Sports Training

The height importance of male athletes for the classification in the world handball championships

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Abstract - Aim: The main purpose of the study was to investigate the height factor and player position concerning final team ranking in the three age categories, youths, juniors, and seniors. Height data were checked. **Methods:** Data was analyzed from 24 participating teams for seniors (n = 972, age = 27.3 ± 4.5), juniors (n = 622 age = 19.9 ± 1.0), and youths (1035 age = 18.8 ± 0.2) from official data from the selected last male World Handball Championships of 2013-2019. For each participating player, his position was noted too: backs (left and right), pivot (line player), goalkeeper, back (center), and wings (left and right). The final team ranking was recorded and the 24 teams were divided into 3 ranking groups of 8 teams. **Results:** The ANOVA test proved that mean heights were significantly different between the three age groups (seniors: 190.04 ± 7.33, juniors: 187.28 ± 8.13, youths: 186.84 ± 7.55, $F(2,3095) = 61.1$ $p < 0.001$). Effect size 0.039. In all ranked groups and all categories, the heights of the players were significantly different between different player positions. The discrimination ability of height in all three categories and player positions represented an overall percentage of around 70% classifying the three 8-team ranking tiers. **Conclusion:** Height is a factor that differentiates high-level performance for both players' position and age categories. The practical results can help the national federations and coaches apply more effective strategies for player selection.

Keywords: somatometric, age, playing position, performance.

Introduction

Handball is in a state of continual development and holds an important position in the athletic world. Its emergence is also based on the great variety of quick movements with continual game changes from defense to the offense which makes it spectacular[1]. Handball has a long tradition in Europe and is making headway in other continents too. It is an invasive team sport with a clear aim to score a goal and hinder the opponent from scoring[2]. It is guided by the International Handball Federation (I.H.F). Competitiveness in international events at the European and World levels is one of the factors for the development of the sport. The I.H.F is responsible to run seniors, junior, and youth world championships. Only athletes under 21 years of age participate in the juniors' events while in youths' events the age is under 19 (International Handball Federation, regulations documents)[3]. These age categories are important as they form the pool of players that progress to the senior level and are vital for the development process of the sport in every country.

The level of the sport in every country is reflected in the club and national team results. The important difference is that clubs can sign on players of different nationalities. In professional team sports, a transfer industry has developed for the free movement of athletes especially after the implications of the 1995 (case C-415/93) Judgement of the European Court of Justice on the case of Jean-Marc Bosman[4-6]. The possibility is unavailable to national teams and consequently, the national team is an important indicator of the sport in every country and is related to the supply of native players. Thus, the national teams somehow reflect the level of the sport in the country, although this depends on many factors such as the organizational structure of the athletic authorities and federations, popularity, and degree of appeal to children, talent identification infrastructure, the operation of sports schools and club investment, whether the sport is played at a professional or amateur level and even the dynamics and competitiveness of the league[7].

Handball is evolving dynamically, becoming more spectacular with an ever-increasing pace in the game[8]. Technical and tactical components, such as throwing velocity, are undoubtedly crucial and have been the topic of many studies[9,10]. Body dimensions influence the choice of the tactical model without underestimating the value of motor skills. The technical, tactical, and physical preparation of the athletes as well as the specific innate body characteristics all together form a complex influential factor in the development of the sport. According to studies, it has been demonstrated that in handball, the anthropometric characteristics are an important and determinant factor in youth and adult level performances[11-13]. The anthropometric index is a factor that affects the results and final ranking of the teams in a study that referred to a sample of teams that participated in the 2017 Men's World Handball Championship[14]. In a study by Debanne and Guillaume[15], once again the anthropometric characteristics are taken as a factor in a multiple regression model concerning the French and German professional seniors handball league.

The advantage of athletes with large anthropometrics has been demonstrated through studies and in particular palm dimensions for both handball and basketball athletes[16] and elite junior handball players[17]. According to a previous study, the body dimensions are factors that discriminate athletes from non-athletes[18]. Moreover, some anthropometric indices had a strong or less strong influence on motor ability tests with respect to age, keeping in mind the multidimensional aspect of handball with many components of performance[19-23]. It is accepted that body structure and morphological characteristics affect athletic performance considering differences in age and type of sport, while they explain the high percentage of variance in physical fitness tests[24]. Despite the many studies concerning somatometric indices and performance, playing position and height in successive age categories have not been adequately studied especially in top-level competitions. The working hypothesis is that the players' height in different positions contributes to the teams' performance as reflected by their ranking in the studied championships. The main purpose of the study was to investigate the height factor and player position concerning final team ranking in the three age categories, youths, juniors, and seniors.

