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STUDY OF THE PHYSICAL CONDITION OF YOUNG ELITE FEMALE HANDBALL PLAYERS

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Summary
The main aim of this study was to determine physical fitness profile of young elite female handball players. A second objective was to establish differences based on their playing positions. Results showed significant differences in all physical fitness tests based on their specific playing positions. In general, wings and first line players (center, left back and right back) obtained the best results, while goalkeepers obtained the worst results.

Keywords
Young female handball players, fitness assessment, physical fitness, playing positions in team handball

Introduction

Team handball is a complex intermittent game, which requires players to have well-developed aerobic and anaerobic capacities (Delamarche et al., 1987; Gorostiaga, Granados, Ibañez, González-Badillo, & Izquierdo, 2006). Motor ability, sprinting, jumping, flexibility and throwing velocity represent physical activities that are considered as important aspects of the game and contribute to the high performance of the team (Granados, Izquierdo, Ibañez, Bonnabau, & Gorostiaga, 2007; Marques & González-Badillo, 2006).

Team positions in team handball can be broadly classified as goalkeepers, first line players and second line players (Pezerat-Correia, Valamantos, Francisco, & Santos, 2007). These positions are: center, back players, wing players, pivots, and goalkeepers. Time motion studies have shown that in the course of the game handball players perform different activities depending on their positions (Cambel, 1985; Sibila, Vuleta, & Pori, 2004). During the game, wings seem to cover the longest total distance and the longest distances while sprinting (Luig, Manchado-Lopez, Perse, Kristan, Schander, Zimmermann, & Platen, 2008; Sibila et al., 2004), while backs seem to execute the largest number of throws (Ohnjec, Vuleta, Milanovic, & Gruic, 2003).

Few studies have realized comparisons between physical fitness characteristics based on specific playing positions in team handball. In addition, few studies has investigated whether there are any differences among playing positions at young age, when athletes begin to specialize in playing positions (Zapartidis, Toganidis, et al., 2009). The aim of the present study was a) to determine the physical fitness profile of female young elite handball players and b) to establish the differences based on their game location.

Additionally, results from motor performance tests will allow trainers to identify players´ weaknesses and design training models for improving specific athletes´ deficiencies, but also follow up the athlete´s improvement during a competitive season. Furthermore, the data of the present study could be added in the international literature and assist in talent identification and development.

Methods

Participants

The total sample consisted of 137 young elite female handball players from 13 to 16 years (M= 14,25; SD= 0,74), which have been playing a mean of 8,66 years (SD=2,16), and a mean of 5,10 years competing (SD=2,18). All players competed in the highest league of their sports category, were selected as the best players of their sport category, belonged to the National Sporting Talent Programme of the Royal Spanish Handball Federation, and commonly performed at least 3 training sessions per week plus one official match.

All players and their parents were informed about the procedures of the measurements and provided their written consent for participating according to the research policy of the Royal Spanish Handball Federation.

Procedure

Six variables were recorder for each young female handball player. These included aerobic capacity (VO_{2max}), explosive power of the lower limbs, throwing velocity, agility and running speed. For motivational purposes, the players were immediately informed of their performance in all tests.

Aerobic capacity was expressed as estimated maximal oxygen uptake using a 20m shuttle run test (Course Navette) and predicted by a regression equation according to the age and the running speed at the last completed stage (Leger, Mercier, Gadoury, & Lambert, 1988). The subjects completed only one attempts of this test.

For *Long jump test*, players were placed in a static position behind a line and they must jump pushing forward with both legs at the same time as far as they could, allowing them countermovement of arms and legs.

For *Squat jump test* was used an Ergo Jump Bosco/System®, where was calculated jump height from flight time on a contact platform, using a microcomputer Posion Organiser II (with accuracy of 0,001 sec.). The players started with their hands on their hips and knees bent at 90º and without previous countermovement jumped upward. The players completed 2 attempts of each type of jump, and the better of each one was used for the subsequent statistical analysis. Between jumps, the participants were allowed to recover for 3 minutes to avoid fatigue.

Throwing velocity was measured using a radar gun (Pocket Radar™ Personal Speed Radar Gun). Evaluator with the pocket radar in his hand was placed behind the standard goal of handball and in a perpendicular direction to the thrower. The female handball players threw a standard ball of handball as fast as possible towards the goal without goalkeeper, using dominant hand and their personal technique. The sequence of throwing was as follows: a 3-step running throw from the 9-m line, and a 3-step running throw from the 9-m line with a jump. Three throws of each type were performed, and the best trial was used for further analysis. A 3-minute rest elapsed between throws to avoid fatigue.

To evaluate the *Running speed* was measured the time taken to run 30 meters using two pairs of photoelectric cells (AFR System ®), interconnected to an accountant Seiko System Stop Watch S129, with a precision of 0,01 seconds. The test consisted in a 30-m sprint, starting from a static position and standing. The players began to run when they wanted and at that moment the first photocells gate were automatically activated. They had to run 30m as fast as

possible until passing the finish line where the second photocells gate was placed. The participants performed twice the 30-m sprint and the best one mark was used for the subsequent statistical analysis. Between each sprint were allowed 3 minutes of rest to avoid fatigue.

