

Original Article

Differences of physical abilities between successful and less successful young female athletes

SOFIA NAISIDOU¹, MAGDA KEPESIDOU², MENELIA KONTOSTERGIOU², ILIAS ZAPARTIDIS²

¹Anavryta Experimental Lyceum, Kifisia, GREECE

²School of Physical Education and Sports Science, National and Kapodistrian University of Athens, GREECE

Published online: March 31, 2017

(Accepted for publication February 15, 2017)

DOI:10.7752/jpes.2017.01044

Abstract:

Competition at the elite level requires as young and as talented athletes as possible. Thus, early talent identification and selection is a major component of any sport development program. The present study sought to identify the anthropometric attributes and physical – technical performance characteristics that differentiate successful or less-successful adolescent female handball players. A sample of elite players (13±0.5 yrs) was divided into the successful (SP=23) and less successful (LSP=63) group based on the expert opinions of 3 national handball team's coaches. Athletes underwent standard anthropometric measurements and were assessed on a battery of six physical and two handball-specific technical tests using objective measurement instruments. Multivariate analysis of variance revealed superior performance between SP and LSP in body height, hand span, hand grip strength, standing long jump, 30-m sprint, agility, ball throwing velocity, VO₂max, 30-m dribble and defensive triangle test. Linear discriminant function analysis identified four predictor variables (ball velocity, standing long-jump, body height and agility) that correctly discriminated between SP and NSP with an overall classification rate of 91%. Our discriminating model indicates that muscle power of upper and lower limbs together with stature and agility could predict performance in handball. Coaches interested in gaining a greater understanding of the factors that influence elite youth talent selection and identification should consider these parameters and combine them with perceptual-cognitive skills, psychological characteristics and training data to ensure optimal evolvement of athletes and supremacy in the sport.

Key words: handball, adolescent athletes, talent, throwing, handgrip.

Introduction

The process of selecting and developing talented young athletes from an early age has become significant, since nowadays competition at the international level has become more arduous entailing athletes of as younger ages as possible. Handball is characterized by highly developed motor skills and physical fitness characteristics such as short-distance sprints, jumping, throwing, agility, explosive power, aerobic and anaerobic capacity and muscular strength (Manchado et al., 2013; Zapartidis et al., 2009). During the game, the mean HR of elite adolescent 15 year old handball players reached 82±3% of HR_{max} with 10% of total playing time being occupied by very vigorous activity, 64% by moderate activity and 28% by low-intensity activity, respectively (Chelly et al., 2011). Pronounced longitudinal dimensions such as body height, arm span, hand span and length are necessary components of a contemporary model of a handball player, as they play a supportive role in enabling athletes to perform under actual competitive conditions (Manchado et al., 2013; Zapartidis et al., 2009). Characteristic feature of the assessment of anthropometric parameters and physical - motor abilities that are being employed at the initial stages of talent identification and selection is that they provide important information for coaches about the strengths, weaknesses, and potentialities of tested athletes. Coaches' main concern at this stage focuses on determining if the child meets the requirements of the game's basic demands (Lidor et al., 2005). Moreover, talent in young athletes is being identified through the interaction of genetically determined abilities and the aptitude of apprehending handball's game patterns and unique demands from an early age (Pearson et al., 2006).

In the literature there exist very few studies relating to the assessment of talented young boys (Lidor et al., 2005; Matthys et al., 2011; Mohamed et al., 2009; Palamas et al., 2015; Zapartidis et al., 2009) and even fewer studies on girls (Lidor et al., 2005; Zapartidis et al., 2009). By investigating the profile of adolescent female players, we can define the attributes that contribute to a player's selection for the team and add the data of the present study to the international literature to assist in female talent identification and development. Thus, the aim of the current study was to detect possible differences in selected anthropometric and physical fitness characteristics between successful and less successful young female handball players. Moreover, we sought to identify those characteristics that could serve as potential predictors for the successful selection of adolescent

athletes participating in such programs. It was expected that the successful young female handball players would have greater longitudinal anthropometric dimensions and higher performance in the physical fitness and motor skills tests than the less successful players.