Methods

Participants

Data were drawn from twenty-four participating teams, male youths, and juniors in 2019, 2017, and 2015 world championships and senior world championships of 2019, 2017, and 2013. In total, n = 2629 athletes (seniors n = 972, age = 27.3 ± 4.5, juniors n = 622, age = 19.9 ± 1.0, youth n = 1035, age = 18.8 ± 0.2) were recorded. For each player, it was obligatory to record measurements of age, height, weight, and player position. If even one measurement was missing then this constituted exclusion of that particular player. The data was compiled from the official published team reports from records of the International Handball Federation (I.H.F)[25].

Anthropometric measurements, player position, team ranking

Height and weight measurements were recorded, and the Body Mass Index was calculated[26] for each participating player while the player position was noted too: backs (left and right, L-R), pivot (line player), goalkeeper, back (center, C) and wings (left and right, L-R). The technical commission of each national federation was obliged to declare the above data. In addition, the final team ranking was recorded, which was from 1 to 24.

Statistical analysis

All the variables satisfied the tests of homoscedasticity (Levene's variance homogeneity test) and normality (Kolmogorov-Smirnov test) of their distributions. Between groups differences of height, weight and BMI were checked with the one-way ANOVA procedure, reporting the p-values and the effect size through partial eta squared (η^2), followed by post hoc pairwise comparisons with Bonferroni corrections. Linear regression analysis per category and players' position was employed to infer the effect of height on the team's final ranking in the championships, assuming the ranking to be a continuous wide range from 1 to 24. Discriminant analysis was also used after dividing the teams into two groups: the first eight versus the rest of the teams. The level of significance was set at 0.05. All statistical analyses were performed with SPSS v.26.

Results

Table 1 shows the descriptive statistics (means and standard deviation) and comparative statistics of height, weight, and Body Mass Index (BMI) between the three age categories. Furthermore, only the height variable was taken into consideration being a prevalent variable in

Table 1 - Descriptive (Mean ± SD) and comparative statistics of height, weight, body mass index between the three age categories. Between age categories ANOVA for each parameter.

Parameter	Senior (n = 972) (Mean ± SD)	Junior (n = 622) (Mean ± SD)	Youth (n = 1035) (Mean ± SD)	ANOVA test	p-value	Effect size (η^2)
Height (cm)	190.04 ± 7.33	187.28 ± 8.13	186.84 ± 7.55	F(2.3095) = 61.1	< 0.001*	0.039
Weight (kg)	91.98 ± 10.13	86.22 ± 11.30	84.77 ± 10.72	F(2.1377) = 151.8	< 0.001*	0.091
BMI (kg/m^2)	25.44 ± 2.03	24.51 ± 2.22	24.21 ± 2.12	F(2.1377) = 107.8	< 0.001*	0.067

SD = Standard deviation, BMI = Body Mass index * = all three age categories differed significantly between each other.

handball while weight and BMI were employed only to characterize the sample.

The ANOVA procedure showed that the three categories differed significantly in all three measurements (height, weight, and BMI). Post-hoc pairwise comparisons with Bonferroni corrections showed that all three categories differed significantly between each other.

The mean heights of the players in the youth teams and junior teams, when compared to those in the senior teams, had differences of -1.68% and -1.45% respectively.

In Table 2 we can see the mean values and standard deviation of height relative to team ranking per eight-tier ranking position

The respective height values of youth and junior with respect to seniors according to eight-tier ranking position is: Positions (1-8: -1.35% and -0.7%), (9-16: -1.71% and -1.68%), (17-24: -1.58 % and -1.85%). The ANOVA test proved those mean heights were significantly different between the three ranking groups in all three categories. Post-hoc pairwise comparisons with Bonferroni corrections showed that all three ranking groups differed significantly between each other in all three categories. In Table 3, we can see the mean height, standard deviation, and ANOVA test per age category and player position.

In all three categories, players playing as pivots or backs (L-R) are significantly taller than players in other positions. In juniors and youths, goalkeepers are as tall as pivots and backs (L-R). In the other positions, the same pattern occurs in all three categories, with Goalkeeper higher than Back (Center Back) higher than Wing (L-R) differing significantly from each other. In Table 4, the mean height, standard deviation, and ANOVA test per age category, player position eight per tier (1-8, 9-16, 17-24) can be seen.

