlete's throwing arm. The contra-lateral leg of the throwing hand was placed to the front steadily on the ground (penalty throw). All subjects performed 3 throws and the best performance was used. Dribbling test for skill-agility-speed was reflected in a distance of 15m (30m total), back and forth, dribbling a handball around 5 cones in a straight line.

The maximal isometric handgrip strength of the dominant hand was measured using a handheld handgrip dynamometer (Lafayette Instrument, Co, Indiana). The subjects were standing with the shoulder adducted, the dynamometer was held freely without support. The palm did not flex on the wrist joint (Visnapuu & Jürriäe, 2007). All subjects performed 3 trials with the dominant hand, and the best performance was used. The anthropometric features were recorded at the beginning of the trial, during the pre-training exercises.

A fifteen minutes pre-training followed, with exercises of general physical preparation, handball throws, and familiarization with the hand dynamometer. All the measurements took place in an indoors gymnasium during evening hours. All the children that showed failure in performing the measurements for any reason were excluded from the process.

2.3. Statistics

2.4. Preliminary analysis

Before proceeding with the data analysis, all variables were screened for possible statistical assumption violations, as well as for outliers using SPSS 11.5 frequencies, explore, plot and regression procedures. Eleven univariate outliers (3 for body mass, 3 for BMI, 1 for arm span, 2 for hand spread and 2 for 30m dribble) were detected. Two of the cases appear to be outliers on more than one variable and were eliminated from the analysis leaving a total of 119 subjects (75 boys and 44 girls). None of the other cases were considered extreme or unusual enough to require deletion. Because of extreme kurtosis, BMI (1.57) and 30m dribble (1.76) was transformed with a base-10 logarithm (Table 1). Multivariate outliers were screened by computing Mahalanobis distance for each case on the ten continuous variables and evaluated with a Table of Critical Values for chi square at alpha level of $p < .001$. No Multivariate outliers were presented. The Kolmogorov-Smirnov and Shapiro-Wilk tests were not significant at the .01 alpha levels.

2.5. Main analysis

Descriptive statistics were applied to all variables. Data analysis included: a) Pearson correlation analysis to evaluate the relationship among the nine measured variables, b) stepwise regression analysis for the predictability control of selected anthropometric characteristics and handgrip strength against ball throwing velocity as well as between anthropometric characteristics and handgrip strength and c) independent sample t – tests to compare sex differences in ball velocity and maximal isometric handgrip strength. Correlation between handgrip strength and ball velocity was computed to the two age groups without sex distinction. The level of statistical significance was set at $p < .05$

3. Results

Descriptive statistics of the measured variables for males, females and all subjects are presented in Table 1. Pearson correlation coefficients among all of the measured variables are presented in Table 2. Ball throwing velocity was found to be moderately correlated ($r = 0.54$ to 0.63 , $p < .001$) to all anthropometric measures. Handgrip strength showed a higher correlation with ball velocity ($r = 0.68$, $p < .001$), and moderate correlation with hand length, arm span and body height ($r = .54$ to $.60$), while 30-m speed dribble time showed a low correlation with ball velocity respectively ($r = -.30$, $p < .001$). Stepwise regression analyses revealed that two of the independent variables (handgrip strength and arm span) contribute significantly to the prediction of ball velocity (Table 3). Handgrip strength was responsible for 46% of the variance ($F_{1,117} = 99.50$, $p < .001$) and arm span for another 9% of the variance ($F_{1,116} = 22.21$, $p < .001$).

Table 1. Descriptive data for male, female and all subjects

	Mean (sd)					
	Males (n = 75)		Females (n = 44)		All (n = 119)	
Body Height (m)	1,67	0,07	1,63	0,38	1,66	0,70
Body Mass (kg)	62,04	10,89	57,64	7,23	60,39	9,93
BMI ($\text{kg} \cdot \text{m}^{-2}$)	22,09	3,13	21,63	2,49	21,89	2,91
LBMI (base-10 logarithm)	1,34	0,06	1,33	0,89	1,34	0,06
Arm Span (cm)	173,26	9,45	165,64	6,49	170,55	9,24
Hand Length (cm)	18,42	1,05	17,30	0,99	18,02	1,16
Hand Spread (cm)	21,37	1,50	20,68	1,34	21,13	1,48
Hand Grip (kg)	39,80	8,07	30,69	0,05	36,59	8,51
30-m Speed Dribble (s)	7,47	0,65	7,76	0,64	7,56	0,66
L 30-m Speed Dribble (base-10 logarithm)	0,87	0,04	0,89	0,04	0,88	0,04
Ball Velocity (km/h)	67,52	7,32	56,45	5,13	63,63	8,49

