



AN ANALYSIS OF ANTHROPOMORPHOLOGICAL CHARACTERISTICS OF PARTICIPANTS IN THE 2008 EUROPEAN FOOTBALL CHAMPIONSHIP

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Abstract Contemporary football tends to place more and more demand on football players with regard to the appropriate body structure, strong, enduring bodies, extensive football intelligence, controlled aggressiveness, highly developed functional and motor abilities, and a sense for improvisation and collective play. The aim of this research is to define the average values for all the 368 participants in the 2008 European Football Championship by analyzing basic anthropomorphological parameters, as well as certain body indices. The research results point to the fact that the average height of all the participants in the 2008 European Football Championship was 182.97 ± 6.59 cm and the average body mass was 77.88 ± 6.98 kg. The tallest average was noted in goalkeepers, followed by defense and forwards players, while the lowest values for height (179.02 ± 5.94 cm) and body mass (73.89 ± 5.81 kg) were noted in midfield players. Body height and body mass in elite football players have increased in the course of time, and it is also noticeable that apart from forwards, each particular position requires a particular body type.

Key words: Height, body mass, selection, football, player position

INTRODUCTION

A successful sport engagement demands continuous training from an early age. Apart from training sessions, in order to succeed in contemporary sport it is essential for an athlete to possess certain genetically conditioned abilities and features. To meet the demands of state-of-the-art football continual guided selections are necessary from early on all the way to the national team selection [10].

Body composition, anthropometric dimensions, and morphological characteristics play a vital role in determining the success of an athlete [15, 26, 33].

Contemporary football presupposes the existence of a certain body structure, of strong enduring football players marked by great football intelligence, controlled aggressiveness, and highly developed functional and motor abilities, with a sense for improvisation and a collective game [4, 7, 12, 19].

The analyses up to date that have researched anthropometric dimensions point to the fact that contemporary football is dominated by football players of above-average height compared to the selection pool population, and their build tends to be athletic. The relation between height and body mass is equally important due to the fact that modern football implies duel play, jump head play, fast activities (alternating offense and defense), all of which are linked to efficient realization and the obligatory playing time during the entire match [4, 8, 9, 13, 16, 30, 32].

In contemporary football, there are fewer football players of lower body height. In case they belong to this category, they must have other qualities to ensure achieving the same results as taller players [10]. Besides their age, it is the weight-height relationship of elite football players observed through the index value of ideal body mass, the body mass index and Kettle's index that represent the subject matter of this research.

The aim of the research was to analyze the height and body mass, along with certain weight-height relations of the 2008 EFC participants. The analysis combined the aforementioned features with the playing positions of the team members (goalkeepers, defense, midfielders, forwards) and the characteristics of the teams holding the first four positions at this Championship.

MATERIALS AND METHODS

SAMPLES

The participants' height and body mass were taken from the UEFA website of the 2008 EFC in Austria and Switzerland [35]. The analysis numbered 368 football players, all participants of the 2008 EFC. Their age ranged from 20 to 39, with an average of 27.57 ± 3.97 .

ANTHROPOMORPHOLOGICAL VARIABLES

During the course of the research the following values were analyzed: the age (Yrs), the Body Height given in cm (BH), the Body Mass given in kg (BM), the Ideal Body Mass given in kg (IBM), the Body Mass Index given in kg/m^2 (BMI), and Kettle's Weight-Height index given in g/cm (KettleW-H). All the characteristics were analyzed for all the subjects according to their playing positions in their teams.

The ideal body mass was measured according to the Lorenz index:

- $\text{IBM in kg} = (\text{BH} - 100) - [(\text{BH} - 150) \times 0.25]$ [17].

The body mass index was measured according to the formula:

- $\text{BMI} = \text{Body Mass in kg} / \text{Body Height (in m}^2)$ [20]

Kettle's index (weight-height index) was calculated according to the formula:

- $\text{KettleW-H} = \text{Body Mass in g} / \text{Body Height in cm}$ [11]

STATISTICAL ANALYSIS

The statistics were computer analyzed by Statistica (Statistics Programme-Version 7). The computations refer to the basic statistic parameters: N – number of examinees, MEAN – average value, MIN and MAX – values, RANGE – difference between Max and Min, SD – standard deviation, Error – Standard error of average value, SKEW – skewness and KURT – Kurtosis. In order to determine the differences between groups at a univariable level we used univariable analysis (ANOVA).