The ANOVA procedure proved that in all ranked groups and all categories, the heights of the players were significantly different between different positions. The patterns of difference to a great extent show that the wing and back (C) positions have statistically significant differences between them and between the other positions. Backs (L R) and pivots are statistically significantly taller than others. It is noteworthy that in ranked positions 1-8, in all three categories, goalkeeper height is not significantly different compared to backs and pivots. The regression analysis, the correlation coefficient of the dependence of the ranking on the player's height for each age category and player position are shown in Table 5. In all cases the negative regression coefficients are all significantly different from zero, thus corroborating the association between players' height and team performance.

The teams' rankings were divided into two groups - in the first group, teams were ranked from 1-8, and in the second group, teams were ranked 9-24. Discriminant ana-

Table 2 - Descriptive (Mean ± SD) and comparative statistics of height (in cm) per 8 ranking positions in each age category. Between ranking groups ANOVA separately for each age categories.

Ranking groups	Senior (n = 972) (Means ± SD)	Junior (n = 622) (Means ± SD)	Youth (n = 1035) (Means ± SD)
1-8	192.19 ± 6.80 (n = 300)	190.84 ± 6.95 (n = 209)	189.60 ± 6.62 (n = 336)
9-16	190.92 ± 6.46 (n = 355)	187.72 ± 7.74 (n = 193)	187.66 ± 6.80 (n = 287)
17-24	186.96 ± 7.68 (n = 317)	183.51 ± 7.90 (n = 220)	184.03 ± 7.80 (n = 412)
ANOVA test	F(2.1377) = 69.1	F(2.620) = 51.0	F(2.1032) = 58.3
p-value	$< 0.001^*$	$< 0.001^*$	$< 0.001^*$
Effect size (η^2)	0.091	0.141	0.102

SD = Standard deviation * = all three ranking groups differed significantly between each other in all three age categories.

Table 3 - Descriptive (Mean ± SD) and comparative statistics of height (in cm) per player position in each age category. Between players positions ANOVA separately for each age categories.

Player position	Senior (Means ± SD)	Junior (Means ± SD)	Youth (Means ± SD)
Backs (L-R)	193.28 ± 6.78^a (n = 290)	189.85 ± 7.68^a (n = 192)	189.09 ± 7.16^a (n = 323)
Pivot	193.66 ± 6.76^a (n = 167)	191.86 ± 7.23^a (n = 76)	190.39 ± 6.82^a (n = 152)
Goalkeeper	191.15 ± 5.83^b (n = 137)	189.62 ± 6.81^a (n = 87)	188.90 ± 6.62^a (n = 145)
Back (C)	187.49 ± 6.27^c (n = 146)	184.64 ± 8.00^b (n = 112)	185.03 ± 6.96^b (n = 161)
Wing (L-R)	184.11 ± 6.01^d (n = 232)	182.37 ± 6.67^c (n = 155)	181.83 ± 6.37^c (n = 254)
ANOVA test	F(4.967) = 88.6	F(4.617) = 36.6	F(4.1030) = 59.5
p-value	< 0.001	< 0.001	< 0.001
Effect size (η^2)	0.268	0.192	0.188

SD = Standard deviation, L-R = Left-Right, C = center. Different superscript letters denote statistically significant differences between player positions.

Table 4 - Descriptive statistics of height (Mean ± SD) in cm per player position in each age category and ranking group. Between positions ANOVA separately for each age category and ranking group.