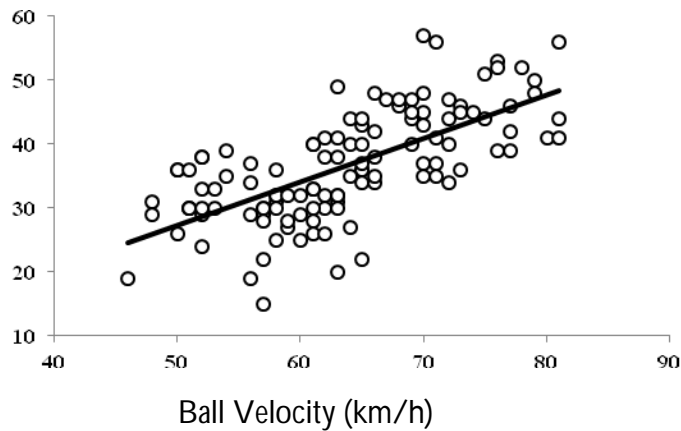


Figure 1: Relationship between throwing velocity and maximal handgrip strength

Table 2: Pearson correlation coefficients among all the measured

	BV	BH	BM	LBMI	AS	HL	HS	HG	LD
BV	1,00	0,60	0,52	0,27	0,63	0,54	0,39	0,68	-0,30
BH		1,00	0,60	0,12	0,91	0,71	0,50	0,54	-0,13
BM			1,00	0,86	0,59	0,51	0,48	0,47	0,09
LBMI				1,00	0,16	0,20	0,28	0,24	0,19
AS					1,00	0,72	0,50	0,58	-0,15
HL						1,00	0,40	0,60	0,05
HS							1,00	0,34	-0,08
HG								1,00	-0,15
LD									1,00

BV= ball velocity, BH= body height, BM= body mass, LBMI= Log base-10 of BMI, AS= arm span, HL= hand length, HS= hand spread, HG= handgrip, LD= Log base-10 of 30-m dribble

Body height, while being positively correlated to ball velocity ($r = .60$, $p < .001$), did not make a statistically significant contribution. Hand length and arm span contribute significantly to the prediction of hand grip strength (Table 4). Hand length was responsible for 37% of the variance ($F_{1,117} = 67.43$, $p < .001$) and arm span for another 4% ($F_{1,116} = 8.52$, $p = .004$). Body height, while was found to be moderately correlated to hand grip strength ($r = .54$, $p < .001$), did not make a statistically significant contribution.

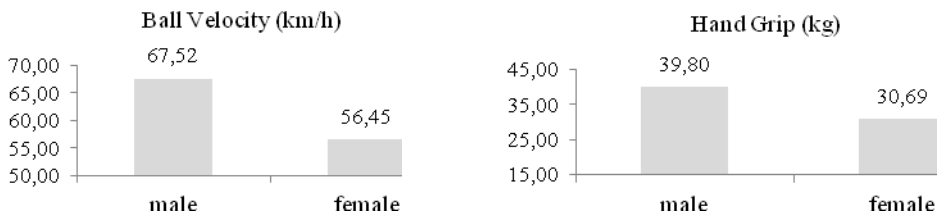
Table 3. Stepwise regression analysis of anthropometric character

Variables	Multiple R	B	Std. Error	Beta	t	Sig
Hand Grip	.68	.47	.08	.47	6.08	.001
Arm Span	.74	.33	.07	.37	4.71	.001

Table 4. Stepwise regression analysis of anthropometric character

Variables	Multiple R	B	Std. Error	Beta	t	Sig
Hand Length†	.61	2.83	.76	.39	3.72	.001
Arm Span	.64	.28	.09	.30	2.92	.004

Regarding the differences between sexes, females were statistically older than males ($t = 2.42$, $p = .17$), and male athletes outperform significantly in ball velocity ($t = 9.64$, $p < .001$) and hand grip strength ($t = 7.15$, $p < .001$) (Fig. 2).