Materials and Methods

Participants

The sample consisted of 91 adolescent female handball players aged 13.0 (0.5) years with 3.3 (1.3) years of playing experience. All players were invited to train in youth pre-selection groups. All players and their parents were informed about testing procedures and provided their written informed consent to participate in the study according to the University's research policy. Following, players were separated into a preliminary national team (successful players, SP, $n = 25$), based on the expert opinions of three national youth team's coaches who were responsible for the first phase of selection. The players, who were not selected, formed the less successful sample (LSP, $n = 66$). The female athletes were selected during a 4-days sports camp early July 2015, when their teams participated in summer open games.

Measurements and Procedures

Anthropometry: body height (to the nearest 0.1 cm), body mass (0.1 kg), body mass index (BMI), arm span (0.1 cm), hand span (0.1 cm) and hand length (0.1 cm) of the throwing hand, were assessed using standardized protocols. Physical – technical performance: standing long jump, running speed at 5, 10 and 30 meters, agility, ball throwing velocity, maximal isometric hand grip strength, aerobic capacity, 30 m slalom dribble and a handball specific defensive sliding movement (defensive triangle) were recorded for each player. Standing long jump was used for assessing the explosive power of the lower limbs, allowing arms and legs countermovement. Running speed was assessed by performing two maximal sprints of 30 m, with split times at 5 m, 10 m and 30 m, with the best used for further analysis. Agility skills were assessed through three different performance tests. A 5-0-5 agility test was used as it has been showed that this test is the most valid test of agility because it resulted in the highest correlation with acceleration in the turning phase of the test, but it did not correlate highly with running velocity (Sheppard and Young, 2006). A handball specific defensive sliding movement (triangle) was used to assess handball speed-agility-skill and the 30 m slalom dribbling test was used to assess player's agility with the ball (Matthys et al., 2011). The sprint and agility performances were recorded using electronic photocells (Brower timing system, USA). Ball velocity was measured by a radar gun from a standing position (penalty throw). Aerobic capacity was estimated using a 20 m shuttle run test (Léger et al., 1988). Maximal isometric handgrip strength was measured with a hand dynamometer (Lafayette Instrument, IN, USA). Anthropometrical measurements took place during first day of camp in the morning, and physical abilities measurements took place same afternoon. Descriptive data of anthropometric and physical fitness characteristics for all subjects prior to selection are presented at Table 1.

Table 1. Anthropometric and physical fitness characteristics of all subjects prior to selection ($n = 91$).

Anthropometric characteristics	Mean $\pm$ s	Range
Age (yrs)	12.98 $\pm$ 0.50	12.11-13.49
Experience (yrs)	3.32 $\pm$ 1.34	1.50-8.20
Body Height (m)	1.62 $\pm$ 0.05	1.49-1.79
Body Mass (kg)	57.35 $\pm$ 8.06	38.50-79.95
BMI (kg·m ⁻²)	21.88 $\pm$ 2.91	16.84-30.45
Arm Span (cm)	164.95 $\pm$ 6.22	151.00-181.80
Hand Span (cm)	20.51 $\pm$ 1.28	16.80-23.20
Hand Length (cm)	17.46 $\pm$ 0.96	15.20-20.10
Physical fitness characteristics		
Standing Long Jump (cm)	171.59 $\pm$ 20.02	127.00-217.00
5 m Speed (s)	1.29 $\pm$ 0.09	1.00-1.48
10 m Speed (s)	2.17 $\pm$ 0.12	1.87-2.47
30 m Speed (s)	5.25 $\pm$ 0.30	4.47-5.97
Agility (s)	3.02 $\pm$ 0.17	2.52-3.43
Ball Velocity (km·h ⁻¹)	55.07 $\pm$ 5.76	41.00-67.00
Hand Grip (kg)	26.91 $\pm$ 5.60	15.00-40.00
VO ₂ max (ml·kg ⁻¹ ·min ⁻¹)	46.67 $\pm$ 4.27	35.09-58.92
30 m Dribble (s)	8.07 $\pm$ 0.93	6.37-11.50
Defensive Triangle (s)	16.20 $\pm$ 0.58	15.00-17.79