RESULTS AND DISCUSSION

By looking at Table 1, where the results of central and dispersion parameters are shown, we can conclude that overall results of the mean value were good (Mean), because the standard error of the mean (Error) was always as much as five times lower than its mean. The values of the basic, central and dispersion parameters in the range of minimal and maximal results (Range) always had five or more standard deviations (SD), whence we can conclude with certainty that the results had a very high level of sensitivity. Besides, there exists the optimal distribution curve in the zones around the mean value (Skew). Skewness indicates that the variable that shows the number of the games played for the national team had slightly more positive results. However, Kurtosis, whose value was significantly lower than 2.75, points out that the distribution differs from normal, which further means that the results of these tests are rather scattered. This can be explained with different positions that the players had (goalkeepers, defense players, forward players).

The average height of all the participants was 182.97 ± 6.59 cm, and the average body mass was 77.88 ± 6.98 kg, which was 3.15 kg more in comparison to the average ideal body mass calculated by means of the Lorenz formula. In 1969, Stojanovic et al. [28] stated that the average height on the national football team was 176.0 cm and that the average weight was 73.27 kg; in 1999, Verdenik [31] spoke about the senior Slovenian national football team model in which the average height was 173.3 cm and the body mass was 68.85 kg; in 2004, according to the research by Wisløff and associates [34], the top football players of the football team Rosenberg (the winners of 11 consecutive national league championships and the 8-time participants of The Champions' League) were of the average age of 25.8 ± 2.9 years, with the average height of 177.3 ± 4.1 cm, and the average body mass of 76.5 ± 7.6 kg. This brings us to the conclusion that the average height of the top football players has been on the rise

since 1969, 1999, or even 2004. Previous research has also shown that the height of the football players has changed from an average height of 170.3 cm in 1928 to an average height of 180.9 cm in 2002. This has been the result of guided selection and partly of general acceleration in growth and development [14].

Table 1. All players: basic descriptive characteristics at the 2008 EFC (N = 368)

Variables	Mean	SD	Min	Max	Range	Error	Skew.	Kurt.
Yrs.	27.58	3.98	20.00	39.00	19.00	0.207	0.435	-0.311
BH (cm)	182.97	6.59	166.00	202.00	36.00	0.344	-0.067	-0.303
BM (kg)	77.88	6.98	60.00	103.00	43.00	0.364	0.181	0.135
IBM (kg)	74.73	4.94	62.00	89.00	27.00	0.258	-0.066	-0.302
BMI (kg/m²)	23.24	1.15	19.86	26.32	6.46	0.060	0.021	-0.085
KettleW-H (g/cm)	425.49	27.02	348.84	509.91	161.07	1.409	0.041	0.169

The BMI was 23.24 ± 1.14 kg/m². These parameters indicate an average level of nourishment in the football players who participated in the 2008 EFC. The maximum value of 26.32 shows that the football players had a high level of BMI due to a high % of muscle mass hypertrophy. It could be supposed that the superfluous weight of top football players is probably achieved through muscle mass and not fat tissue. A study carried out during the American Cup of 1995, in Uruguay, evidenced an approximate of 11% of fat and 62 % of muscular mass [24]. The anthropometric profile in professional football players can be characterized by its heterogeneity, and this may be partially explained by the ethnic and racial differences of its practitioners [23, 27].

