Profile of Young Handball Players by Playing Position and Determinants of Ball Throwing Velocity

by
Ilias Zapartidis[1], Panagiotis Kororos[1], Triantafyllos Christodoulidis[2],
Dimitrios Skoufas[2], Ioannis Bayios[1]

This study defined the differences in physical qualities and anthropometric characteristics among playing positions in young male handball players, and investigated the relationship between ball throwing velocity and all measured parameters.

182 young male handball players, aged 14.3yrs, with playing experience of 4.5yrs, were classified as: back players, centre backs, pivots, wing players, and goalkeepers. Body height, body mass, BMI, arm span, hand length, standing long jump, 30m sprint, flexibility, VO$_{2max}$ and throwing velocity were measured.

Significant differences were detected among individual positions for all measured variables, except for flexibility. Backs were tallest, while pivots showed the largest arm span and hand length. Wings were shortest, with the lowest weight and BMI. Backs and wings performed best in the standing long jump, 30m sprint, flexibility and VO$_{2max}$. Goalkeepers underperformed in all motor abilities. Ball velocity significantly correlated to all variables except for BMI and flexibility. Anthropometric and physical differences exist among different positions in young male handball players. These parameters influence ball velocity.

The findings suggest that a high performance level requires advanced physical qualities as well as anthropometric features for these ages, and coaches should apply specific training programs for each playing position.

Key words: *handball, physical fitness, anthropometric variables, throwing velocity*

Introduction

Team handball is a multi-component sport and the involved athletes are required to possess many skills and specific physiologic characteristics. In order to maximize team performance, it is important to clarify the contribution of the different roles that players have in the team, as expressed from their different positions. During the evolution of the game,

[1] -National and Kapodistrian University of Athens, Department of Physical Education & Sport Science, Greece**.**
[2] -Aristotle University of Thessaloniki, Department of Physical Education & Sport Science, Greece.

specific individual playing positions have been classified as back players, wings, pivots, centre backs and goalkeepers (Šibila et al., 2004; Zapartidis et al., 2009a). One of the main factors that appears to distinguish an elite from an average male athlete is ball throwing velocity (Gorostiaga et al., 2004; Zapartidis et al., 2009b). Ball throwing velocity may be influenced by certain anthropometric characteristics (Skoufas et al., 2003; Zapartidis et al., 2009c), as well as physical fitness capacity and specific motor abilities, as shown in a study involving young female handball players (Zapartidis et al., 2009c).

The designation and identification of talents for team sports at a young age is more complex and differs significantly from the identification of talents in individual sports. The coaches believe that certain anthropometric characteristics and motor abilities are the most important prognostic factors of future performance (Lidor et al., 2000). Body height is greater than the average population and it's importance during the game correlates with the playing position that the athlete holds on the court (Srhoj et al., 2002). Back players are the tallest with the largest arm span followed by goalkeepers, whereas wing players are the shortest members of the team (Srhoj et al., 2002; Chaouachi et al., 2009).

Maximal oxygen uptake for elite players is high (Buchheit et al., 2009), while no differences are reported between playing positions. Regarding motor abilities, goalkeepers seem to be least fit (Rogulj et al., 2005; Chaouachi et al., 2009). There are only few comparisons of the characteristics of athletes playing different positions. In addition, to our knowledge, no studies investigated differences among playing positions in young males, in the beginning of the position-specialized training. Performance maximizing involves a long training process; corresponding to the athletes' biological development and in this very beginning of this process the basis of the future sport performance is set.

The aim of the present study was a) to determine the differences in motor abilities and anthropometric characteristics between the five classified playing positions and b) to examine the relationship between anthropometric variables, motor abilities and ball throwing velocity to young male handball players. It was hypothesized that, when referring to the individual playing positions, there would be specific differences in the anthropometric and physical qualities indices.