Statistical Analysis

Preliminary analysis: Before proceeding with data analysis, all variables were screened for possible statistical assumption violations, as well as for outliers using SPSS 11.5 explore, plot and regression procedures. Correlation analysis revealed a high positive correlation between body mass and BMI ($r = 0.892$), body height and arm span ($r = 0.886$) 5 m sprint and 10 m sprint ($r = 0.912$). The variables of BMI, arm span and 10 m sprint

were excluded from further analysis. Four univariate outliers were observed and were eliminated from the main analysis, leaving a total of 87 subjects (24 SP and 63 NSP). Box's test of equality of covariance matrices was not significant (Box's $M=170.35$, $P>0.05$) and Bartlett's test of sphericity was statistically significant (approx. $chi\ square=4419.37$, $P<0.001$). Evaluation of the properties of the data set determined that these data met the necessary statistical assumptions to support the analyses.

Main analysis: To investigate possible differences on the dependent variables (anthropometric characteristics, physical – technical performance), a multivariate analysis of variance was conducted with the selection level as the fixed factor. A linear discriminant function analysis using the criterion Wilks' lambda was also conducted to determine the variables that distinguish SP from NSP players. Statistical significance for all tests was set at $P<0.05$.

Results

Using the Wilk's lambda criterion, the composite dependent variate was significantly affected by successful level (Wilk's $\lambda=0.452$, $F=5.73$, $P<0.001$, partial $\eta^2=0.548$). Mean values estimation for each variable revealed the superiority of successful players in regard to body height ($F_{1,85}=19.65$, $P<0.001$, $\eta^2=0.188$), hand span ($F_{1,85}=6.31$, $P<0.05$, $\eta^2=0.069$), standing long jump ($F_{1,85}=29.72$, $P<0.001$, $\eta^2=0.259$), 30 m sprint ($F_{1,85}=7.03$, $P<0.010$, $\eta^2=0.076$), agility ($F_{1,85}=13.32$, $P<0.001$, $\eta^2=0.136$), ball throwing velocity ($F_{1,85}=42.42$, $P<0.001$, $\eta^2=0.333$), VO_{2max} ($F_{1,85}=12.87$, $P<0.01$, $\eta^2=0.131$), defensive triangle ($F_{1,85}=4.68$, $P<0.05$, $\eta^2=0.052$), 30 m dribble ($F_{1,85}=4.67$, $P<0.05$, $\eta^2=0.052$) and hand grip strength ($F_{1,85}=7.68$, $P<0.01$, $\eta^2=0.083$). No statistically significant differences were found regarding chronological age, playing experience, body mass, hand length and 5 m acceleration. Descriptive data for all variables after the preliminary analysis and significant differences between SP and LSP are presented at Table 2.

Table 2. Anthropometric and physical fitness characteristics of the successful (SP, $n=24$) and less successful players (LSP, $n=63$) after the preliminary analysis.