For *Illinois agility test*, players had to run a circuit race that occupied an area of 10 m long by 5 m wide, where four cones were used to mark the start, finish and the two turning points. Another four cones were placed down the center an equal distance apart. Each cone in the center was spaced 3,3 meters apart. Athlete must be placed lying on his front (head to the start line) and hands by his shoulders. On the "ready, steady, go" command the stopwatch started to run, and the athlete had to get up as quickly as possible and run around the circuit in the direction indicated, without knocking the cones over, to the finish line, where the timing was stopped. The fastest value obtained from two attempts with 3min recovery in-between was used as the agility score.

Data analysis

Standard statistical methods were used to calculate the mean and SDs. All data are expressed as mean (SD), minimum and maximum (all data were checked for distribution normality and homogeneity with the Kolmogorov-Smirnov and Lilliefors tests). Differences in physical fitness profile based on playing positions were compared using a one-way analysis of variance using Scheffe´s post-hoc test. Statistical significance was set at $p \leq 0,05$. The results were analyzed using SPSS software, version 17.0.

Results

Descriptive statistics for physical fitness profile for all young female handball players are presented in Table 1.

Table 1. Physical fitness profile of young elite female handball players (N=137).

	Mean (SD)	**Min.**	**Max.**	**Centiles**						
				5	**10**	**25**	**50**	**75**	**90**	**95**
30-m sprint (sec)	5,01 (0,30)	4,37	6,29	4,60	4,66	4,80	4,98	5,17	5,37	5,59
Squat jump (cm)	31,78 (5,66)	13,50	45,00	22,30	25	28	32	36	38	41
Long jump (m)	1,77 (0,21)	0,98	2,30	1,41	1,50	1,62	1,80	1,90	2,03	2,10
Throwing vel. ($Km.h^{-1}$) (3-step running)	68,66 (6,25)	48	84	57,80	59,80	65	69	72	76,20	79
Throwing vel. ($Km.h^{-1}$) (3-step running with a jump)	69,58 (5,74)	52	80	58,70	61	67	70	73	77	78,10
VO_{2max} ($ml.kg^{-1}.min^{-1}$)	45,60 (3,94)	32,27	55,73	39,53	40,60	42,23	46,15	47,63	50,33	50,74
Illinois agility test (sec)	19,76 (1,46)	17,25	27,07	17,96	18,30	18,85	19,41	20,37	21,44	22,44

Table 2 shows the differences in physical fitness characteristics between positions as obtained by the post-hoc test.

30m sprints: Centers and wings showed higher velocity values than do backs (p<0,05), pivots (p<0,01) and goalkeepers (p<0,01). However, no significant differences in 30m sprints were found between centers and wings.

Squat jump test: Centers showed best performance among all players with significant differences from goalkeepers (p<0,05). Wings performed better than backs, pivots and goalkeepers with significant differences from goalkeepers (p<0,01). Backs on average performed better than pivots and goalkeepers but without significant differences.

Long jump: Centers and wings best performance among all players with significant difference from pivots (p<0,01) and goalkeepers (p<0,01). Backs performed better than pivots and goalkeepers with significant differences from goalkeepers (p<0,01). Goalkeepers showed the worst standing long jump values.

Throwing velocity (3-step running throw from the 9-m line): centers players achieved the highest values of all players while goalkeepers had the lowest scores, with significant differences only between both positions (p<0,01).

Throwing velocity (3-step running throw with a jump from the 9-m line): we were found significantly different with regard to play positions, where goalkeepers obtained poor results (p<0, 01).

Estimated VO_{2max}: centers and wings showed best performance among all players with significant difference from goalkeepers (p<0,01). Backs performed better than pivots and goalkeepers but without significant differences.

Illinois agility test: centers and wings showed best performance among all players with significant difference from pivots (p<0,01) and goalkeepers (p<0,01). Backs on average performed better than pivots and goalkeepers with significant differences from goalkeepers (p<0,05).

Table 2. Mean score (SD) of running speed, explosive power of the lower limbs, ball velocity, aerobic capacity and agility of young female handball players according to their playing position.

Test/Specific playing positions	**(C)Center (N=22) Mean (SD)**	**(B)Backs (N=40) Mean (SD)**	**(W)Wings (N=30) Mean (SD)**	**(P)Pivots (N=25) Mean (SD)**	**(G)Goalkeepers (N=20) Mean (SD)**
30-m sprint (sec)	4,81(0,19)^{BPG} [4,45-5,09]	5,04(0,22)^{CW} [4,67-5,63]	4,83(0,22)^{BPG} [4,37-5,33]	5,17(0,38)^{CW} [4,68-6,29]	5,20(0,32)^{CW} [4,83-6,02]
Squat jump (cm)	34,26(4,38)^{G} [25,9-43,00]	31,25(5,18) [21,4-41,00]	34,12(5,67)^{G} [23,9-45,00]	30,22(4,78)] [19,00-40,00]	28,46(6,64)^{CW} [13,5-41,00]
Long jump (m)	1,88(0,15)^{PG} [1,48-2,12]	1,79(0,18)^{G} [1,48-2,17]	1,84(0,19)^{PG} [1,38-2,30]	1,66(0,20)^{CW} [0,98-1,98]	1,61(0,19)^{CBW} [1,26-2,00]
Throwing velocity (Km.h^{-1}) (3-step running)	70,77(6,11)^{G} [55-80]	69,25(5,26) [59-79]	69,60(6,86) [48-84]	68,32(6,47) [55-79]	64,20(5,36)^{C} [55-72]
Throwing velocity (Km.h^{-1}) (3-step and jump)	71,23(4,24)^{G} [61-79]	71,10(4,33)^{G} [59-80]	70,43(5,72)^{G} [55-79]	69,72(5,86)^{G} [56-80]	63,25(5,72)^{CBWP} [52-73]
VO_{2max} (ml.kg^{-1}.min^{-1})	47,36(3,48)^{G} [40,60-55,73]	45,91(2,71) [39,54-50,33]	46,52(3,61)^{G} [40,60-55,73]	44,58(4,76) [34,14-53,03]	41,68(4,28)^{CW} [32,27-50,33]
Illinois Agility Test (sec)	18,88(0,72)^{PG} [17,72-21,35]	19,76(0,92)^{G} [17,81-22,38]	18,93(0,93)^{PG} [17,25-21,87]	20,70(1,67)^{CW} [18,66-24,90]	20,87(1,98)^{CBW} [18,28-20,07]