Material and methods

Participants

The sample consisted of 182 male young handball players from all over Greece, with a mean age of 14.26 ± 0.44 years and 4.46 ± 1.67 years of playing experience. Players were classified according to their playing positions into 5 groups: backs (*n* = 55), pivots (*n* = 27), wings (*n* = 43) centre backs (*n* = 29) and goalkeepers (*n* = 28). All players participated at the highest league for their age category for which they were participating in 3 training sessions and one game

per week. The training sessions were of 90 to 105 minutes length and included classic training units of conditioning, technique and tactics. Data were collected from April to June 2008, after the competitive season. All tests were conducted indoors. Both players and their parents were informed about the procedures of the measurements including the risks and provided their written consent for participating according to the research policy of the University of Athens.

Anthropometry

The anthropometric characteristics included body height and mass, body mass index (kg·m^{-2}), arms span and hand length. Body height was measured at standing position with the shoulders and heels adjacent to a wall using a height meter (220 Seca, Germany). The intra-class correlation coefficient (ICC) for test-retest reliability and the typical error (TE) of measurement (Hopkins, 2000) was 0.99 and 0.1%. Body mass was measured using a precision scale (Bilance Salus, Italy) to the nearest 0.5 kg., (ICC=0.99, TE=0.2%). Arm span was measured from the right to the left middle finger tip with the arms extended and abducted (ICC=0.99, TE=0.7%). Hand length from the mid-stylion to dactylion (ICC=0.99, TE=0.3%).

Physical qualities

Physiological assessment included measurement of ball throwing velocity, standing long jump, running speed, sit and reach flexibility, and maximal oxygen uptake (VO$_{2max}$).Ball velocity was measured from a standing position (penalty throw) by a radar gun (Sports Radar 3300, Sports Electronics Inc, USA) (ICC=0.90, TE=3.2%). For the standing long jump test, players stood behind a line and jumped as far as possible – allowing arm movement and legs countermovement (ICC=0.97, TE=3.2%). Running speed was evaluated by 30m sprints from a standing position. The time was measured using a handheld stopwatch (ICC=0.91, TE=1.8%). For measuring flexibility of the hamstring muscles and the lower back, the modified sit-and-reach test was used (Hoeger et al., 1990) (ICC=0.97, TE=2.8%). Aerobic capacity was expressed as the estimated VO$_{2max}$ using a 20m shuttle run test and predicted by a regression equation according to the age and the running speed at the last completed stage. The test stopped when the participant was no longer able to follow the set pace (Léger et al., 1988). Except for the 20m shuttle run test, all other tests were performed twice and the best performance was selected for analysis.

Statistical Analysis

Differences in anthropometric and physical qualities of the different playing positions were compared using one-way analysis of variance. Comparisons of group means were performed using *Scheffé's post-hoc* tests. All data are reported as means ± standard deviations. *Pearson* product-moment correlations were used to examine the relationship between anthropometric and physical qualities and ball throwing velocity.

A multiple regression analysis was conducted to illustrate which variables in

combination might be more strongly associated with ball velocity. Statistical significance was set at $p < 0.05$.

Results

Descriptive statistics for anthropometric and physical qualities for all players are presented in Table 1. Significant differences were detected among positions for height (F = 23.25, p < 0.001), body mass (F = 28.88, p < 0.001), BMI (F = 22.86, p < 0.001), arm span (F = 16.66, p < 0.001), hand length (F = 10.32, p < 0.001), standing long jump (F = 8.88, p < 0.001), ball throwing velocity (F = 7.52, p < 0.001), 30m sprint (F = 6.77, p < 0.001) and estimated VO_{2max} (F = 12.77, p < 0.001)

Table 1

Anthropometric characteristics and physical fitness of young male team handball players.

Variables	Mean
Body Height (m)	1.75
Body Mass (kg)	70.99
BMI (kg·m^{-2})	23.19
Arm Span (cm)	180.42
Hand Length (cm)	19.39
Standing Long Jump	202.96
30m Sprint (sec)	4.72
Estimated VO_{2max}	50.31
Ball Velocity (km·h^{-1})	70.10
Sit and Reach (cm)	32.14

There were no significant differences in age (F = 2.05, p = 0.96), playing experience

(F = 2.34, p = 0.06) and sit and reach flexibility (F = 1.17, p = 0.33).