	Successful		Less successful	
	Mean $\pm$ s	Range	Mean $\pm$ s	Range
Anthropometric characteristics				
Age (yrs)	12.94 $\pm$ 0.51	12.14-13.49	13.00 $\pm$ 0.50	12.11-13.49
Experience (yrs)	3.60 $\pm$ 1.37	1.50-6.00	3.13 $\pm$ 1.18	1.50-6.27
Body Height (m)	1.65 $\pm$ 0.05	1.56-1.79	1.60 $\pm$ 0.05**	1.49-1.74
Body Mass (kg)	57.15 $\pm$ 5.12	43.00-67.00	57.38 $\pm$ 8.90	38.50-79.95
Hand Span (cm)	21.05 $\pm$ 1.09	19.40-23.20	20.29 $\pm$ 1.32*	16.80-22.80
Hand Length (cm)	17.73 $\pm$ 1.05	16.40-20.10	17.37 $\pm$ 0.93	15.20-20.00
Physical fitness characteristics				
Standing Long Jump (cm)	187.75 $\pm$ 13.71	170-217	165.37 $\pm$ 18.22**	127-210
5 m Speed (s)	1.28 $\pm$ 0.09	1.00-1.43	1.29 $\pm$ 0.09	1.11-1.48
30 m Speed (s)	5.11 $\pm$ 0.16	4.92-5.58	5.29 $\pm$ 0.33*	4.65-5.97
Agility (s)	2.93 $\pm$ 0.11	2.69-3.06	3.07 $\pm$ 0.17**	2.82-3.43
Ball Velocity (km·h ⁻¹)	60.46 $\pm$ 3.28	54.00-67.00	53.19 $\pm$ 5.07**	41.00-63.00
Hand Grip (kg)	29.42 $\pm$ 4.92	20.00-40.00	25.81 $\pm$ 5.60*	15.00-39.00
VO_{2max} (ml·kg ⁻¹ ·min ⁻¹)	49.26 $\pm$ 3.42	42.95-56.93	45.80 $\pm$ 4.22*	35.09-58.92
30 m Dribble (s)	7.71 $\pm$ 0.77	6.72-9.97	8.14 $\pm$ 0.85*	6.37-10.34
Defensive Triangle (s)	15.97 $\pm$ 0.46	15.06-16.75	16.26 $\pm$ 0.59*	15.00-17.79

Note: Significant differences between groups ** $P<0.001$, * $P<0.05$

A linear discriminant function analysis was conducted to determine whether the predictors could predict handball performance. The overall Wilk's lambda was significant (Wilk's $\lambda=0.502$, $\chi^2=57.21$, $P<0.001$), indicating that the overall predictors differentiated between the two group internship performance groups. Table 3 presents the standardized coefficients and correlation of predictor variables of the discriminant function. Based on these coefficients, ball velocity demonstrated the strongest relationship with the discriminant function. Table 4 demonstrates how well the discriminant function classified the cases for each group of the dependent variable.

Table 3. Standardized coefficients & correlations of predictor variables

Predictors	Correlation Coefficients	Standardized Coefficients
Ball velocity	0.709	0.569
Standing long jump	0.594	0.438
Body height	0.483	0.367
Agility	-0.397	-0.400

Table 4. Classification results of the discriminant function analysis

		Predicted Group Membership		Total
		Successful	No	Yes
Original Count	No		4	59
	Yes		4	20
%	No		93.7	6.3
	Yes		16.7	83.3

