

Influence of Morphological Characteristics on Physical and Physiological Performances of Tunisian Elite Male Handball Players

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Abstract

Purpose: The purpose of this study was to describe the body structure and morphological characteristics of Tunisian elite handball players, and to determine the effect of these variables on functional and physical performance levels.

Methods: A sample of 42 male handball players (mean age 21.98 ± 3.24 years; training duration 12 years) at international level was submitted to a test battery comprising morphological, physical and physiological assessments. Tests were yo-yo intermittent recovery test, squat jump test, countermovement jump test, vertical-jump test, and Repeated sprint Ability. Measures for assessment of anthropometric characteristics were age, size, weight, body mass index, body fat, fat mass and thin mass.

Results: Weight was negatively correlated to the squat jump and the countermovement jump performance. Age, weight, and body composition measures (fat and thin body mass) were additionally negatively related to the maximal oxygen uptake, and to the maximal velocity obtained in the Yo-Yo recovery test. No relationship was found between size, body mass index, body fat and the physical abilities considered. Concerning the effects of physical characteristics on the functional performances, we can note a positive relationship between squat jump, countermovement jump, and the yo-yo recovery test performance. No relationship was found between vertical jump, repeated sprint ability, and the physiological performances.

Conclusions: Study results point to the existence of strong correlation between morphological and physical characteristics with functional characteristics. In handball, it is possible to have a reliable estimate of anthropometric measurements, physical and physiological performances.

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INTRODUCTION

Handball is an Olympic team sport that requires significant physical preparation in order to complete 60 minutes of competitive play to achieve a success. This game's movement patterns are characterized as intermittent and continuously changing responses to different offensive and defensive situations [1]. Anthropometric factors, physiologic and morphological characteristics can influence the effectiveness of such responses, as has been observed

in other team ball sports [2]. Therefore, anthropometric profiles may contribute to understanding a player's suitability, particularly at high standards of play. In fact, morphological characteristics of players have become a major field of interest for many trainers and sports scientists.

Previous reports have shown that body structure and morphological characteristics are important determinants of performance in many sports and certain physical impressions such as body composition (body fat, body mass, muscle mass) and physique can

significantly influence athletic performance [3]. Some of these researchers have studied the relationship between morphological characteristics and physical performance in order to evaluate the effect of physical predisposition on the choice of sport and the influence of training on the morphological characteristics [2,4].

According to these studies, most successful athletes have the appropriate structures with their performance task; therefore, assessment of the variability between these structures and tasks will enhance our understanding of the aspects of human physique [1,2,5,6]. Carter [4] reported that Somatotype explained from 25% to 60% of the variance in physical fitness tests. He concluded that handball players should be classified as "endomorph". Deng et al. [7] suggested that male Chinese handball players should be muscular, strong and tall. The Asian players participating in the 1995 World Championships in Iceland were smaller and lighter than their European counterparts. French international handball players were on average 13cm taller, 5.4 kg heavier and had 1.2 % less body fat than their national-level counterparts [8]. Despite the game's world-wide popularity, there have been few other investigations of anthropometric and physiological characteristics of elite male handball players.

However, morphological characteristics of Tunisian handball players and their performance level were not clearly defined in the literature. The degree to which fundamental performance characteristics contribute to a player's ability to be selected for team play in handball was also not determined. Moreover, studies about Tunisian handball players designed for analyzing their Somatotype and body compositions did not describe performance level or other determinants of training [9,10], and didn't demonstrate if there was a relationship between morphological characteristics and performance. Therefore, identifying the physiological requirements of Tunisian handball players might provide a more objective basis on which coaches can formulate training programs, and plan team strategy.

The purpose of this study is to describe body structure and morphological characteristics, and to determine the effect of these variables on the functional and physical performance in Tunisian elite male handball players.

METHODS AND SUBJECTS

Subjects:

Data were collected on forty-four senior male handball players having more than 10 years of training experience (age: 21.98 ± 3.24 yrs, body mass: 85.16 ± 20.29 kg, height: 181.83 ± 5.82 cm). In the year 2009, all subjects were members of the three top-quality Tunisian handball teams: Esperance, African Club, and Star club of Sahel respectively the first, second, and third places in the Tunisian Championship League in the season 2009/2010). The data collection took place in the first part of the season, after the preparation phase (September and October). All subjects have a Tunisian origin, were nonsmokers and none were ergogenic aid or medication users known to affect cardio respiratory function during the study. The protocol of this study was in accordance with the guidelines of the Ethical Tunisian Olympic Committee, and all participants gave their written consent.