Anthropometry

Table 2 shows the mean values in anthropometric characteristics for playing positions and the differences among them as obtained by the *post-hoc* tests.

Backs and pivots were the tallest players, with the largest arm span and hand length, while wings were the shortest with the smallest longitudinal dimensions. Pivots were significantly heavier and they showed the highest BMI among all other players. Goalkeepers were the second heaviest group differing significantly from wings and with higher BMI than backs and wings.

Physical fitness

Table 3 shows the mean values in physical qualities for playing positions and the differences among them as obtained by the *post-hoc* tests. Backs and wings showed the best performance among all players in the standing long jump, 30m sprint and VO_{2max}. Pivots and backs achieved the highest values in ball throwing velocity. Goalkeepers performed poorer than all other players when it comes to motor abilities. No significant differences were found among groups in flexibility, although backs seem to be the most flexible players.

Factors correlated to ball throwing velocity

Ball throwing velocity was significantly correlated (p < 0.001) to all anthropometric variables except BMI (Table 4).

Concerning physical variables, ball velocity was positively correlated to the standing long jump and estimated VO_{2max} ($p < 0.001$).

The time achieved in the 30m sprint was negatively correlated ($p = 0.014$) to ball velocity, indicating that, as long as the ability of attaining maximal speed increases, the ball throwing velocity also increases

Table 2

Differences in anthropometric characteristics
among specific individual playing positions

Characteristic	Backs	Centr	Wing	Pivot	Goalke
Body Height (m)	1.79 ±	1.73 ±	1.69 ±	1.78 ±	1.74 ±
Body mass (kg)	69.57	68.61	62.60	87.14	74.04 ±
BMI (kg·m^{-2})	21.80	22.85	21.84	27.45	24.37 ±
Arm span (cm)	183.68	178.86	174.2	185.2	180.47
Hand Length (cm)	19.76	19.27	18.81	19.88	19.16 ±

Significantly different from backs. ^{C}Significantly different from centre backs.
^{W}Significantly different from wings. ^{P}Significantly different from pivots.
^{G}Significantly different from goalkeepers. ($p < 0.05$)

Table 3

Differences in physical fitness
among specific individual playing positions

Characteristics	Ba	Centre	Win	Pivots	Goalke
Long Jump (cm)	214	199.48	205.	194.15	187.75
Ball Velocity	72.	69.59 ±	67.4	73.56 ±	65.79 ±
30m sprint (sec)	4.6	4.79 ±	4.62	4.85 ±	4.88 ±
VO_{2max} (ml·kg$^-$	52.	50.31 ±	51.8	47.74 ±	46.41 ±
Sit and Reach	33.	31.03 ±	31.2	31.52 ±	31.98 ±

Significantly different from backs. ^{C}Significantly different from centre backs.
^{W}Significantly different from wings. ^{P}Significantly different from pivots.
^{G}Significantly different from goalkeepers. ($p < 0.05$)

Variables contributed to the prediction of ball throwing velocity.

The intercorrelations between the independent variables, showed higher than 0.80 bivariate correlations between body height and arm span (r= 0.85), and body mass and BMI (r= 0.91). Thus, arm span, and BMI was not included in the multiple regression analysis. When all independent variables entered to the model, multiple R for regression was statistically significant, *F*=12.26, *p* < 0.001, *R² adj* = 0.35.

Four of the seven independent variables (height, body mass, standing long jump and estimated VO$_{2max}$) contributed significantly to the prediction of ball throwing velocity (Table 5).