^{C} Significantly different from centers. ^{B} Significantly different from backs. ^{W} Significantly different from wings. ^{P} Significantly different from pivots. ^{G} Significantly different from goalkeepers.

Discussion

Despite the importance of physical fitness has on performance in handball, few studies have studied this matter in this age group. The aim of the present study was to determine the physical fitness profile of young elite female handball players and to establish the differences based on their playing positions. This is a very important issue because there are few studies on the differences in physical fitness profile in young elite female Spanish handball players. This article contains new information about young elite female handball players by specific playing positions that could be extremely useful for coaches.

Previous literature has been reported similar results to those found in our study except in squat jump test and throwing velocity test (Civar, 2012; Zapartidis, Toganidis, et al., 2009; Zapartidis, Vareltzis, Gouvali, & Korocos, 2009). Nevertheless, interpretation of these comparisons should be made with care because there are few studies published and methodologies and sample levels are also different.

The present study found that centers and wings were significantly faster than backs, pivots and goalkeepers. In addition, backs showed superiority, although not significant to pivots and goalkeepers. These findings are in agreement with previous studies (Rogulj, Srhoj, Nazor, Srhoj, & Cavala, 2005; Sibila et al., 2004), which have found that wings are the fastest players of elite male and female teams. However, the results obtained by centers are not agreed with those found in other studies (Civar, 2012; Zapartidis, Toganidis, et al., 2009; Zapartidis, Vareltzis, et al., 2009). Sprinting velocity for short distances is an important element of performance in team handball. Players are required to cover distances between 20-30 m with maximal speed from the phase of attack to the phase of defense after a ball loss, or in order to run a fast break. Wings participate in such moves commonly. Studies have shown than wings spend 18% and 4% of the total playing time running faster than 3,5 m/s and 5,2 m/s, respectively (Sibila et al., 2004). These finding suggest a greater requirement for acceleration and sprint in wings that the other players.

Standing long jump test and squat jump test are available tests for evaluating the ability to achieve high muscular force very quickly, which is very importance in team handball. Our players exhibit similar values in standing long jump compared other players with a similar age (Lidor et al., 2005; Zapartidis, Toganidis, et al., 2009; Zapartidis, Vareltzis, et al., 2009). Centers and wings showed significant differences with respect to pivots and goalkeepers. Wings perform throwing with jump forwards in an effort to reach the goalpost as closely as possible, either from the position they have in the game, or at the end of a counter-attack. These actions are performed by other players as well, but, with a considerably lesser extend and intensity (Rogulj et al., 2005). In fact, during the phase of attack, wings move in a limited space of 2-3 meters and require a greater ability to generate great force rapidly.

The squat jump mean scores of our players are lower than those previously reported (Civar, 2012). Significant differences were found in vertical jump (SJ) among specific playing positions in our sample, where centers and wings showed significant differences with respect to goalkeepers. Unluckily, we have no found data concerning squat jump according to handball player´s position to compare our results.

In the present study, centers showed a significantly higher velocity in throwing the ball with 3-step running from the 9 m line than goalkeepers. On the other hand, goalkeepers showed statistical significance in throwing the ball with 3 steps running from the 9 m line with jump

over all other positions. Unfortunately, there are no studies using our throwing velocity test to which compare our results with the same group of age.

Players of team handball required a high aerobic uptake (between 4-6,5 km per game) depending on the player´s positions and the competitive level of the teams (Luig, Manchado-Lopez, Perse, Kristan, Schander, Zimmermann, Henke, et al., 2008; Pers, Bon, Kovacic, Sibila, & Dezman, 2002; Sibila et al., 2004). The present study found that centers and wings had greater estimated VO_{2max} than all other playing positions, with significant differences from goalkeepers. These finding are also in agreement with a previous study (Zapartidis, Toganidis, et al., 2009) which reported similar VO_{2max} performance among playing positions, with centers and wings showing significantly higher values than goalkeepers. In addition, it has been reported that wings cover significantly greater total distance during the game than other players, whereas goalkeepers cover the smallest total distance (Luig, Manchado-Lopez, Perse, Kristan, Schander, Zimmermann, Henke, et al., 2008; Sibila et al., 2004). High aerobic fitness is important for wings, as they are the players who perform the most picks and require high levels of aerobic capacity to aid recovery after high-intensity sprint.