Table 2. Goalkeepers: basic descriptive characteristics at the 2008 EFC (N = 48)

Variables	Mean	SD	Min	Max	Range	Error	Skew.	Kurt.
Yrs.	29.42	4.76	20.00	39.00	19.00	0.687	0.229	-0.831
BH (cm)	189.06	4.54	180.00	199.00	19.00	0.655	0.268	-0.449
BM (kg)	84.60	5.64	74.00	98.00	24.00	0.814	0.082	-0.548
IBM (kg)	79.30	3.41	72.50	86.75	14.25	0.492	0.268	-0.449
BMI (kg/m²)	23.66	1.13	21.65	26.32	4.67	0.163	0.225	-0.313
KettleW-H (g/cm)	447.36	23.64	402.17	500.00	97.83	3.413	0.043	-0.668

Table 2 shows basic statistical parameters for the goalkeepers at the 2008 European Championship. By analyzing the table we can notice that the results of the tests are as good as those in Table 1. The distribution is rather curved in the zones around the arithmetic mean. Similarly, the results concerning all the variables are scattered.

The results shown in Table 2 deal with the goalkeepers' weight-height values. The research included 48 goalkeepers of an age average of 29.42 ± 4.762 . The difference in age between the oldest and the youngest goalkeepers was 19 years. The average height of the goalkeepers was 189.06 ± 4.54 cm, which exceeded the height average of the participants at the Championship. The average body mass of the goalkeepers was 84.60 ± 5.637 kg, which was on average 5.31 kg more compared to the average ideal body mass calculated by means of the Lorenz formula. The average values of the BMI were within the limits set for people of normal body weight.

All the goalkeepers were taller than 180.0 cm.

Higher values for the height of goalkeepers compared to the average height of other football players have been noted and cited by more than one author [9, 13]. Elsner [7] in "The Model Player" gives the Austrian model in which the football player's height is at least 175.0 cm and the goalkeeper's height is at least 180.0 cm. Moreover, in this research the minimum height of a goalkeeper is 180 cm.

A number of studies have verified that goalkeepers and center backs are taller compared to other athletes analyzed [23, 24, 26]. Contemporary football demands goalkeepers who are experienced in playing for the national team or in international matches. The average age of the goalkeepers at the Championship was 29.42 ± 4.76 , which was above the average age of all other participants.

Table 3 shows great statistical difference between goalkeepers and other players in all variables (Yrs., BH, BM, IBM, BMI, KettleW-H).

Table 3. Univariant differences between goalkeepers and other players (defense players, midfielders and forwards)

Variables	Goalk/Rest	N	Mean	SD	F	p
Yrs.	Goalkeepers	48	29.42	4.76	12.19	0.001
	Rest	320	27.30	3.78		
BH (cm)	Goalkeepers	48	189.06	4.54	53.88	0.000
	Rest	320	182.06	6.37		
BM (kg)	Goalkeepers	48	84.60	5.64	59.48	0.000
	Rest	320	76.87	6.59		
IBM (kg)	Goalkeepers	48	79.30	3.41	53.89	0.000
	Rest	320	74.05	4.77		
BMI (kg/m²)	Goalkeepers	48	23.66	1.13	7.64	0.006
	Rest	320	23.17	1.14		
KettleW-H (g/cm)	Goalkeepers	48	447.36	23.64	39.98	0.000
	Rest	320	422.21	25.98		

By analyzing Table 4, which shows the basic statistical parameters for the defense players, we can see that the results are as good as those in the previous tables. The results of skewness are quite similar, while the results of kurtosis show a wider range of scattering.

Table 4. Defense football players: basic descriptive characteristics of the 2008 EFC (N=121)

Variables	Mean	SD	Min	Max	Range	Error	Skew.	Kurt.
Yrs.	27.79	3.56	21.00	36.00	15.00	0.323	0.192	-0.588
BH (cm)	184.69	5.43	170.00	198.00	28.00	0.494	-0.221	0.268
BM (kg)	78.99	6.14	62.00	92.00	30.00	0.558	-0.192	0.133
IBM (kg)	76.02	4.08	65.00	86.00	21.00	0.370	-0.221	0.268
BMI (kg/m²)	23.15	1.07	20.01	26.09	6.08	0.097	0.142	0.222
KettleW-H (g/cm)	426.98	24.88	359.60	484.21	124.61	2.262	-0.319	0.263

The defense football players were of an average height of 184.69 ± 5.43 cm, which, similarly to the goalkeepers, was above the average height of all the participants at this championship (Tables 4 and 10). There were no players under 170 cm. In order for a team to be successful, it is essential that both its center backs and goalkeepers have a privileged height, as they perform a higher amount of vertical jumping, and thus, they are bound to be successful in their movements [1, 2]. The average body mass of the defense players was 3 kg greater than the average ideal body mass, but 2 kg less than the goalkeepers.