Table 4

Results of Pearson coefficients of correlation between throwing velocity and anthropometric characteristics and physical qualities parameters

	Statistics	
Variables	*r*	*p*
Body Height	0.440	< 0.001
Body Mass	0.282	< 0.001
BMI	0.104	0.169
Arm Span	0.430	<0 .001
Hand Length	0.373	< 0.001
Standing Long	0.336	< 0.001
30m Sprint	-0.185	0.014
Sit and Reach	0.117	0.129
VO$_2$max (estimated)	0.247	< 0.001

Table 5

Regression analysis summary with all variables included for predicting ball throwing velocity

Variables	B	Std. Error	Beta	t	Sig.
(Constant)	-25,169	19,379		-1,299	0,196
Body height	25,525	11,101	0,218	2,299	0,023
Body mass	0,216	0,054	0,355	3,976	0,000
Hand length	-0,136	0,732	-0,017	-0,186	0,853
Standing long jump	0,100	0,030	0,303	3,329	0,001
Estimated VO2 max	0,356	0,128	0,215	2,777	0,006
Sit and reach	0,041	0,069	0,039	0,594	0,554
30m Sprint	-0,332	2,225	-0,013	-0,149	0,882

Table 6a

Regression analysis summary using only anthropometric variables for predicting ball throwing velocity

Variables	B	Std. Error	Beta	t	Sig.
(Constant)	-17,768	14,827		-1,198	0,232
Body height	38,512	11,545	0,326	3,336	0,001
Body mass	0,039	0,048	0,064	0,812	0,418
Hand length	0,917	0,750	0,117	1,223	0,223

Table 6b

*Regression analysis summary using only physical fitness variables
for predicting ball throwing velocity*

Variables	B	Std. Error	Beta	t	Sig.
(Constant)	30,032	17,887		1,679	0,095
Standing long jump	0,104	0,033	0,314	3,186	0,002
Estimated VO2 max	0,178	0,139	0,108	1,283	0,201
Sit and reach	0,088	0,078	0,084	1,132	0,259
30m Sprint	1,528	2,517	0,059	0,607	0,545

When anthropometric and physical fitness variables were separately inserted in the model, multiple R for regression was statistically significant, F=14.66, $p < 0.001$, R^2 *adj* = 0.20, and F=6.04, $p < 0.001$, R^2 *adj* = 0.13 respectively. Only body height from anthropometric and standing long jump from physical fitness variables contributed to the prediction of ball throwing velocity (Table 6a,b).

Discussion

In a few previous studies of elite adult male and female handball players, significant differences were demonstrated among playing positions for height (Srhoj et al., 2002; Chaouachi et al., 2009; Ohnjec et al., 2003), body weight (Srhoj et al., 2002; Chaouachi et al., 2009), arm span and hand length (Srhoj et al., 2002). Regarding physical fitness, significant differences among playing positions have been reported only for female adult players, specifically for the standing long jump, 30m sprint (Rogulj et al., 2005) and throwing velocity (Fábrica et al., 2008).

Back players are typically the tallest in the team followed by pivots and goalkeepers and they have large body segments, while wings are the shortest players. Our results are in agreement with previous studies involving male adult players (Šibila et al., 2004; Chaouachi et al., 2009) and young female players aged 14.1yrs (Zapartidis et al., 2009a). However, in a research where Croatian top level players participated, it was found that pivots are the shortest players with statistically significant differences from backs and goalkeepers (Srhoj et al., 2002). Backs participate in the central defense field, aiming to block the opponents' shoots, they are specialized in distant shots and they are efficient in shooting at the goal over the defensive wall. In handball, a principal requirement for this position is height, as this has a positive influence on all longitudinal body dimensions. Tall athletes are superior in space coverage with their limbs and they have an advantage in power production in regards to leverage body systems. Additionally, tall backs have better visual control of the court and

cooperate better with pivots and wings. Wings are the shortest players in the team and in linear defense (6:0) they play at the court boundaries and usually confront players of the same height. When in attack, they do not shoot from a distance and over blocks –as backs do, but from positions near the 6m goal area line, using dive, falling, or curved jump throws (Srhoj et al., 2002). Centre backs are significantly shorter than pivots and backs. Their main mission is game organizing. In modern handball the anthropometric characteristics of these players should be similar to those of the backs. This is not a finding of the present study, as they appear to be shorter than expected based on literature. This finding is in accordance with a previous study involving young female centre backs who were the second shorter position group (Zapartidis et al., 2009a). This is probably due to coaches' decision, for this age range to assign the taller players in back positions.