Note: 90.8% of original grouped cases correctly classified

Discussion and Conclusions

The purpose of this study was to examine differences in the anthropometric and physical – technical performances of successful and less successful adolescent female handball players. Present results demonstrate that muscle power of the upper and lower limbs (as expressed by ball throwing velocity and standing long jump), in combination with stature and agility, distinguished successful from less successful young female players. The discriminant function analysis correctly predicted 20 out of 24 SP and 59 out of 63 LSP, that is 79 out of 87 players in total. The prediction of internship performance was impressive with an overall classification rate of 91%. There was a greater success rate for LSP (94%) than for the SP (83%). The main finding of the present study was that the successful adolescent female handball players (SP), performed on average higher in a battery of motor abilities and technical skills tests. Particularly, SP showed significantly better performance in the standing long jump, 30 m sprint, agility, ball throwing velocity, aerobic capacity, isometric strength, slalom dribble and defensive movement. With regard to anthropometric characteristics, SP had a higher body height and a greater hand span. In team sports that use a ball, morphology of the hand combined with its functional abilities can unquestionably play a decisive role on performance. Moreover, as in other team sports, adult athletes of long stature have an advantage at covering court space due to their long extremities and they also benefit in muscle power production with regard to the body's leverage systems. There is a scarcity of data regarding female handball athletes of such a young age, thus making comparison of results relatively difficult. An earlier study, which examined female athletes from Israel mean aged $13.4 \pm .05$ years, did not indicate any differences in body height, 4x10 m agility, medicine ball throw, 20 m sprint and slalom dribble between selected and non-selected for national team girls. The standing long jump was the only variable that discriminated between groups (Lidor et al., 2005). A previous study involving Greek female players mean aged $13.7 \pm .05$ years also reported no differences between selected and non-selected girls in anthropometric characteristics and several motor abilities, with the exception of muscle power (ball velocity and standing long jump). In particular, ball throwing velocity was the parameter indicating the most significant difference comparing selected to non-selected girls. However, when players were divided according to playing position, the selected backcourt players were significantly taller and had longer arm span than their non-selected peers (Zapartidis et al., 2009). Further, the influence of anthropometric characteristics on selected basketball skills that verify efficient handling of the basketball was reported for basketball players aged 13-14 years old. Specifically, it was found that body height and hand span could significantly predict the speed and performance on obstacle dribble skills (Apostolidis and Zacharakis, 2015).

Previous studies that have examined male adolescent handball players report elite players to be significantly better than their non-elite counterparts on several fitness tests with stature and the 10x5 m shuttle run being the most important discriminators (Mohamed et al., 2009). In addition, Flemish elite male players were significantly better in the countermovement jump, five-jump test for distance, sit-ups and hand grip strength when compared to their non-elite counterparts at three different ages (Matthys et al., 2011). Mohamed et al. (2009) also reported significant differences between elite and non-elite 15-year-old male players in standing long jump, vertical jump, and hand grip strength. A recent study that detected differences between selected and non-selected Greek adolescent male handball players stated the superiority of selected athletes in stature, ball throwing velocity, standing long jump, aerobic capacity, 30 m sprint, agility and maximal isometric hand grip strength, with ball throwing velocity demonstrating the strongest relationship with the discriminant function (Palamas et al., 2015). Overall, previously existing studies suggest that the explosive muscle power of upper and lower limbs, as recorded by ball throwing velocity and jump tests, is the most important component that discriminates successful from less successful male and female athletes (Current study; Lidor et al., 2005; Matthys et al., 2011; Mohamed et al., 2009; Palamas et al., 2015; Zapartidis et al., 2009).

It has been reported that muscle power of the lower limbs (standing long jump or vertical jump) is an important factor influencing ball throwing velocity among several motor tests typically being used in young male and female handball and volleyball players (Forthomme et al., 2005; Zapartidis et al., 2011; Zapartidis et al., 2009). Previous research has shown that the effective energy transition from the ground to the throwing arm through the kinematic chain is the main factor affecting ball velocity in handball athletes (Bayios et al., 2001). Responsible parameters for this fact seem to be the type of muscle fibers and neural aspects, as in high velocity movements like throwing, the fast motor units are preferentially recruited (Ziv and Lidor, 2009). In sports characterized by very short, high intensity actions lasting less than 1-2s, the ATP depots in the muscle will be