**Figure 2: Sex differences in ball velocity and maximal hand grip strength**

3. Discussion

The aim of the present study was to investigate the relationship between basic anthropometric characteristics throwing velocity and hand grip strength of adolescent's handball players. Main finding is the positive correlation of ball throwing velocity to hand grip strength and arm span. These results are in accordance with previous study (Ferragut et al., 2011), which supported the significant correlation ($r = .60$, $p = .05$) of the hand grip strength with throwing velocity in elite water polo players. A moderate correlation was also found between serving velocity and handgrip strength in adolescent female volleyball players aged 12 to 17 years. (Melrose et al., 2007).

In a study of Vila et al., (2012), describing anthropometric profile, throwing velocity, handgrip strength, and muscular power in female handball players, is mentioned that the players, who exhibited stronger hand-grip values, showed and higher ball velocities. In the present study, basic anthropometric parameters such as body height, arm span, hand length, and body mass showed a significant moderate correlation with ball velocity and hand grip strength, however, only arm span and hand length revealed predictability. We could not find any similar studies concerning handgrip strength and ball throwing velocity in any other sport.

A strong positive correlation between ball velocity and arm span is reported by Skoufas et al., (2003). Previous study investigated the relationship between ball velocity and anthropometric characteristics of 220 female handball players aged 14 years showed low correlation ($r = .34$ to $.37$) to body dimensions with the hand spread and arm span to reveal the higher relation to ball velocity. (Zapartidis et al., 2009a) In a previous study (Debanne & Laffaye, 2011) body mass, lean mass, BMI, height, were correlated with throwing velocity ($r = .55$ to $.70$), while hand perimeter, finger span, middle finger length and arm span were also correlated with ball velocity but more weakly ($r = .35$ to $.51$).

It is generally accepted that body height is positively affecting all body dimensions. When a player has augmented segments, he has an advantage of throwing the ball at a higher speed, as an increase of a rotation radius should cause a proportional increase of the torque and consequently an increase in the linear velocity of the ball. (Fleising et al., 1999) On the other hand, Jöris et al., (1985) did not find any relationship between ball throwing velocity and segmental body lengths. The author's contention that players with short segments are capable to reach high throwing performance levels as a result of a more efficient energy transition.

Other study who examined 182 male handball athletes aged 14.3 years mentions body height, body mass and hand length as the most important variables that contribute to ball throwing velocity. Arm span was not included in the multiple regression analysis as it showed very high correlation with body height, however, arm span showed a significant correlation ($p < .001$) to ball throwing velocity. (Zapartidis et al., 2011a) In the present study, body mass was also significantly correlated with ball velocity but less strongly than the arm span, the hand length and the body height.

Conversely, earlier studies did not report such correlations between body mass and ball throwing velocity concerning female volleyball (Ferris et al., 1995) and female handball players, (Jöris et al., 1985) these differences could be due to the different sample used and to a potential linear relationship between body mass and muscular mass.

Regarding the relationship of anthropometric parameters and handgrip strength, current study revealed significant correlation of handgrip and basic anthropometric parameters such as hand length, arm span, body height, and body mass. However, hand length and arm span seems to be the most important factors influencing handgrip strength. The results fully confirm the recent literature. A study of 106 basketball players aged 13-14 yrs revealed strong correlation of handgrip strength with body height, and arm span.

(Apostolidis & Zacharakis, 2015) Another study which examined young basketball players, found that hand length, body height and hand spread had the most relationship with handgrip strength. (Chahal & Cumar, 2014) Koley et al., (2010) stated that hand length has the significant effect on the handgrip strength in basketball players. Hewson et al., (2010) made an effort to predict maximal grip strength from several anthropometric characteristics (body height and mass, hand circumference, hand and palm length). Among these parameters, hand circumference had the strongest correlation with hand grip strength.

In recent years many reports studies involving handgrip strength and anthropometric characteristics have been published with ambiguous results. Some of them supported the strong influence of body height and arm span on handgrip strength (Apostolidis & Zacharakis, 2015; Jörimäe et al., 2009; Melrose et al., 2007) while others argue that body mass, arm's and forearm's lengths, and hand surface are the strongest predictors of handgrip strength. (Fallahi & Jadidian, 2011; Hewson et al., 2010; Vinsapuu & Jörimäe, 2007) Previous studies (Häger-Ross & Rösblad, 2002; Vaz, Hunsberger & Diffey, 2002) have demonstrated that several anthropometric attributes such as body height, body mass and palm length, combined together affect the handgrip positively, during developing ages.