Pivots were significantly the heaviest players with the highest BMI. These findings are in agreement with other studies in which pivots had greater body mass in relation to body height and higher BMI from all other playing positions concerning male top level players (Srhoj et al., 2002; Chaouachi et al., 2009), or young female players (Zapartidis et al., 2009a). The position of pivots is in the middle of the opponent's defense on the 6m goal area line and they have to maintain their balance and resist the defense's pressure and pushes/collisions. Greater muscle mass in combination with a low center of gravity,

strong upper body and relatively large total body mass are required to succeed in game conditions (Srhoj et al., 2002). However, high BMI values are not acceptable for athletes.

Goalkeepers differ mostly from the wings and pivots with respect to body height, body mass, BMI and arm span. Top class goalkeepers should be tall enough and relatively light so that they are able to efficiently move body parts. They should also have big upper and lower extremities in order to cover as large area as possible of their goalpost (Srhoj et al., 2002). The mean value of 24.4 BMI that goalkeepers had in this study is not only too high for athletes but also for sedentary people (Gil et al., 2007). The anthropometric characteristics of the young goalkeepers in this population seem to be inefficient comparing to the requirements of this sport for this specific playing position. In many cases, and especially at younger ages, coaches select tall children for goalkeepers not because they are more eligible but because they are less fit than the rest. Additionally, the young goalkeepers are not subjected to strict training, as the other players are, because they consider their position as less demanding. This training attitude is completely wrong as the goalkeeper position is of outmost importance in handball.

Physical fitness

Backs and wings displayed the best performances in the standing long jump, 30m sprint and shuttle run test, while pivots achieved the highest values in ball throwing velocity.

Wings were the fastest players in the 30m sprint with no significant differences from backs.

These findings are in agreement with previous studies that found that wings are the fastest players of elite adult male (Šibila et al., 2004), female (Rogulj et al., 2005) and young female teams (Zapartidis et al., 2009a), followed by backs. Sprinting velocity for short distances is an important component for optimal performance in team handball. Players are required to cover distances from 20 to 30m with maximal speed in the transition from defense to offense or, after a ball loss, to prevent a fast break. Studies have shown that wings and backs spent 14% and 4% of the total playing time running with speed higher than 3.5 m/s and 5.2 m/s respectively (Šibila et al., 2004). In addition, wings seem to cover significantly shorter distances with slow running but significantly longer distances with fast running and sprinting from all other players (Luig et al., 2008). These findings suggest that acceleration and sprinting are major requirements for wing and back players. On the other hand, goalkeepers were the slowest players as there are no such requirements for their position. They seem to cover more than 85% of the total distance during a game with speed lower than 1.4 m/s (Šibila et al., 2004; Luig et al., 2008). Therefore, there is a need for designing more specific tests so that their abilities are properly measured.

A similar explanation could also apply to the results of the standing long jump. Wings perform throwing with long jumping in an effort to reach as close as possible to the goalpost, either from the position they hold in the game (sides and close to 6m), or at the end of a counter-attack. Backs perform more vertical jumps than all other position groups in their effort to overcome the opponent's defense block. These attacks are performed from other players as well, but to a considerably lesser extent and intensity (Rogulj et al., 2005). These findings are also in agreement with previous studies, which reported similar standing long jump performance among playing positions (Chaouachi et al., 2009) and wing players having significantly higher values from goalkeepers (Rogulj et al., 2005). Data concerning young female players renders wings and backs to be superior to other position groups with goalkeepers presenting the lowest performance (Zapartidis et al., 2009a). An interesting finding of this study was that pivots presented worst performance from all other field positions. This is probably due to the specially developed shape of strength (maximum strength vs explosive power) as maximal force is more important in pivots, in combination with the large body mass and BMI. In their efforts to support their large body mass, during the movements, pivots will probably have a reduced performance in these tasks.