The mean scores obtained in Illinois agility test by our players are in line with those previously reported in other sports (BenOunis et al., 2013). Nevertheless it is difficult to compare the current results according to player´s positions with other studies, as there are few data for similar age in handball players.

Conclusions

The present study compared physical fitness profile with to specific playing position of young elite female handball players. The results showed differences in physical fitness profile between playing positions. Above results can prove to be extremely useful for coaches and trainers, as they are based on tests that reflect the specific characteristics of individual playing positions. More profiling studies of young elite female handball players are required in order to obtain normative data. These finding could be added to the international literature and assist in talent identification and development.

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THE RELATIONSHIP BETWEEN CHOSEN FACTORS OF PLAYING PERFORMANCE AND THE LENGTH OF ACTIVE CAREER OF AN ACTIVE CAREER OF FEMALE HANDBALL PLAYERS

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Summary
The aim of the study was to find out possible effects of career length on selected factors of playing performance. We used a correlation method to determine the relationship between career length and selected factors of playing performance. Career length has an influence on two factors of playing performance – the number of stolen balls and also the number of turn overs. There is only one team in which career length has an influence on the results of the team.

Keywords
Career length, playing performance, European Championships

Introduction

Evaluation of playing performance is one of the most important methods of gathering data not only for a team´s sports preparation, but also for further fields of the development of handball (keeping in touch with development trends, description of skills within the range of handball theory etc.) In principle, there are two basic types of playing performance – individual and team one. Team playing performance is correlative with not just the quantity and quality of individual playing performances, but also with their mutual relations. In both types, their basic features are considered to be: non-standard match conditions, a large amount of motor skills and motor structures, variability, creative combinations, anticipation, the choice of solutions in changeable playing situations, fulfillment of tasks within the range of individual functions in the team.

The above-mentioned facts suggest that the demands on the quantity and quality of skills and knowledge of individual players as well as teams are high and learning them requires sufficient amount of time filled with training process and games. In this connection, the term very often applied is „playing experience“or its equivalents. On international level, the number of played international games is often considered to be the index of experience. It is naturally connected with the age of the participants of top competitions, as it is automatically presumed that a higher age means a higher number of played matches and thus also more experience, but there is a connection with the length of the player´s active career as well. So the personal make-up of a team might be a factor that influences the playing performance of a team not only in a single match, but in a long-term competition as well.

In professional debates, playing experience expressed by means of the length of a player´s career is usually related to the placement of the team in competitions. This naturally reflects the actual playing performances of both players and teams. Nevertheless, available sources failed to contain an expression of a direct relation between the length of playing career and individual indexes of playing performance. We believe that a reliable evaluation of this relation might complement a rather more objective basis to empirical experience which is precisely what our research endeavoured to find out. We set the following aims:

1. To find what was the make-up of the teams as for the career length of individual players in European Championships in 2000- 2010.
2. To find the influence of the team make-up as for career length on the selected factors of team playing performance.
3. To find out to what extent the make-up of a team as for career length influences the final placement in European Championships.

Methods

Characteristics of the investigated group

In the first part of our research, the investigated sample consists of all the participants of European Women´s Championships (further on just ECHs) in 2000 – 2010. The group comprises 919 players who took part in any ECH during the investigated period. The investigated period remains the same in the second part, but we only deal with 7 teams. These are the teams which took part in all the ECHs in 2000 – 2010. They are the teams of Norway, Denmark, Germany, France, Ukraine, Russia and Hungary. Altogether 434 players were listed in all the teams in the given period, which is about half of all the participants. Besides the number of participations in ECHs, we also investigated the data concerning playing performance.

Methods of evaluation

We drew our data from official information available on the web sites of EHF (http://activities.eurohandball.com/analyses). To evaluate „playing experience“ we chose the criterion of the number of participations in ECHs during the followed period (the research started in the year 2000, so the initial data are the same for all the teams, as we did not take in consideration the starts at previous ECHs). The participants were divided into three groups:

A – players who participated in one or two Championships during the investigated period („inexperienced“)

B – players who participated in three or four Championships during the investigated period („experienced“)

C – players with five or more participations („very experienced“)

In the teams which participated in ale the investigated ECHs we allotted one point for each participation to individual players. The sum of points of each team was then put in relation with cumulative indexes of several factors of playing performance in an actual ECH. These included: shooting efficiency, number of assists, number of stolen balls and turn overs, number of blocked shots, goalkeepers´ efficiency. And besides we related the number of points “for participation“ with the final placement in a ECH. To evaluate mutual relations, we selected Pearson´s correlation coefficient.

$$r = \frac{\sum_{i=1}^{n} (x_i - \overline{x})(y_i - \overline{y})}{\sqrt{\sum_{i=1}^{n} (x_i - \overline{x})^2 \sum_{i=1}^{n} (y_i - \overline{y})^2}}$$

The value of the correlation coefficient can oscillate between -1 and 1. The closer to the extreme values, the stronger the dependence. Positive values of the correlation coefficient show a positive dependence (more playing experience means a higher value of the coefficient). Negative values of the correlation coefficient mean a negative dependence. When evaluating the dependence, we applied the value of correlation coefficient higher than ±0.7 as a measure of material significance.