Ranking group	Player position	Senior (Means ± SD)	Junior (Means ± SD)	Youth (Means ± SD)
	Backs (L-R)	196.21 ± 5.89^a (n = 95)	194.24 ± 5.17^a (n = 68)	192.10 ± 5.65^a (n = 99)
1-8	Pivot	195.64 ± 4.40^a (n = 55)	194.85 ± 3.80^a (n = 26)	193.28 ± 6.08^a (n = 53)
	Goalkeeper	193.92 ± 5.45^a (n = 39)	192.29 ± 6.15^a (n = 28)	191.14 ± 5.19^a (n = 44)
	Back (C)	189.45 ± 5.08^b (n = 44)	189.95 ± 5.84^b (n = 37)	188.79 ± 4.79^b (n = 57)
	Wing (L-R)	184.84 ± 5.61^c (n = 67)	183.98 ± 6.38^c (n = 50)	183.99 ± 6.13^c (n = 83)
	ANOVA test	F(4.295) = 54.4	F(4.204) = 29.0	F(4.331) = 32.0
	p-value	< 0.001	< 0.001	< 0.001
	Effect size (η^2)	0.420	0.362	0.279
9-16	Backs (L-R)	194.24 ± 4.78^a (n = 109)	189.60 ± 7.28^a (n = 60)	189.84 ± 6.59^a (n = 97)
	Pivot	195.97 ± 6.22^a (n = 61)	193.75 ± 8.18^a (n = 24)	191.12 ± 5.75^a (n = 43)
	Goalkeeper	191.88 ± 4.60^b (n = 49)	192.12 ± 4.59^b (n = 26)	190.16 ± 5.77^b (n = 38)
	Back (C)	188.57 ± 4.73^c (n = 54)	185.34 ± 6.43^c (n = 35)	185.64 ± 6.04^c (n = 42)
	Wing (L-R)	185.54 ± 5.06^d (n = 82)	181.50 ± 5.14^d (n = 48)	182.12 ± 4.80^d (n = 67)
	ANOVA test	F(4,350) = 52.1	F(4,188) = 21.8	F(4,282) = 24.7
	p-value	< 0.001	< 0.001	< 0.001
	Effect size (η^2)	0.373	0.317	0.259
17-24	Backs (L-R)	188.84 ± 7.62^a (n = 86)	185.44 ± 7.75^a (n = 64)	186.17 ± 7.54^a (n = 127)
	Pivot	188.76 ± 7.00^a (n = 51)	187.12 ± 6.68^a (n = 26)	187.11 ± 6.94^a (n = 56)
	Goalkeeper	188.20 ± 5.99^b (n = 49)	185.39 ± 6.82^b (n = 33)	186.59 ± 7.29^b (n = 63)
	Back (C)	184.46 ± 7.61^c (n = 48)	179.13 ± 7.51^c (n = 40)	181.16 ± 7.27^c (n = 62)
	Wing (L-R)	182.12 ± 6.68^d (n = 83)	181.68 ± 7.81^d (n = 57)	179.93 ± 6.90^d (n = 104)
	ANOVA test	F(4.312) = 13.3	F(4.215) = 7.4	F(4.407) = 18.1
	p-value	< 0.001	< 0.001	< 0.001
	Effect size (η^2)	0.146	0.121	0.151

SD = Standard deviation, L-R = Left-Right, C = center. Different superscript letters denote statistically significant differences between player positions.

Table 5 - Regression analysis of the dependence of ranking on player height for each category and player position. Shown are the correlation coefficients, the beta coefficients of the regression equations and their corresponding p-values.

Player	Senior			Junior			Youth		
Position	r	b	p-value	r	b	p-value	r	b	p-value
Backs(L-R)	0.472	−0.473	0.000	0.455	−0.406	0.000	0.318	−0.316	0.000
Pivot	0.432	−0.433	0.000	0.459	−0.398	0.000	0.395	−0.425	0.000
Goalkeeper	0.437	−0.518	0.000	0.496	−0.486	0.000	0.332	−0.368	0.000
Back (C)	0.387	−0.410	0.000	0.576	−0.492	0.000	0.471	−0.489	0.000
Wing (L-R)	0.234	−0.269	0.000	0.204	−0.204	0.011	0.283	−0.331	0.000

L-R = Left-Right, C = center, r = correlation coefficient, b = regression coefficient.

lysis for each category and position proved that in most cases, height could correctly predict more than 70% of the final group membership of the teams (Table 6).

Discussion

The main purpose of the study was to investigate the height factor and player position concerning final team ranking in the three age categories, youths, juniors, and seniors. The player positions were backs (left and right), pivot (line player), goalkeeper, back (center), and wings (left and right). The results show that height is statistically significantly different between categories. Corresponding studies present similar results[27,28]. Anthropometric characteristics are fundamental to achieving the optimum development of athletic performance and can influence how well players respond to the demands of the specific game position. The training process is among the basic

Table 6 - Discrimination ability of the player height on the ranking of the teams, grouped as the first eight versus the rest of the teams, expressed as the proportion (%) of correctly classified teams.