A high aerobic uptake is required in team handball, as players have been reported to cover between 4-6.5 km per game (Šibila et al., 2004; Luig et al., 2008), depending on their position and the competitive level of the teams. The present study found that backs and wings had a greater VO$_{2max}$ from all other playing positions with significant differences from pivots and

goalkeepers. Goalkeepers displayed the lowest performance in 20m SRT. It is reported that wings cover significantly greater total distance during the game than other players whereas goalkeepers cover the smallest total distance (Šibila et al., 2004; Luig et al., 2008). A high aerobic fitness is important for wings and backs as they are the players who perform the most picks and require high levels of aerobic capacity to aid recovery after bouts of high-intensity activity. In addition, it has been reported that players during the game should maintain the ability of the optimal output in shooting and throwing effectiveness regarding aiming accuracy (Zapartidis et al., 2007) or ball velocity (Fábrica et al., 2008). The demands of aerobic capacity on goalkeepers differ from field players on a handball team. However, a well developed aerobic capacity is important for this group in order to keep on with training season and games.

With regard to flexibility, there were no differences among playing positions. Flexibility is one of the basic motor abilities characterizing the goalkeeper's performance and the findings of the present study were not expected. It was clear that goalkeepers underperformed in relation to all motor abilities from all other playing positions. This might be due to the kind of training for the specific position, and coaches' negligence for their performance development, or their selection of athletes who do not perform well as field players. Coaches should pay more attention to goalkeepers' selection and training, as this position is basic for team's total performance.

In the present study, pivots showed a significantly higher ball throwing velocity than goalkeepers and wings, and no significant superiority over all other positions. This is probably explained due to the largest arm span and hand length, as well as greater body mass they presented in comparison with other playing groups, as it has been reported that these characteristics influence ball throwing velocity at young ages (Zapartidis et al., 2009c). Previous studies have shown that goalkeepers fall short in medicine ball throwing (Rogulj et al., 2005) or ball throwing velocity (Zapartidis et al., 2009a), compared to all other players. Ball throwing constitutes an important competitive skill that contributes to the performance of the player and consequently to the performance of the team. Regarding playing positions, the largest number of throws is executed from the backcourt position (Ohnjec et al., 2003), from a distance 9 to 13m and therefore players at this position need a high level of muscle power to throw the ball with high velocity.

Factors that correlate and contribute to ball throwing velocity

Body height, arm span, hand length and body mass are positively correlated to ball throwing velocity according to the results of the present study. From these parameters, body size as expressed by body height and mass seem to be the most important variables that contribute to ball throwing velocity. It is generally accepted that body height is positively affecting all body dimensions. The positive correlation of these

specific anthropometric variables to ball velocity is in accordance with a previous research involving young female athletes (Zapartidis et al., 2009c). When an athlete has increased body segments, he has an advantage of throwing the ball at a higher velocity, 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). In the present study a positive correlation between ball velocity and body mass was found. This is in accordance with other research concerning adult handball players (Skoufas et al., 2003) and young female handball players (Zapartidis et al., 2009c). Conversely, previous studies did not report such correlations between body mass and ball throwing velocity, concerning male baseball athletes (Hooks, 1959), female volleyball (Ferris et al., 1995) and female handball players (Jöris et al., 1985). The positive correlation between body mass and ball throwing velocity in the present study could be attributed to a potential linear relationship between body mass and muscular mass.

Standing long jump seems to be the most important factor that influences ball throwing velocity among the parameters measured in the present study. Our data are in accordance with studies involving young female handball players (Zapartidis et al., 2009c). In addition, it has been reported that there is a significant correlation between vertical jump performance and ball velocity during volleyball spiking (Forthomme et al., 2005). This is supported by the fact that the main factor affecting ball velocity is the effective energy transition from the ground to the lower extremities 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 and Almåsbakk, 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 extremity (Bergh et al., 1978). As the activation of the IIx type fibers is frequent in handball, this could explain the correlation between ball velocity and running speed. Estimated aerobic capacity has been correlated and contributed to ball throwing velocity. There is a lack of relevant reports, as only one study has examined this relationship, referring to young female handball players, observing a positive correlation between ball velocity and estimated VO_{2max} (Zapartidis et al., 2009c). In an early study involving adult subjects (Drake et al., 1968), maximal oxygen uptake expressed in absolute values ($l \cdot min^{-1}$) showed a high correlation with medicine ball throwing. Handball training consists of medium intensity endurance exercises combined with high intermittent exercises with many throws. This training results to equal improvement of both aerobic and anaerobic capacity, as well as power (Izumi et al., 1996).