mostly involved and performance will depend on the muscle fibers' cross-sectional area and the ability of the central nervous system to excite the motor units at a high rate (Bencke et al., 2002). Handball training requires many throws, jumps and sprints of 5-15 meters, namely movements which activate the fast-twitch fibers and, as these movements are frequent and highly trained in handball, possibly this could explain the association. Present results confirm the importance of muscle power in elite adult athletes and strongly suggest that muscle power is equally important in adolescent athletes. Compared to handball players of a lower competitive level, players competing at a higher level of competition appear to have an increased power production by 25% at the upper limbs and by 12% at the lower limbs, respectively (Granados et al., 2007). Girls of 14 years of age who had been playing handball for an average of 4 years were found to produce 18% higher power in the vertical jump compared to girls of the same age that have been exercising for recreation. Moreover, handballers attained better results in aerobic and anaerobic capacity, and 30 m sprint compared to the control group (Vicente-Rodriguez et al., 2004). Handball players need lactic acid-tolerance training to improve their intramuscular buffering capacity. However, aerobic training is also required because if oxygen availability is impaired, then the elimination of lactate acid is minimal during the recovery intervals. This will result in lactate acid accumulation, which will limit the player's ability to sustain a high power output, since performance in the physiological parameters has been shown to significantly decrease between the first and the second half of the game (Chelly et al., 2011, Zapartidis et al., 2007). Physical and motor tests are widely used for screening and identification of prepubertal athletes.

A weakness of the present study is that biological maturation was not assessed. The coaches who were responsible for the selection of the U-16 pre-national team based their decision on the chronological age and current abilities of players, since those players will constitute the U-16 national handball team in the next two years. However, when the aim is selection of athletes on a longitudinal basis and selection is based solely on anthropometric attributes and motor abilities, caution should be taken because these characteristics are affected by biological maturation (Matthys et al., 2011; Zapartidis et al., 2009). Anthropometric attributes and physical abilities combined with technical characteristics should be evaluated in frequent time intervals during the prepubertal period. An important reason being, that selected athletes who possess a maturation advantage during early adolescence might not probably retain these advantages till adulthood. On the other hand, evaluation of these attributes provides important information about the strengths and weaknesses of athletes as well as about individual training adaptations. However, in order to select athletes who demonstrate the potential to evolve and become part of what is defined as elite level sport, other parameters such as perceptual-cognitive skills, psychological characteristics, environmental-sociological factors and training data should be taken into consideration. Coaches usually imply that elite players are in a way gifted with unique abilities that will ensure them supremacy in their sport. It is true, that early selection of athletes relates with their overall initial performance (motor skills, technical and anthropometric characteristics, physical abilities and psychological profile), which through the training process will lead to an expected elite performance. However, to be at the elite level, the athlete must devote significant time in training and have the appropriate guidance to improve his performance. Practice history profiles of soccer players have shown that the amount of time spent in training was the strongest discriminator among different level groups (Williams & Hodges, 2005). It has generally been reported that in sports, science and arts, for someone to reach international competition levels, 10.000 practice hours must take place (Williams & Hodges, 2005). Further, during a child's evolvement though the training process, environmental, social and economic factors play an important role.

Therefore, identification and selection models of athletes should be thoroughly examined, young children be assessed at frequent time intervals and factors relating to the child's environment be taken into account. Coaches should contribute significantly in their athletes' maturation process and provide them with the proper stimuli for the evolvement of their personality whilst setting the foundation for a long-term stay in the sport. Future studies investigating the anthropometric attributes, motor, technical and psychological characteristics of players in combination with training-specific adaptations could shed light and provide sport scientists, coaches and athletes with meaningful information about the aptness of early selection.

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 Educ Sport*, 15, 330-337.
- Bayios, I. A., Anastasopoulou, E. M., Sioudris, D. S., & Boudolos, K. D. (2001). Relationship between isokinetic strength of the internal and external shoulder rotators and ball velocity in team handball. *J Sport Med Phys Fit*, 41, 229-235.
- Bencke, J., Damsgaard, R., Saekmose, A., Jørgensen, P., Jørgesen, R. & Klausen, K. (2002). Anaerobic power and muscle strength characteristics of 11 year old elite and non-elite boys and girls from gymnastics, team handball, tennis and swimming. *Scand J Med Sci Spor*, 12, 171-178.
- Chelly, M.S., Hermassi, S., Aouadi, R., Khalifa, R., Van Den Tillaar, R., Chamari, K. & Shephard, R.J. (2011). Match analysis of elite adolescent team handball players. *J Strength Cond Res*, 25, 2410-2417.
- Forthomme, B., Croisier, J., Ciccarone, G., Crielaard, J. & Cloes, M. (2005). Factors correlated with volleyball spike velocity. *Am J Sport Med*, 33, 1513-1519.