The aforementioned points to the fact that the selection of defense football players should consider taller, stronger players with body mass index values within the range of normal nourishment and with more extensive international experience.

Table 5. Univariant differences between defense players and other players (goalkeepers, midfielders and forwards)

Variables	Defense/Rest	N	Mean	SD	F	p
Yrs.	Defense	121	27.79	3.56	0.498	0.481
	Rest	247	27.47	4.17		
BH (cm)	Defense	121	184.69	5.43	12.682	0.000
	Rest	247	182.13	6.95		
BM (kg)	Defense	121	78.99	6.14	4.641	0.032
	Rest	247	77.33	7.30		
IBM (kg)	Defense	121	76.02	4.08	12.664	0.000
	Rest	247	74.10	5.21		
BMI (kg/m²)	Defense	121	23.15	1.07	1.186	0.277
	Rest	247	23.28	1.18		
KettleW-H (g/cm)	Defense	121	426.98	24.88	0.545	0.461
	Rest	247	424.76	28.03		

Table 5 shows univariant differences between defense players and the other players at the 2008 European Championship. Its analysis reveals statistically significant differences in the following variables: BH, BM, IBM, while there were no differences in Yrs., BMI and KettleW-H.

Table 6. Midfield football players: basic descriptive characteristics at the 2008 EFC (N=119)

Variables	Mean	SD	Min	Max	Range	Error	Skew.	Kurt.
Yrs.	26.97	3.83	20.00	37.00	17.00	0.351	0.443	-0.571
BH (cm)	179.02	5.95	166.00	196.00	30.00	0.545	0.243	-0.264
BM (kg)	73.89	5.82	60.00	90.00	30.00	0.533	0.078	0.203
IBM (kg)	71.77	4.45	62.00	84.50	22.50	0.408	0.244	-0.258
BMI (kg/m²)	23.04	1.10	20.27	25.56	5.29	0.101	-0.278	-0.535
KettleW-H (g/cm)	414.04	24.78	348.84	491.30	142.46	2.271	0.089	0.692

Table 6 shows several basic statistic parameters for the midfielders in the 2008 European Championship. By analyzing it we can conclude that the results are as good as the previous ones. Skewness shows normal distribution, while kurtosis shows scattering of the results.

Football players playing in the midfield position (midfielders) were of an average height of 179.02 ± 5.94 cm, which was lower than the overall average height of the participants at the European Championship. Running backs, midfielders and strikers are shorter and rather run with the ball, and they are quicker, and this fact grants to them an additional advantage against the center backs [1, 2]. The average body mass of the midfielder players was 2.1 kg greater than the ideal body mass of the mentioned line position players, which showed the least difference in the study. Both the body mass index and Kettle's weight-height index for the midfielders were on average the lowest values compared to the players of other line positions on the team. The mentioned values of body mass, ideal body mass, body mass index and Kettle's weight-height index all point to the fact that relatively small body mass is necessary for the football players who are characterized by impressive endurance and a large movement radius. It is also interesting that the average age of the midfield players was lower than that of the players of the other lines or positions.