Results

Team make-up

23 national teams took part in ECHs during the investigated period. The participants made various use of including the allowed number of players on the lists and their changes. The investigated group thus consisted of 918 players. By means of a more detailed analysis we found out the following percentages of individual groups:

Group A – 83.79% players
Group B – 14.80% players
Group C - 1.41% players

There is naturally an explanation that a more extensive change of players is understandable, namely if there was a considerable time gap between the participation of a team in ECHs. However, even in teams with regular participation in ECHs (n=7, i.e. nearly 1/3 of all the participants) we have not found extremely different percentages:

Group A – 77.45%
Group B – 20.16%
Group C - 2.39%

Anyway, even in the teams which participated in ECHs regularly, the rate of „experienced" players does not exceed one quarter of the participants, which might be, among other factors, a consequence of gradual changes of players in the team. We should not forget to mention that there was a large ratio of goalkeepers in C group, out of 13 players with five or more participations five were goalkeepers! Thus it generally seems that coaches do not really bank on the amount of experience (with the exception of goalkeepers) that follows from the length of the career, but rather on the current form of a player or her ability to adapt to dynamic development of handball.

As has been stated above, the relationships between individual factors of playing performance and the make-up of a team were investigated only in the teams that took part in all the ECHs in the given period. See Table 1 for the number of points that express playing experience.

	NOR	DEN	FRA	GER	HUN	RUS	UKR
2000	16	16	16	16	16	16	16
2002	22	22	25	21	24	21	21
2004	27	25	27	27	28	25	23
2006	35	23	36	30	33	32	31
2008	34	31	29	36	31	30	27
2010	45	37	38	40	40	33	30

Tab.1 Summary expression of the evaluation of player's participation in ECHs in points.

The above mentioned results suggest a relatively stable make-up of the NOR team (a higher number of points means a higher number of repeated participations), on the other hand there is a tendency to rather extensive changes apparent in the team of UKR.

Both individual and team playing performance can be described and evaluated by means of a number of factors. The following were selected for the purposes of our research: shot efficiency, number of assists, number of stolen balls and turn overs, number of blocked shots, goalkeepers´ efficiency.

Shot efficiency and thus also goalkeepers´ efficiency tends to be generally regarded as one of the most important factors of playing performance, whereas other factors are often connected to anticipation. Therefore we believe that „playing experience“ might often be manifested in these factors.

Shot efficiency
The results of the investigation of shot efficiency to the length of playing career are very interesting. A positive (but not high) correlation was found only in three teams (NOR, RUS, UKR). The remaining teams had a negative correlation. It is even materially significant (t = -0.725) in the team of HUN. A negative correlation means that the more experienced the player, the less probable a lower shot efficiency. We can perhaps speculate that a more frequent participation in ECHs enables the opponent teams to get to know a certain player and prepare the goalkeepers better for her. Nevertheless, the relation may apply also vice versa – a multiple participation in ECHs means a better knowledge of the opponent´s goalkeepers (compare the number of repeated participations as for goalkeepers) and consequently better information for targeting the shots. Yet another explanation implies that with increasing age it gets more difficult to achieve a high level of dynamic strength level necessary namely for shots from the area of backs. See Table 2 for a detailed survey of the relationship of shot efficiency and the length of playing career.

Number of assists
Similar results have been found in the relation of the length of active career and the number of assists. A positive value of the correlation has been discovered only in two teams (RUS, NOR). In other teams it is therefore valid that the higher number of participations in ECHs means a lower number of assists. We can again speculate that it might be the consequence of more knowledge and information and that the opponent teams were able to better prepare for cooperation during the offensive phase of individual teams. On the other hand it is possible to consider the fact that even slight changes in the make-up of the team complicate (do not enable) the realization of well-trained combinations (cooperation during offensive phase of game). It should also be added that the assessment of assists is one of the hardest tasks for the observers collecting data for statistical evaluation. Various perception of the course of the game situation might thus partly influence objectivity of the data. See Table 2 for a detailed survey of the relationship of number of assists and the length of active career.

Turn overs
The notion of a positive influence of the length of career on playing performance is best fulfilled by the correlation between the number of turn overs and career length. There is a negative correlation coefficient found in all the teams. In other words – the longer the playing experience, the lower number of turn overs. This relationship even has material significance in the teams of HUN and UKR! It might be speculated that more frequent changes in the make-up of a team result in a less coordinated game and therefore in a higher number of misunderstandings and the following higher number of turn overs. Nevertheless, the least closeness of the relationship was found in the teams of FRA and GER, which are among those in which the change of the team make-up during the investigated period was not as significant as for instance in the teams of UKR and DEN (see Table 1) This suggests that individual experience of individual players will probably carry more weight. Statistical data are presented in Table 2.

Goalkeepers´ efficiency
When evaluating the playing performance, it is necessary to maintain a certain balance in the assessment of indexes of the play in offensive and defensive phases. That is partly why we selected three factors documenting playing in defence. Many coaches consider goalkeepers´ efficiency to be the most complex index of defensive play, as it reflects (namely on top level) not just the actual performance of the goalkeeper, but the team effectivity of players in the field during the defensive phase. A strong tendency of higher effectivity connected with growing experience of the players has been confirmed in a number of investigated teams. It should be noticed in this connection that four out of the investigated teams (NOR, DEN, HUN and GER) have their goalkeepers in group C. And just as it is in shots, there are two exceptions as well. The reams of DEN and UKR have a negative correlation coefficient, which is namely interesting in DEN team. This relation is even materially significant in UKR team! As it is the team with the most change in the team make-up (of all the investigated teams), we might speculate that the cause might be rather the performance of the whole team in the defensive phase. Data see Table 2.