In the study of Visnapuu and Jürimäe (2007), body height was the most significant parameter for 10 and 11 years old subjects, predicting maximal handgrip strength, instead, at the age of 12 and 13 years old, body mass was the significant parameter that determined maximal handgrip strength.

30-m speed dribble, as analyzed by base-10 logarithm, showed a low correlation only with ball throwing velocity. In the literature there are no reports to aid to a comparison of our results to relevant studies. One study indicates low correlation ($r = -.24$, $p = .009$) of the ball velocity with 30-m sprint running in female adolescent handball players. (Zapartidis et al., 2009a) If we consider 30-m dribble as a combination of technical skill and explosive lower limb power, this association may be attributed to the type of the muscle fibers as in high velocity movements fast motor units are preferentially recruited. It is reported that in sprinters and throwers the size of the glycolytic fibers is approximately the triplicate of the oxidative glycolytic fibers. (Bergh et al., 1978) A recent research, that young basketball players, aged 13-14 years old were studied, handgrip strength revealed predictability on speed dribble and obstacle dribble. (Apostolidis & Zacharakis, 2015) This may have to do with that basketball player's use too much dribble unlike the handball players in few cases.

Regarding sex differences, as was expected, male adolescent handball players performed significantly better than female ones in ball velocity and handgrip strength. Researchers have documented that sex differences in motor performances of children are rather small during early adolescence and become established in mid-to-late adolescence. (Malina et al., 2010) Throwing seems to be a very dividing factor between the sexes from the very early ages, as males attain higher performances than females in throwing distance and throwing velocity in all age groups. (Zapartidis et al., 2011b) Obviously biological factors are responsible for these differences, as females have shown lower levels of neuromuscular coordination in maximally fast elbow flexion movements in comparison to males. (Ives et al., 1993).

From the other hand, maximal gains in muscle strength and power occur after PHV in both sexes, but the estimated gain in males is about twice as large as the one in females. (Malina et al., 2010) In the present study, male and female adolescent handball players differ significantly in handgrip strength. In contrast, male and female 12 years old distance runners and sprinters did not differ in the sum of right and left handgrip strength.

(Malina et al., 2010) An earlier study tested a total of 530 children aged 4 to 16 years in handgrip strength, showed no differences between the genders until around 10 years of age. After this age the boys were significantly stronger than girls and displayed a gradual increase in grip strength year by year compared with the girls. (Häger-Ross & Rösblad, 2002)

Conclusions

The aim of present study was to confirm the relationship among anthropometric characteristics, hand grip strength, and ball throwing velocity, in adolescent handball players. While the present results demonstrate that basic anthropometric characteristics influence ball velocity and hand grip strength, current literature reports conflicting results. Overhead throw is a very complex movement which involves rotations of all joints of the arm. The maximum ball velocity is achieved through the successful coordination of all body joints and segments in the movement and requires high technical skill. In addition, the muscle force generated by the upper limbs gives a final result in the throwing of the ball. In handball game, the adolescent players who have greater grip strength, arm span and hand length exhibit advantage in ball throwing velocity. This could help trainers to detect pre-pubertal and adolescent handball players take under consideration the specific characteristics.

References

- Apostolidis, N. & Zacharakis, E. (2015). The influence of the anthropometric characteristics and handgrip strength on the technical skills of young basketball players. *J Phys Edu Sport*, 15(2), 330-337.
- Bergh, U., Thorstensson, A., Sjödin, B., Helten, B., Piehl, K. & Karlsson, J. (1978). Maximal oxygen uptake and muscle fiber types in trained and untrained humans. *Med Sci Sports*, 10, 151-154.
- Chahal, A. & Kumar, B. (2014). Relationship of hand anthropometry and hand grip strength in junior basketball boys. *Int J Health Sci Res*, 4(11), 166-173.
- Debanne, T. & Laffaye, G. (2001). Predicting the throwing velocity of the ball in handball with anthropometric variables and isotonic tests. *J Sports Sci*, 29(7), 705-713.
- Fallahi, AA, and Jadidian AA. (2011), The Effect of hand dimensions, and hand shape and some anthropometric characteristics on handgrip strength in male grip athletes and non-athletes. *J Hum Kinet*, 29, 151-159.