Player position	Senior	Junior	Youth
Backs (L-R)	71.4%	68.8%	69.7%
Pivot	64.1%	67.1%	70.4%
Goalkeeper	73.7%	70.1%	68.3%
Back (C)	69.9%	75.9%	67.7%
Wing (L-R)	71.1%	69.0%	68.9%

L-R = Left-Right, C = center.

factors that determines the athlete's morphological differences in the circular measures of the body volume, but height, which is the subject of the study, is genetically determined and age-related and remains largely unaffected by training[29,30]. In the senior category, the mean height of players in the 24 participating teams was 190.04 cm, similar to the height noted by Chaouachi et al.[31] with a mean height reported as 189.5 cm in a sample comprising athletes from the Tunisian national team. The corresponding height for juniors was 187.28 cm while for youths it was 186.84 cm. The statistical differences of mean height between seniors, juniors, and youths are deemed to be logical because especially for youths, their maturity is still in process[32,33]. This is also explained by the age-limited choice from the pool of players in-these two categories, which is laid down by the rules of the federation.

Despite the differences of mean height between categories, it must be noted that the mean values of height for youths and juniors respectively comprise -1.68% and -1.45% of the mean height of the senior team. The compared height values for youths and juniors decrease even more to -1.35% and -0.7% respectively when in the study we take into account the team ranking position within the first 8 positions. In effect, this means that high-level seniors teams choose to build them from the youth and junior categories based on somatometric criteria obviously with the development of technical and tactical skills and through talent identification programs[34-36]. It is obvious that an athlete's development process and performance continues to evolve thus enhancing physical parameters and perfecting the technical tactical characteristics and gained playing experience. Participation of athletes in the youth and junior categories is a critical stage before finally entering the seniors national team. Childhood training is important for their future development taking into account the pedagogical aspect but their performance before the age of sixteen is not a good predictor of adult performance[37] while accounting for the relative age effect on the selection of athletes and team performance[38]. Only in exceptional cases do we witness younger talented players becoming part of a higher age category.

The twenty-four teams participating in the world championships were divided into three ranking dependent groups, 1-8, 9-16, and 17-24 per age category. The analysis of variance between the three ranked groups in all three categories showed that there were statistically significant differences between these groups in all three age categories. It is evident that a taller body equates to a better ranking position. The taller player has an advantage as he can cover greater defense areas which are very important in any zone defense provided that other performance parameters such as technical, tactical, and physical condition are at a satisfactory level. Concerning offense, the ability of the player to shoot above the defense block is a clear advantage. Our results are in accordance with those of Hasan et al.[39] with a sample of the teams participating in the 12th Asian Games in Hiroshima, Japan. The players in the successful teams, the ones ranked in the first three positions, compared to the players in the remaining two participating teams, the unsuccessful ones, were found to be significantly statistically taller. It seems that being taller is not only correlated with better results for national teams but also for the club teams comparing teams from both the first and second league handball in national championship[40]. Our findings show similar results to those of Fieseler et al.[41] where players in the first German league were statistically higher compared to players in the third German handball league.

In handball, there is a defined position role for every player even though it is advantageous for a player to take on different position roles in the field of play. Regarding height, according to the results of our study, backs (left and right) and pivots are the tallest players followed by the goalkeeper, back (center), and wing who are the shortest of all. At the senior level, no significant differences exist between backs (L-R) (193.28 ± 6.78), and pivots (193.66 ± 6.76) who are taller, followed by goalkeepers, backs (center), and wings who are the shortest players. In junior and youth goalkeepers are as tall as pivots and backs (L-R), followed by backs (center) and wings who have significant differences between them. Our results partially agree with those of Srhorj et al.[42] that mentions backs as the tallest players, and differences between the backcourt players and wing attackers are biggest in skeletal dimensions while Schwesig et al.[43] conclude that wings, pivots, and goalkeepers were significantly shorter than backs. Accordingly, Sibila and Pori[44] note that shorter players can occupy the wing position as body height is not a decisive factor for this position. The same pattern of height and playing position in selected athletes of national Greek teams between the ages of 16 and 20 was presented by Rousanoglou et al.[45]. In addition, Hermassi et al.[46] note that wings showed the lowest body height.

In our study, players in back positions have been differentiated into two parts, left and right and center although in many studies these positions are taken as one unified position. The backs score a large percentage of the total goals and have a complementary relation to the pivots, related to the technical tactical aspect[47]. Tall body height is an asset for the backs who should have the ability in throws too. Height is also an advantage for the pivot player for both scorings in difficult and pressing situations and in his role in creating conditions for scoring by other players in the team. According to Almeida et al.[48] with a sample of seniors from world handball championships, concludes that the best teams have the tallest players, which we witness in first division national championships[49]. Further investigation into the ranking tiers, 1-8, 9-16, 17-24, concluded that players in the back (L-R) and pivot positions were statistically the tallest in seniors, juniors, and youths in all the ranked positions. In addition, for ranking tiers 1-8 in all three categories, the goalkeeper is included in this group of taller players. This confirms that top performance teams invest in players with high body dimensions. The wings are the shortest players who, however, possess special skills and are necessary for fast break situations and often aggressive defense. The back (C) is taller than the wing and in modern handball does not only have to organize the play but also contribute to scoring. The back (C) is often seen to temporarily change positions with the left and right backs something necessary in modern handball.