Table 7. Univariant differences between midfielders and the other (goalkeepers, defense and forwards players)

Variables	Midfield/Rest	N	Mean	SD	F	p
Yrs.	Midfielders	119	26.97	3.83	4.173	0.042
	Rest	249	27.87	4.02		
BH (cm)	Midfielders	119	179.02	5.95	76.321	0.000
	Rest	249	184.86	6.03		
BM (kg)	Midfielders	119	73.89	5.82	67.897	0.000
	Rest	249	79.78	6.68		
IBM (kg)	Midfielders	119	71.77	4.45	76.218	0.000
	Rest	249	76.15	4.53		
BMI (kg/m²)	Midfielders	119	23.04	1.10	5.272	0.022
	Rest	249	23.33	1.16		
KettleW-H (g/cm)	Midfielders	119	414.04	24.78	34.488	0.000
	Rest	249	430.97	26.37		

Table 7 shows that the average values for age, body height, body mass, ideal body mass, BMI and Kettle's index for midfielders were statistically significant; besides, they were lower than the overall values for the participants at the EFC. This points to the fact that midfielders to be selected should have lower both absolute and relative values compared to the body height and mass of all other football players.

Table 8. Forward football players: basic descriptive characteristics at the 2008 EFC (N=80)

Variables	Mean	SD	Min	Max	Range	Error	Skew.	Kurt.
Yrs.	27.06	3.98	20.00	39.00	19.00	0.445	0.609	0.360
BH (cm)	182.60	6.42	170.00	202.00	32.00	0.718	0.157	0.192
BM (kg)	78.09	6.79	64.00	103.00	39.00	0.759	0.756	1.515
IBM (kg)	74.45	4.82	65.00	89.00	24.00	0.539	0.157	0.192
BMI (kg/m²)	23.42	1.26	19.86	26.30	6.44	0.141	-0.028	-0.139
KettleW-H (g/cm)	427.16	26.59	367.57	509.91	142.34	2.973	0.363	0.538

Table 9. Univariant differences between forward players and the other (goalkeepers, defense and players midfielders)

Variables	Forward/Rest	N	Mean	SD	F	p
Yrs.	Forward	80	27.06	3.98	1.709	0.192
	Rest	288	27.72	3.97		
BH (cm)	Forward	80	182.60	6.42	0.326	0.568
	Rest	288	183.08	6.65		
BM (kg)	Forward	80	78.09	6.79	0.092	0.762
	Rest	288	77.82	7.04		
IBM (kg)	Forward	80	74.45	4.82	0.330	0.566
	Rest	288	74.81	4.98		
BMI (kg/m²)	Forward	80	23.42	1.26	2.544	0.112
	Rest	288	23.19	1.11		
KettleW-H (g/cm)	Forward	80	427.16	26.59	0.390	0.533
	Rest	288	425.03	27.16		

Table 8 shows the results of basic statistic parameters for forward players at the 2008 European Championship. By analyzing it we can conclude that the results were as good as the previous ones, while the results for skewness and kurtosis were the same as in Table 6.

The height of the forward players was 182.60 ± 6.42 cm and fell within the range of the overall average height of the participants of the 2008 European Championship. The difference between the average values of the ideal body mass and the average body mass of the offense players was 3.64 kg. The body mass index was within the limit, which indicates normal body mass. Their average playing time for the national team was greater than the overall average playing time at the European Championship, which shows that more experienced players should be engaged to play in forward position and, in the national team selection, players with extensive international experience should be selected.

Table 9 shows that there were no statistically significant differences between forward players and the other players at the 2008 European Championship. All the parameters analyzed are almost identical. In selection, forward players' age, body mass and height should be identical to those of other players.

Table 10 shows a survey of the height of the participants in the 2008 EFC, expressed in numbers and percentage, for all players compared to particular position lines which the players took on their national team selection. This was done with the practical purpose of helping coaches to create the team model.

Most of the football players were taller than 180 cm, 264 or 71.74% of the total number. A total of 324 subjects or 88.04% were taller than 175 cm. These findings show that contemporary football requires football players who are taller than 175 cm; according to Wisløff et al. [2004], the average height of football players is 177.3cm. All the goalkeepers were taller than 180.0 cm, and 22 or 45.83% of the goalkeepers exceeded 190.0 cm.

The height of 105 defense players, or 86.78%, was within the range of 180 cm, and the taller players, those over 190.0 cm, made up 21.49% or 26 out of the overall of 121 football players. The height of 175.1 to 180.0 cm was noted in the case of 9 players or 7.44%. The number of players of a height of 170.1 to 175.0 cm was very small, and made up 5, or 4.13%, of the total number.