Number of blocked shots
Goalkeepers´ efficiency is closely related to the number of shots blocked by defenders. The system of defence applied by the team naturally plays an important role as well. Blocking is usually connected with the systems with a low number of forward defenders (namely with the system 6:0). But blocking, even in open defensive systems, can be applied either as an „emergency" solution of a current playing situation or in standard playing situations (free throw). Neither in this factor was there found an unequivocal influence of playing experience. Therefore we were rather surprised that in the teams with the dominant playing system 6:0 (DEN, NOR) we have found out a negative correlation coefficient, meaning a tendency of a decreasing number of blocked shots with increasing playing experience. The bases for explanation might be found in a deeper analysis of the conception of play in defence, which unfortunately exceeds the given range of our contribution. See Table 2 for a detailed survey of the relationship of number of blocked shots and the length of playing career.

Stolen balls
In the defensive phase, the notion of a positive influence of career length on playing performance is best fulfilled by the connection between the number of stolen balls and career length. Anticipation plays the main role in steals. The ability to „read" the opponent´s game depends, among other factors, also on the amount of experience of individual players and thus on the length of their active careers. Its influence is confirmed by the fact that with the exception of UKR, this dependence is materially significant in all the teams. Statistical data are presented in Table 2.

Placement
All the above mentioned factors influence the playing performance of a team and thus also the final placement in ECHs. Therefore we also correlated overall placement of a team and the length of active playing career. It follows from the results presented in Table 2 that materially significant connection between placement and career length has been found only in one team (HUN). In this case a higher playing experience means a „higher" (worse) placement. There might be an explanation that a higher number of participations means that the opponents have detailed information concerning the way of play at their disposal, thus being able to prepare better for matches. The alternative that with view to a higher age of the players there is a decrease in condition predispositions cannot be judged without the knowledge of respective data, so we are not dealing with it any further.

	TS EFF	AS	TO	GK EFF	BS	ST	PL
NOR	0.509	0.021	- 0.891	0.867	- 0.532	0.940	- 0.678
DEN	- 0.515	- 0.109	- 0.670	- 0.251	- 0.671	0.808	0.111
FRA	- 0.134	- 0.333	- 0.439	0.910	0.205	0.850	- 0.349
GER	- 0.131	- 0.129	- 0.401	0.851	0.217	0.818	0.081
HUN	- 0.725	- 0.578	- 0.823	0.670	0.232	0.888	0.751
RUS	0.181	0.406	- 0.571	0.646	0.444	0.709	0.132
UKR	0.267	- 0.541	- 0.837	- 0.704	- 0.059	0.397	0.491

Tab. Nr. 2. Overview of correlation coefficients (TS EFF – team shots efficiency, AS – assists, TO – turnovers, GK EFF – goalkeepers efficiency, BS – blocked shots, ST – steals, PL – placement)

Discussion and conclusions

Make-up of teams

The percentage of the three groups defined by us suggests that players most frequently appear in one or two Championships. Hypothetically, the most usual composition of an EC team (consisting of 16 players) could be calculated like this: 12 players from A group, 3 players from B group and maximally one player from C group. From this point of view it seems that when nominating players, coaches prefer rather current sports form or other factors, whereas playing experience is not a necessary prerequisite of participation. However, it should be emphasized that the source of playing experience is not only participation at ECHs, but also at World Championships, or Cup competitions, or else Olympic Games. During the period we investigated there were five World Championships and three Olympic Games. The number of participations of the investigated teams oscillates between eight (FRA, HUN) and four (GER). There should be also added the participation of most players in club cups. Especially in their finals, they are mostly matches with playing performance on the level of top representative events. In other words – even players included in A group can, during a relatively short time, get sufficient experience necessary for the participation in an ECH.

Playing performance

The efficiency of individual playing activities is generally influenced by a number of factors like technique, tactics, level of fitness, current mental state etc. The length of active career may play here both a positive role (perfection of technique, tactical experience, mental resilience) and a negative one (deficits as for condition, social relationships). With regard to different personal characteristics of individual players the impact of experience is different even in within the range of individual teams. That is why we found a different relationship between their number, or efficiency, and the length of playing career in most of the selected playing activities. The results confirm the empirical finding that playing experience has the most impact on playing activities in which anticipation plays a major part. From this point of view it is interesting that there has been found a higher material significance in a defensive activity - stolen balls, than in an offensive activity – turn overs.