- Ferragut, C., Vila, H., Abalades, J.A, Argudo, F., Rodriguez, N. & Alcaraz, P.E. (2011). Relationship among maximal grip, throwing velocity and anthropometric parameters in elite water polo players. *J Sport Med Phys Fitness*, 51, 26-32.
- Ferris, D.P., Signorile, J.F. & Caruso, J.F. (1995). The relationship between physical and physiological variables and volleyball spiking velocity. *J Strength Cond Res*, 9, 32-36.
- Fleising, G., Barrentine, S., Zheng, N., Escamilla, R. & Andreews, J. (1999). Kinematic and kinetic comparison of baseball pitching among various level of development. *J Biomech*, 18(6), 409-414.
- Häger-Ross, C. & Rösblad, B. (2002). Norms for grip strength in children aged 4-16 years. *Acta Paediatr*, 91(6), 617-625.
- Hewson, LK, Duchene, DJ, and Hogrel, JY. (2010). Predicting maximal grip strength using hand circumference. *Manual Therapy*, 15, 579-585.
- Jöris, H., van Muyen, E., van Ingen, S.G. & Kemper, H. (1985). Force, velocity and energy flow during the overarm throw in female handball players. *J Biomech*, 18, 409-414.
- Jürimäe, T., Hurbo, T. & Jürimäe, J. (2009). Relationship of handgrip strength with anthropometric and body composition variables in prepubertal children. *Homo – J Comparative Hum Biol*, 60, 225-238.
- Koley S, Singh J, Kaur S. (2010). A study of arm anthropometric profile in Indian interuniversity Basketball players. *Serb J Sports Sci*, 5(1), 35-40.
- Malina, R., Stawinska, T., Ignasiak, Z., Rožek, K., Kochan, K., Domaradzki, J. & Fugiel, J. (2010). Sex differences in growth and performance of track and field athletes 11-15 years. *J Hum Kin*, 24, 79-85.
- Melrose, D., Spaniol, F., Bohling, M. & Bonnette, R. (2007). Physiological and performance characteristics of adolescent club volleyball players. *J Strength Cond Res*, 23(2), 481-486.
- Palamas, A., Zapartidis, I., Kotzampouikidou, Z., Tsakalou, L., Natsis, P. & Kokaridas, D. (2015). The use of anthropometric and skill data to identify talented adolescent team handball athletes. *J Phys Edu Sports Management*, 2(2), 174-183.
- Skoufas, D., Kotzamanidis, C., Hatzikotoylas, K., Bebetos, G. & Patikas, D. (2003). The relationship between the anthropometric variables and throwing performance in handball. *J Hum Mov Stud*, 45, 469-484.
- Vaz, M., Hunsberger, S. & Diffey, B. (2002). Prediction equations for handgrip strength in healthy Indian male and female subjects encompassing a wide age range. *Ann Hum Biol*, 29(2), 131-141.
- Vila, H., Manhado, C., Rodriguez, N., Abalades, J.A., Alcaraz, P.E. & Farragut C. (2012). Anthropometric profile, vertical jump and throwing velocity in elite female handball players by playing position. *J Strength Cond Res*, 26(8), 2146-2155.

- Visnapuu, M, and Jürimäe, T. (2007). Handgrip strength and hand dimensions in young handball and basketball players. *J Strength Cond Res*, 21, 923-929.
- Zapartidis, I., Kororos, P., Christodoulidis, T., Skoufas, D. & Bayios, I. (2011a). Profile of young handball players by playing position and determinants of ball throwing velocity. *J Hum Kinet*, 27, 17-30.
- Zapartidis, I., Nikolaidou, M.E., Varelzis, I. & Kororos, P. (2011b). Sex differences in the motor abilities of young male and female handball players. *Biol Sport*, 28, 171-176.
- Zapartidis, I., Skoufas, D., Varelzis, I., Christodoulidis, T., Toganidis, T. & Kororos, P. (2009a). Factors influencing ball throwing velocity in young female handball players. *Open Sports Med J*, 3, 39-43.
- Zapartidis, I., Varelzis, I., Gouvali, M. & Kororos, P. (2009b). Physical fitness and anthropometric characteristics in different levels of young team handball players. *Open Sports Sci J*, 2, 22-28.
- Zapartidis, I., Toganidis, T., Varelzis, I., Christodoulidis, T., Kororos, P. & Skoufas, D. (2009c). Profile of young female handball players by playing position. *Serb J Spots Sci*, 3(2), 53-60..