- Granados, C., Izquierdo, M., Ibañez, J., Bonnabau, H. & Gorostiaga, E.M. (2007). Differences in physical fitness and throwing velocity among elite and amateur female handball players. *Int J Sports Med*, 28, 860-867.
- Léger, L.A., Mercier, D., Gadoury, C. & Lambert, J. (1988). The multistage 20 metre shuttle run test for aerobic fitness. *J Sport Sci*, 6(2), 93-101.
- Lidor, R., Falk, B., Arnon, M., Cohen, Y. & Segal, G. (2005). Measurement of talent in team handball: the questionable use of motor and physical tests. *J Strength Cond Res*, 19, 318-325.
- Manchado, C., Tortosa, J., Vila, H., Ferragut, C. & Platen, P. (2013). Performance factors in women's team handball: physical and physiological aspects--a review. *J Strength Cond Res*, 27, 1708-1719.
- Matthys, S.P.J., Vaeyens, R., Vandendriessche, J., Vandorpe, B., Pion, J., Coutts, A.J., ... Philippaerts, R.M. (2011). A multidisciplinary identification model for youth handball. *Eur J Sport Sci*, 11, 355-363.
- Mohamed, H. S., Vaeyens, R., Multael, M., Matthys, S., Lefevre, J., Lenoir, M. 2009. Anthropometric and performance measures for the development of a talent detection and identification model in youth handball. *J Sport Sci*, 27, 257-266.
- Palamas, A., Zapartidis, I., Kotsampoukidou, Z., Tsakalou, L., Natsis, P. & Kokaridas, D. (2015). The use of anthropometric and skill data to identify talented adolescent team handball athletes. *J Phys Educ Sports Management*, 2, 174-183.
- Pearson, D.T., Naughton, G.A. & Torode, M. (2006). Predictability of physiological testing and the role of maturation in talent identification for adolescent team sports. *J Sci Med in Sport*, 9, 277-287.
- Sheppard, J.M., & Young, W.B. (2006). Agility literature review: classifications, training and testing. *J Sport Sci*, 24, 919-932.
- Vicente-Rodriguez, G., Dorado, C., Perez-Gomez, J., Gonzalez-Henriquez, J.J. & Calber, J.A.L. (2004). Enhanced bone mass and physical fitness in young female handball players. *Bone*, 35, 1208-1215.
- Williams, M.A., & Hodges, N.J. (2005). Practice, instruction and skill acquisition in soccer: challenging tradition. *J Sport Sci*, 23(6), 637-650.
- Zapartidis, I., Gouvali, M., Bayios, I. & Boudolos, K (2007). Throwing effectiveness and rotational strength of the shoulder in team handball. *J Sport Med Phys Fit*, 47, 169-178.
- Zapartidis, I., Kororos, P., Christodoulidis, T., Skoufas, D. & Bayios, I. (2011). Profile of young handball players by playing position and determinants of ball throwing velocity. *J Hum Kinet*, 27, 17-30.
- Zapartidis, I., Varelziz, I., Gouvali, M. & Kororos, P. (2009). Physical fitness and anthropometric characteristics in different levels of young team handball players. *The Open Sports Sci J*, 2, 22-28.
- Ziv, G., & Lidor, R. (2009). Physical characteristics, physiological attributes, and on court performances of handball players: A review. *Eur J Sport Sci*, 9, 375-386.