We might speculate that in offensive, a player is more limited by the rules concerning playing the ball, and thus certain individual flaws for example in technique or preparedness of current condition can be more difficult to eliminate by mere anticipation. Even with view to the more numerous representation of goalkeepers in C group we may have expected a higher material dependence between their efficiency and the length of playing career. This was only manifested in the teams of FRA, NOR and GER. Here it should be mentioned that

goalkeepers are not really a numerous group, which may influence the calculation of their efficiency. There is a hint of a tendency in the comparison of the relationship of the length of an active playing career and offensive and defensive activities. There was only one team (UKR) which showed prevalence of a negative influence of playing experience on defensive activities. At the same time, it is a team with the worst total placement. In four teams (DEN, FRA, GER and HUN), there is a prevalence of negative impact on offensive activities, in DEN team there is a „balanced" influence

Placement

The final placement of a team in a competition may be influenced by a number of circumstances as well. These factors may be manifested either directly (playing system) or in the playing efficiency (injuries of players). The preceding text clearly suggests that playing experience may be included in the second group as well. If its impact on playing performance is not unambiguous, it cannot be ambiguous even with respect to placement. That is why a materially significant dependence has been found in one team only. However, when analyzing the results in greater detail, we find out that the two teams with the lowest sum of placements during the investigated period (NOR, RUS) also have the lowest number (1, 0 respectively) of factors of playing performance negatively influenced by the length of playing career!

Conclusions

- playing experience expressed by the number of participations in ECHs is neither the sole or main factor deciding about the personal make-up of a team, as coaches rather prefer current sports form or other factors
- the influence of playing experience on individual factors of playing performance is not unambiguous. A more significant positive influence has been documented in the playing activities with a high impact of anticipation
- the length of playing career has a negative influence rather on offensive factors of playing performance
- the teams that are able to eliminate the negative influence of the length of active career on individual factors of playing performance have a hope of a better placement

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THE EFFECT OF MORPHOLOGICAL PARAMETERS ON PLAYER PERFORMANCE IN ELITE FEMALE HANDBALL GOALKEEPERS

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SUMMARY
The purpose of the cross-sectional study was to determine the effect of morphological parameters on player performance in elite female handball goalkeepers. The correlation analysis showed that investigated morphological parameters in both U17 and U19 goalkeepers poorly correlated with goalkeeping efficiency assessed using 6 cumulative goalkeeping statistics.

Keywords
Anthropometry, competitive performance, handball players

Introduction
The performance of goalkeepers has a fundamental effect upon the performance of the team. Goalkeepers' performances are multifactorial manifestations of abilities and skills, where individual factors co-interact. Top level goalkeepers are supple and fast. Somatically, goalkeepers have long arms and are mostly tall. (Kovacs, 2009). Previous studies dealing with handball goalkeepers have investigated their psychological traits (Kajtna et al., 2012), associations between motor abilities and competitive performance (Pori et al., 2012) or cumulative statistics of goalkeeping efficiency (Táborský, 2008, Rizescu, Mihaila, Macovei, 2009). However, there is a paucity of studies dealing with the association between morphological parameters and goalkeeping efficiency. Only few studies have dealt with the effect of anthropometric parameters on goalkeeper's performance (Visnapuu et al., 2011).

Methods
The purpose of the cross-sectional study was to determine the effect of morphological parameters on player performance in elite female handball goalkeepers.

One hundred eighty-five elite female players participated in the study. In total, the study sample consisted of forty-two U17 goalkeepers and thirty-five U19 goalkeepers. All goalkeepers were tested during 2011 Women's 17 and Women's 19 European Handball Championships in Czech Republic and Netherlands, respectively. The goalkeepers were divided into four performance groups according to the final team standings: 1st to 4th place (1-4), 5th to 8th place (5-8), 9th to 12th place (9-12) and 13th to 16th place (13-16). The following morphological parameters were measured and correlated with goalkeeping efficiency: body height, body mass, percentage subcutaneous fat (fat %), arm span (D-D), shoulder breadth (A-A) and somatotype components: endomorphy, mesomorphy and ectomorphy. The somatotypes were determined according to Heath, Carter (1967). Goalkeeping efficiency was assessed using six EHF cumulative statistics based on the following parameters: total goal save percentage, goal saves from 7 meters, goal saves from 9 meters, goal saves from 6 meters, saves from wing positions and saves following a fast break. The effect of morphological parameters on goalkeeping efficiency in goalkeepers was determined using Spearman's rank order correlation.

Results and discussion

The data were analyzed in terms of goalkeepers' morphological parameters, goalkeeping efficiency and correlation between goalkeeping efficiency and morphological parameters. Mean values of morphological parameters and 6 goalkeeping efficiency statistics are presented in Tables 1 through 8. The correlation coefficients expressing associations between morphological parameters and variables of goalkeeping efficiency are presented in Table 5.

As shown in Table 1, mean values of morphological parameters in U17 goalkeepers: body height, arm span, shoulder breadth are highest in 1-4 performance group. This has shown that goalkeepers of 1-4 group are taller with greater arm span and skeletal robustness. The difference between mean body height and mean arm span was negative in 13-16 group only. The highest mean value of body mass was observed in 13-16 group of goalkeepers. An interesting finding is higher percentage of subcutaneous fat found in 9-12 and 13-16 groups compared to 1-4 and 5-8 groups. This is indicative of lower volume of fat-free mass. As for the somatotype components, the lowest degree of relative fatness as expressed by endomorphy was found in 5-8 goalkeepers. All groups were predominantly mesomorphic. Somatotype categories were found to be identical in groups 9-12 and 13-16, but different in 1-4 and 5-8 groups. Mean somatotypes in groups 9-12 and 13-16 were categorized as *endomorphic mesomorphs*. Mean somatotype in 1-4 group was classified as *balanced mesomorph* and in 5-8 group as *ectomorphic mesomorph*.