Table 10. The number and the percentage of the 2008 European Championship football players according to their height and team position

Category	All participants		Goal - keepers		Defense players		Midfielder players		Forward players	
	N	%	N	%	N	%	N	%	N	%
190.0 <	63	17.12	22	45.83	26	21.49	4	3.36	11	13.75
185.1– 190.0	93	25.27	20	41.67	35	28.93	18	15.13	20	25.00
180.1- 185.0	108	29.35	6	12.50	44	36.36	32	26.89	26	32.50
175.1- 180.0	60	16.30	-	-	9	7.44	35	29.41	16	20.00
170.1- 175.0	39	10.60	-	-	5	4.13	25	21.01	7	8.75
170.0 >	5	1.36	-	-	2	1.65	5	4.20	-	-
Total	368	100	48	100	121	100	119	100	80	100

The greatest number of midfield players, 85 or 71.43%, fell within the height range of 175.1 to 190 cm. The majority of the forward players (62), or 77.50%, were in the height range of 175.1 to 190 cm. Only 11 forward players, or 13.75%, were taller than 190.0 cm.

The data on height, body mass and body composition of soccer teams in other studies suggest that players vary widely in body size [22].

CONCLUSIONS

The analyses of body mass, height, ideal body mass, body mass index and weight-height index of 368 participants of the 2008 EFC, as well as the number times they had played for the national team, yielded the following conclusions:

1. The average height of the participants of the 2008 Football Championship was 182.97 ± 6.59 cm, and the average body mass was 77.88 ± 6.97 kg; this was above the average values for height of the national team players, since 1928 up to 1980, and below the average height of the Yugoslav national team in 2001 [4, 5, 7, 8]. The results of our research show that contemporary football demands players whose body height is above the average of the selection pool. Certain lines in the team demand an above-average height (goalkeepers, forward and defense players). The lowest average height is to be found in the case of midfield players (midfielders).
2. The lowest body mass, on average, was found in midfield players, while goalkeepers had the greatest body mass. The highest aberration from the Lorenz formula was found in the goalkeepers, the defense players, and forward players, while the least aberration was found in the football players of the midfield.
3. The values of the body mass index as well as the weight-height index were the highest in the goalkeepers, followed by the forward and defense players; they were the lowest in the midfield players. It can be added that the midfield players had the lowest body mass values.
4. Elite football players today have higher body height and mass than years ago. We can also notice that each position requires a particular body type, which can serve as a model when selecting football players for a given position. We have concluded this from the results that indicate the differences between goalkeepers, defense players and midfield players and other players. This research, similarly to the research by Bloomfield and associates, points out that there are significant differences in age, stature, body mass and body mass index in elite players of different positions, suggesting that players of particular size and shape may be suitable for the demands of the various playing positions [3]; as well as by Melo [18], who maintains that soccer athletes possess specific physical characteristics for a particular position.

Only forward players seem not to require a particular body type. In practice usually one of the two forward players is taller, while the other is shorter than the average team height. The example for this

can be seen in: Arsenal: Emmanuel Adebayor 1.93m, Theo Walcott 1.75m – season 2008/09; Manchester United: Dimitar Berbatov 1.89m, Wayne Rooney 178cm – season 2008/09; Liverpool: Fernando Torres 1.86m, Robbie Keane 1.73m – season 2008/09; Real Madrid: Raul 1.80m, Ruud van Nistelrooy 1.88m – season 2008/09; Barcelona: Thierry Henry 1.88m, Lionel Messi 1.69m – season 2008/09; Ajax: Klaas-Jan Huntelaar 1.87m, Miralem Sulejmani 1,78m – season 2008/09; Bayern Munich: Luca Toni 1.96m, Miroslav Klose 1.81m – season 2008/09; Juventus: Alessandro Del Piero 1.73m, Vincenzo Iaquinta 1.91m – season 2008/09.

PRACTICAL APPLICATION

The results of this research can be used in team selection as well as in the national team selection, and it can also be utilized for the selection of young football players striving towards top sports achievements.

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