Regression analysis found that the players' height was a significant predictor of the ranking position for each age category and player position. Teams with taller players in all positions were found to rank high. Higher correlations at the senior level were found to be for backs (L-R), followed by the goalkeeper and pivot. In the junior category, this correlation was highest for center backs followed by the goalkeeper and similarly, in the youth categories, this correlation was highest for the center back followed by the pivot. At top-level handball, the highest percentage of total goals in a game is seen by backs and the pivot[50]. Therefore, for these player positions directly related to scoring, height is an advantage. The weakest correlation of player position with team ranking is exhibited in the wing position. In this particular player position, as our results show, we find shorter players who often participate in other roles such as in fast break and fast throw offense.

The team rankings were divided into two groups - in the first group, the teams were ranked from 1-8, and in the second group, the teams were ranked 9-24, to carry out a discrimination analysis. The results showed that there was a significant discrimination ability of height in all three categories and player positions representing an overall percentage of around 70% in classifying the three 8-team ranking tiers. This correct classification proportion exceeds the theoretically expected one. The height advantage holds if other performance parameters are at a satisfactory level as mentioned before. The results of the study have also shown the importance of the goalkeeper's height. The particularity of this position lies in the longer limbs that can cover a larger area of the goalpost. The efficacy of shooting and the efficacy of the goalkeeper are key performance indicators in handball. The difference between winning and losing teams are related to shots and in particular unsuccessful goal attempts (shots saved, shots missed, and shots blocked)[51]

Coaches and team leaders are obliged to plan a tactical model of the game such that it is adapted to the somatometric and technical tactical characteristics of their players. A team without a height advantage will probably employ more of an offensive defense to lead the opponent to make mistakes and allow steals. It will attempt to sustain fast gameplay and fast breaks rather than a positional attack. In practice, however, top-level teams have athletes who are both tall and possess all the characteristics (technical, tactical skills, explosive power, psychological skills, and other) that lead them to be at the top. An overview of the results shows the importance of height in team performance[52]. Despite this, handball is a sport that entails many characteristics such as running, jumping, and throwing, with a wide array of movements and fast decisions that require tactical and technical skills, and therefore all these components should be considered.

Conclusion

The results of our study support the importance of height as a factor that differentiates high-level performance teams. This is particularly true for the positions of backs, pivot, and goalkeeper. Although height is an asset, it is not sufficient on its own to provide high-level performance as the athletes need to be in great physical condition and possess complex technical tactical prowess. It seems that to reach the top position in sports, all the above conditions need to be fulfilled simultaneously. The results of the study are based on a range of data from three age categories from the strongest national teams whose participation in world championships is possible only after preliminary rounds. The practical results of the study can help the national federations and coaches in devising more effective strategies for player selection and development.

References

1. Wagner H, Finkenzeller T, Würth S, Von Duvillard SP. Individual, and team performance in team-handball: A review. J sports Sci Medicine. 2014;13(4):808-16.
2. Lamas L, Barrera J, Otranto G, Ugrinowitsch C. Invasion team sports: strategy and match modeling. Int J Perform Analysis in Sport. 2014;14(1):307-29.
3. International Handball Federdation (Statutes and Regulations) https://www.ihf.info
4. Quirk J, Fort RD. Pay dirt: Business professional team sports. Princeton University Press; 1997.