Tab. 1 *Morphological parameters: U17 goalkeepers*

Ranking	**1st - 4th**	**5th - 8th**	**9th - 12th**	**13th - 16th**
	X ±SD	*X ±SD*	*X ±SD*	*X ±SD*
Body Height (cm)	180.1±3.77	177.3±3.37	176.1±4.71	175.6±6.14
D-D (cm)	181.6±5.77	178.7±2.53	177.8±5.70	174.7±6.41
A-A (cm)	39.8±1.80	38.4±1.16	39.5±1.64	38.6±1.66
Body Mass (kg)	74.5±4.54	69.1±5.06	72.5±5.09	74.6±8.06
Fat (%)	11.7±2.46	9.1±3.94	14.1±2.58	14.0±5.89
Endomorphy	2.3±0.37	1.8±0.93	2.8±0.61	3.0±1.22
Mesomorphy	3.8±0.57	3.3±0.93	3.9±0.57	4.4±1.35
Ectomorphy	2.6±0.47	2.8±0.74	2.1±0.73	2.0±1.16

Tab. 2 *Morphological parameters: U19 goalkeepers*

Ranking	**1st - 4th**	**5th - 8th**	**9th - 12th**	**13th - 16th**
	X ±SD	*X ±SD*	*X ±SD*	*X ±SD*
Body Height (cm)	176.1±4.70	176.3±4.39	178.3±4.99	176.9±2.91
D-D (cm)	175.7±4.53	180.4±3.03	177.9±5.18	174.8±5.14
A-A (cm)	40.3±0.71	39.5±2.19	38.6±1.29	38.5±1.27
Body Mass (kg)	73.5±4.51	79.3±11.15	73.0±6.75	73.3±6.03
Fat (%)	14.20±2.69	13.8±6.36	12.2±3.65	13.0±3.01
Endomorphy	2.7±0.72	3.0±1.51	2.2±0.72	2.5±0.65
Mesomorphy	4.3±1.13	4.7±1.79	3.9±1.60	3.8±0.93
Ectomorphy	2.0±0.81	1.9±0.92	2.5±1.67	2.2±0.81

Unlike U17 goalkeepers, mean body height in U19 goalkeepers was found to be lowest in 1-4 group. Negative difference between body height and arm span was observed in 13-16 group only. The highest degree of skeletal robustness expressed by shoulder breadth was found in 1-4 group. Mean body mass was greatest in 5-8 group. The differences between mean values of body mass in 1-4, 9-12 and 13-16 groups were minimal. Paradoxically, the highest volume of subcutaneous fat was observed in 1-4 group. However, the highest volume of subcutaneous fat in kilograms was found in 5-8 group. Mean values of endomorphic components ranged from 2.2 to 3.0. The highest degree of relative fatness expressed by endomorphy was observed in 5-8 group. Mean somatotypes of all groups were found to be predominantly mesomorphic. The highest degree of muscular development was observed in 5-8 group. Mean somatotypes in groups 1-4 and 5-8 were identically categorized as *endomorphic mesomorphs*. The same was observed in groups 9-12 and 13-16 as mean somatotypes in both groups were identically classified as *balanced mesomorphs.*

Tab. 3 *Goalkeeping efficiency: U17 goalkeepers*

Ranking	**1st - 4th**	**5th - 8th**	**9th - 12th**	**13th - 16th**
	Total ±SD	*Total ±SD*	*Total ±SD*	*Total ±SD*
Total shots	809±74.81	1109±34.36	1150±67.14	1174±70.65
Total saves	310±30.63	376±11.59	387±25.77	388±26.25
Total % saves	**38.3**	**33.9**	**33.7**	**33.0**
6m shots	211±21.39	296±12.93	290±16.69	291±20.89
6m saves	77±7.09	111±5.62	92±5.21	97±6.98
6m % saves	**36.5**	**37.5**	**31.7**	**33.3**
7m shots	72±6.58	133±6.57	81±5.31	96±3.89
7m saves	10±1.71	30±2.00	17±1.30	27±1.83
7m % saves	**13.9**	**22.6**	**21.0**	**28.1**
9m shots	225±20.89	224±10.03	302±21.53	232±10.67
9m save	108±11.52	112±4.65	156±13.43	109±6.13
9m % saves	**48.0**	**50.0**	**51.7**	**47.0**
Wing shots	125±12.34	162±5.17	185±9.28	164±9.48
Wing saves	64±7.60	64±2.59	78±5.14	72±5.30
Wing % saves	**51.2**	**39.5**	**42.2**	**43.9**
FB shots	115±13.23	187±7.97	197±14.44	239±14.49
FB saves	43±5.72	40±1.67	34±2.71	49±4.60
FB % saves	**37.4**	**21.4**	**17.3**	**20.5**

As shown in Table 3, the total percentage of saves was highest in group 1-4 and lowest in 13-16 group. The table clearly shows that the number of shots at the goal was lowest in 1-4 group. This is indicative of good defense strategy of the team and individual defensive skills of players. However, goalkeeping efficiency when saving shots from 6-meter distance was highest in 5-8 group. When standing against 7-meter shots, the highest number of saves was paradoxically observed in 13-16 group. Table 1 shows that goalkeepers in 9-12 group had to save the highest number of shots from 9-meter distance and were also most effective in saving them reaching over 50 percent efficiency. However, the highest degree of goalkeeping efficiency from the wing positions and after fast breaks was found in group 1-4.