Lower back and hamstring flexibility, did not affect throwing velocity in these subjects. A previous study involving young female handball players refers to a positive correlation between these two factors (Zapartidis et al., 2009c). It has been reported that the elements of torso flexibility and motor control can considerably affect throwing performance (Hong et al., 2001). It seems that at young age, when throwing technique is not yet developed, boys take more advantage of their anthropometric characteristics, in order to throw the ball with high velocity.

Conclusions and practical implications

The results demonstrate that many anthropometric and physical fitness differences exist among playing positions. The best performance in motor abilities and VO_{2max} was observed in the backs and wings, while goalkeepers underperformed in relation to all motor abilities from all other players. Pivots were the heaviest and showed the highest values of BMI, followed by goalkeepers. One of the most important negative factors for players' performance is an excessive amount of fat.

Additionally, the lowest aerobic capacity was shown by pivots and goalkeepers. Demands on these positions are different than the others, something that is often used as an excuse for lack of fitness for goalkeepers and pivots. Each training session should partially focus on specific playing positions, as each one has its own physiological load in team handball. The playing position of goalkeepers requires special training, different than the other positions and should not be neglected by the coaches. Achievement of high performance is a result of systematic and long term efforts. Talent identification and selection requires a high quality index of motor abilities and anthropometric characteristics. Body size, muscular fibre type (inborn qualities) – beyond specialized training - seem to be crucial contributing factors to ball throwing velocity, and therefore they are promptly connected to performance. Athletes' selection at this age should focus on watching and defining the value of these characteristics, which are largely genetically endowed and limit training effect significantly.

References

Bergh U, Thorstensson A, Sjôdin B, Helten B, Piehl K, Karlsson J. Maximal oxygen uptake and muscle fiber types in trained and untrained humans. Med Sci Sports 1978; 10: 151-154.

Buchheit M, Lepretre PM, Behaegel AL, Millet GP, Cuvelier C, Ahmaidi S. Cardiorespiratory responses during running and sport specific exercises in handball players. J Sci Med Sport 2009; 12: 399-405.

Chaouachi A, Brughelli M, Levin G, Boudhina N, Cronin J, Chamari K. Anthropometric, physiological and performance characteristics of elite team-handball players. J Sports Sci 2009; 27(2): 151-157.

Drake V, Jones G, Brown J, Shephard R. Fitness performance tests and their relationship to the maximal oxygen uptake of adults. Can Medical Assoc J 1968; 99: 844-848.

Fábrica G, Gómez M. Fariña R. Angle and speed in female handball penalty throwing: effects of fatigue and player position. In J Perform Analysis Sport 2008; 8: 56-67. Ferris DP, Signorile JF, Caruso JF. The relationship between physical and physiological variables and volleyball spiking velocity. J Strength Cond Res 1995; 9: 32-36.

Fleising G, Barrentine S, Zheng N, Escamilla R, Andreews J. Kinematic and kinetic comparison of baseball pitching among various level of development. J Biomech 1999; 18(6): 409-414.

Forthomme B, Croisier J, Crielaard J, Cloes M. Factors correlated with volleyball spike velocity. Am J Sports Med 2005; 33: 1513-1519.

Gil SM, Gil J, Ruiz F, Irazusta A, Irazusta J. Physiological and anthropometric characteristics of young soccer players according to their playing position: relevance for the selection process. J Strength Cond Res 2007; 21(2): 438-445.

Gorostiaga E, Granados C, Ibáñez, J, Izquierdo M. Differences in physical fitness and throwing velocity among elite and amateur male handball players. Int J Sports Med 2004; 25: 1-8.