5. Terviö M. Transfer fee regulations, and player develop. J Eur Econ Assoc. 2006;4(5):957-87.
6. Biner JJ, Findlay M. The effects of the Bosman ruling on national and club teams in Eur J Sports Econom. 2012;13 (2):107-29.
7. Meletakos P, Noutsos K, Manasis V, Bayios I. The mediating effect of competitive balance on the relation between foreign players and performance of the Greek National Basketball Team. J Phys Educ Sport Manag. 2014;5(7):72-80. doi
8. Meletakos P, Bayios I. General trends in European handball: A longitudinal study. Int J Perform Analysis Sport. 2010;10 (3):221-8. doi
9. Vila H, Ferragut C. Throwing speed in team handball: a systematic review. Int J Perform Analysis Sport. 2019;19 (5):724-36. doi
10. Vila H, Zapardiel JC, Ferragut C. The relationship between effectiveness and throwing velocity in a handball match. Int J Perform Analysis Sport. 2020;20(2):180-8. doi
11. Skoufas D, Kotzamanidis C, Hatzikotoylas K, Bebetsos G, Patikas D. The relationship between the anthropometric variables and the throwing performance in handball. J Hum Mov Stud. 2003;45:469-48.
12. Lidor R, Falk A, Arnon M, Cohen Y, Segal G, Lander Y. Measurement of talent in team handball: The questionable use of motor and physical tests. J Strength Cond Res. 2005;19:318-25. doi
13. Mohamed H, Vaeyens R, Matthys S, Multael M, Lefevre J, Lenoir, et al. Anthropometric and performance measures for the develop of a talent detection and identification model in youth handball. J Sports Sci. 2009;27:257-66. doi
14. Noutsos SK, Rousanoglou NE, Meletakos GP, Bayios AI, Boudolos DK. Performance indicators and competition ranking in women's and men's World Handball Championship 2017. J Phys Educ Sport. 2018;18(3):1761-6. doi
15. Debanne T, Laffaye G. Effects of game location, quality of opposition, number of foreign players and anthropometric factors in elite handball games. Kinesiology. 2017;49:194-201. https://hrcak.srce.hr/ojs/index.php/kinesiology/article/view/5261
16. Visnapuu M, Toivo J. Handgrip strength and hand dimensions in young handball and basketball players. J Strength Cond Res. 2007;21(3):923-9.
17. Noutsos K, Nassis G, Vareltis I, Kororos P, Skoufas D, Bayios I. Physiological and anthropometric characteristics of elite junior handball players. Communication to the Congress Eur Coll Sport Sci. 2008. Estoril, Portugal.
18. Malina RM, Meleski BW, Shoup RF. Anthropometric, body composition, and maturity characteristics of selected school-age athletes. Pediatr Clin North Am. 1982;29 (6):1305-23. doi
19. 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. 2009;2:22-8. doi
20. Visnapuu M, Jürimäe T. Relations of anthropometric parameters with scores on basic and specific motor tasks in young handball players. Percept Mot skills. 2009;108 (3):670-6. doi
21. Ziv G, Lidor R. Physical characteristics, physiological attributes, and on-court performances of handball players: A review. Eur J Sport Sci. 2009;9:375-86. doi
22. Wagner H, Finkenzeller T, Würth S, Von Duvillard SP. Individual, and team performance in team-handball: A review. J Sports Sci Med. 2014;13(4):808-16. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4234950/
23. Tuquet J, Zapardiel JC, Saavedra JM, Jaén-Carrillo D, Lozano D. Relationship between Anthropometric Parameters and Throwing Speed in Amateur Male Handball Players at Different Ages. Int J Environ Res Public Health. 2020;17(19):7022. doi
24. Carter JEL. Somatotypes of Olympic athletes. In: J.E.L. Carter (ed.) Physical Structure of Olympic Athletes. Part II: Kinanthropometry of Olympic Athletes. Karger, Basel. 1984;80-109.
25. International Handball Federation (Competitions) https://www.ihf.info/
26. Matz, R. Calculating body mass index. Ann Int Med. 1993;118(3):232.
27. Michalsik LB, Madsen K, Aagaard P. Technical match characteristics and influence of body anthropometry on playing performance in male elite team handball. J Strength Cond Res. 2015;29(2):416-28. doi
28. Sporiš G, Vuleta D, Vuleta D Jr, Milanović D. Fitness profiling in handball: physical and physiological characteristics of elite players. Coll Antropol. 2010;34(3):1009-14. https://hrcak.srce.hr/59364
29. McEvoy BP, Visscher PM. Genetics of human height. Econ Hum Biol. 2009;7(3):294-306. doi
30. Weedon MN, Frayling TM. Reaching new heights: insights into the genetics of human stature. Trends Genet. 2008;24 (12):595-603. doi
31. Chaouachi A, Brughelli M, Levin G, Boudhina NB, Cronin J, Chamari K. Anthropometric, physiological and performance characteristics of elite team-handball players. J Sports Sci. 2009;27:151-7. doi
32. Fransen J, Bush S, Woodcock S, Novak A, Deprez D, Baxter-Jones AD, et al. Improving the prediction of maturity from anthropometric variables using a maturity ratio. Pediatr Exerc Sci. 2018;30(2):296-307.
33. Jones MA, Hitchen PJ, Stratton G. The importance of considering biological maturity when assessing physical fitness measures in girls and boys aged 10 to 16 years. Ann Hum Biol. 2000;27(1):57-65.
34. Brown, J. Sports Talent. Human kinetics; 2001.
35. Mohamed H, Vaeyens R, Matthys S, Multael M, Lefevre J, Lenoir M, et al. Anthropometric and performance measures for the development of a talent detection and identification model in youth handball. J Sports Sci. 2009;27(3):257-66.
36. Matthys SP, Vaeyens R, Vandendriessche J, Vandorpe B, Pion J, Coutts AJ, et al. A multidisciplinary identification model for youth handball. Eur J Sport Sci. 2011;11(5):355-63.
37. Boccia G, Moisè P, Franceschi A, Trova F, Panero D, La Torre A, et al. Career performance trajectories in track and field jumping events from youth to senior success: the importance of learning and development. Plos one. 2017;12 (1):e0170744.

38. Rubia ADL, Bjørndal CT, Sánchez-Molina J, Yagüe JM, Calvo JL, Maroto-Izquierdo S. The relationship between the relative age effect and performance among athletes in World Handball Championships. Plos one. 2020;15(3):e0230133.
39. Hasan A, Rahaman JA, Cable NT, Reilly T. Anthropometric profile of elite male handball players in Asia. Biol Sport. 2007;24(1):3-12.
40. Bayios IA, Anastasopoulou EM, Sioudris DS, Boudolos KD. Relationship between isokinetic strength of the internal and external shoulder rotators and ball velocity in team handball. J Sports Med Phys Fitness. 2001;41(2):229-35.
41. Fieseler G, Hermassi S, Hoffmeyer B, Schulze S, Irlenbusch L, Bartels T, et al. Differences in anthropometric characteristics in relation to throwing velocity and competitive level in professional male team handball: a tool for talent profiling. J Sports Med Phys Fitness. 2017;57(7-8):985-92. doi
42. Srhoj M, Marinovic M, Rogulj N. Characteristics of Male Handball Players. Coll Antropol. 2002;26(1):219-27.
43. Schwesig R, Hermassi S, Fieseler G, Irlenbusch L, Noack F, Delank KS, et al. Anthropometric and physical performance characteristics of professional handball players: influence of playing position. J Sports Med Phys Fitness. 2017;57(11):1471-78. doi
44. Sibila M, Pori P. Position-related differences in selected morphological body characteristics of top-level handball players. Coll Antropol. 2009;33(4):1079-86. https://hrcak.srce.hr/51458
45. Rousanoglou EN, Noutsos KS, Bayios IA. Playing level and playing position differences of anthropometric and physical fitness characteristics in elite junior handball players. J Sports Med Phys Fitness. 2014;54(5):611-21. https://europepmc.org/article/med/25270781
46. Hermassi S, Laudner KG, Schwesig R. Playing level and position differences in body characteristics and physical fitness performance among male team handball players. Front Bioeng Biotechnol. 2019;7:149. doi
47. Meletakos P, Vagenas G, Bayios I. A multivariate assessment of offensive performance indicators in Men's Handball: Trends and differences in the World Championships. Int J Perform Analysis Sport. 2011;11(2):284-94. doi
48. Almeida AG, Merlin M, Pinto A, Torres RDS, Cunha SA. Performance-level indicators of male elite handball teams. Int J Perform Analysis Sport. 2020;20(1):1-9. doi
49. Nikolaidis PT, Ingebrigtsen J. Physical and physiological characteristics of elite male handball players from teams with a different ranking. J Hum kinetics. 201;38:115.
50. Meletakos P, Noutsos K, Bayios I. Stable and changing characteristics of high-level handball as evidenced from World Men's Championships, J Phys Educ Sport. 2020;20(3):1354-61. doi
51. Daza G, Andrés A, Tarragó R. Match statistics as predictors of team's performance in elite competitive handball. [Estadística del partido como predictor del rendimiento de equipo en el balonmano de élite]. Rev Int Ciencias del Deporte. 2017;13(48):149-161. doi
52. Khosla, T. Sport for tall. Br Med J. 1983:287(6394):736-8. doi

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