Hoeger WWK, Hopkins DR, Button S, Palmer TA. Comparing the sit and reach with the modified sit and reach in measuring flexibility in adolescents. Pediatr Exerc Sci 1990; 2: 156-162.

Hoff J, Almåsbakk B. The effects of maximum strength training on throwing velocity and muscle strength in female team-handball players. J Strength Cond Res 1995; 13: 255-258.

Hong DA, Cheung TK, Roberts EM. A three-dimensional, six-segment chain analysis of forceful overarm throwing. J Electrom Kinesiol 2001; 11: 95-112.

Hooks G. Prediction of baseball ability through an analysis of measurement of strength and structure. Res Q Exerc Sport 1959; 30: 38-43.

Hopkins WG. Measures of reliability in sports medicine and science. Sports Med 2000; 30: 1-15.

Izumi T, Kouji, N, Motoki K, Yuusuke H, Futoshi O, Motohiko M, et al. Effects of moderate-intensity endurance and high-intensity intermittent training on anaerobic capacity and VO_{2max}. Med Sci Sports Exerc 1996; 28: 1327-1330.

Jöris H, van Muyen E, van Ingen Schenau G, Kemper H. Force, velocity and energy flow during the overarm throw in female handball players. J Biomech 1985; 18: 409-414.

Léger L, Mercier D, Gadoury C, Lambert J. The multistage 20 metre shuttle run test for aerobic fitness. J Sports Sci 1988; 6: 93-101.

Lidor R, Arnon M. Developing indexes of efficiency in basketball: talk with coaches in their own language. Kinesiol 2000; 2: 31-41.

Luig P, Manchado-Lopez C, Perse M, Kristan M, Schander I, Zimmermann, M, et al. Motion characteristics according to playing position in international men's team handball. Proceedings of 13th Annual Congress of the European College of Sports Science; 2008 July 9-12; Estoril, Portugal.

Ohnjec K, Vuleta, D, Milanović D, Gruić I. Performance indicators of teams at the 2003 world handball championship for women in Croatia. Kinesiol 2003; 40: 69-79.

Rogulj N, Srhoj V, Nazor M, Srhoj L, Čavala M. Some anthropologic characteristics of elite female handball players at different playing positions. Coll Antropol 2005; 29: 705-709.

Šibila M, Vuleta D, Pori P. Position related differences in volume and intensity of large scale cyclic movements of male players in handball. Kinesiol 2004; 36: 58-68.

Skoufas D, Kotzamanidis C, Hatzikotoylas K, Bebetsos G, Patikas D. The relationship between the anthropometric variables and throwing performance in handball. J Hum Mov Stud 2003; 45: 469-484.

Srhoj V, Marinović M, Rogulj N. Position specific morphological characteristics of top-level male handball players. Coll Antropol 2002; 1: 219-227.

Zapartidis I, Toganidis T, Vareltzis I, Christodoulidis T, Kororos P, Skoufas D. Profile of young female handball players by playing position. Serb J Sports Sci 2009a; 3(2): 53-60.

Zapartidis I, Vareltzis I, Gouvali M, Kororos P. Physical fitness and anthropometric characteristics in different levels of young team handball players. Open Sports Sci J 2009b; 2: 22-28.

Zapartidis I, Skoufas D, Vareltzis I, Christodoulidis T, Toganidis T, & Kororos, P. Factors influencing ball throwing velocity in young female handball players. Open Sports Med J 2009c; 3: 39-43.

Zapartidis I, Gouvali M, Bayios I, Boudolos K. Throwing effectiveness and rotational strength of the shoulder in team handball. J Sports Med Phys Fitness 2007; 47: 169-178.

Corresponding author:

Ilias Zapartidis
National and Kapodistrian University of Athens,
Department of Physical Education & Sport Science,
41 Ethnikis Antistasis st., 172 37 Dafni, Greece
Phone: +30-210- 72760120; Fax: +30-210- 7276090
E-mail: elzapa@phed.uoa.gr