Procedures:

Participants were asked to report to the Sports Medicine Centre of the Ksar-Said Physical Education Institute in the morning on 3 separate occasions and to refrain from exercise 24h before the study. The first day of testing comprised the medical checking, anthropometric measurements and an incremental exercise test called yo-yo intermittent recovery test [11]. Anthropometric measurements were made of height, body mass and skinfold thickness. The height was measured by means of stadiometry to the nearest 0.5 cm and a scale (Tanita) was used to measure body mass to the nearest 0.1 kg. The % body fat was estimated by the sum of four skinfold thickness (biceps, triceps, sub-scapular, suprailiac) determined by the formula of Brozek et al [12] based on body density determination by the formulas of Lohman et al [13] and Sinning et al [14]. All skinfold measurements were made in triplicate by the medical center doctor following the Anthropometric Standardization Reference Manual [13]. Body mass index was calculated as $Wt (kg)/Ht (m)^2$, fat mass (FM) as $Wt (kg) * \% \text{body fat}$, and thin mass as $Wt (kg) - FM (kg)$.

The yo-yo intermittent recovery test is similar to the Yo-Yo Endurance Test, except in the intermittent tests

the participants have a short active break (5 and 10 seconds for the intermittent endurance and intermittent recovery test, respectively). The test evaluates an individual's ability to repeatedly perform intervals over a prolonged period of time, particularly for athletes from sports such as tennis, team handball, basketball and soccer or similar sports. Cones are used to mark out three lines; 20 meters and 5 meters apart. The subject starts on the middle line, and begins running 20m when instructed by the recorded beep. This subject turns and returns to the starting point when signaled by the beep. There is an active recovery period during which the subject must walk or jog around the other cone and return to the starting point. A warning is given when the subject does not complete a successful out and back shuttle in the allocated time, the subject is removed the next time they do not complete a successful shuttle. The athlete's score is the total distance covered before they were unable to keep up with the recording, and VO_{2max} was estimated by the formula: $VO_{2max} \text{ (ml/min/kg)} = \text{distance in meter} \times 0.0136 + 45$ [15].

One week later, participants performed at identical conditions the Repeated Sprint Ability test (RSA) [16]. It was assessed through 6 repetitions of maximal 2x15m shuttle sprints (~6s) departing every 20 s. During the 14 s recovery between sprints, subjects had a passive standing recovery. Three seconds before starting each sprint, subjects were asked to assume the ready position and await the start signal.

Strong verbal encouragement was provided to each subject during all sprints. The speed was evaluated by using 2 pairs of photocells and reflectors connected with an electronic timer (Tag Hower, Marin, Switzerland). The photocells were placed at shoulder height and the time was given in hundredths of a second. At the third trial, participants performed the Jumping Performance using 3 different events. For each test, subjects performed 3 trials barefoot with 60 seconds of rest between trials, and the best performance based on height was used for analysis. The jumping performance was collected by using an Optojump dispositive (*Microgate SRL, Italy*) connected with a personal computer, and 3 minutes of rest were used between each 2 tests [12]. Tests were Vertical jump (VJ), Countermovement jump (CMJ) [17] and Squat

jump (SJ) [3].

Statistical Analyses:

Distribution normality was proved with the Kolmogorov-Smirnov test. All variables were normally distributed and therefore parametric statistics were applied. All values were expressed as means \pm SD. The Pearson correlation coefficient was used to evaluate the relationship between the variables. For Statistical analysis, SPSS 16 for Windows was used (Statistical Package for the Social Sciences, Chicago, IL). In all cases the level of statistical significance was set at $P < 0.05$.

RESULTS

All subjects performed all exercise tests. Mean and standard deviation of anthropometric characteristics and body composition of participants were summarized in table 1. In Table 2 the correlations between morphological characteristics and physical performance measurements are presented.

We can observe that weight was negatively correlated to the VJ and the CMJ performances. Age, weight and body composition measures (fat and thin body mass) were additionally negatively related to the VO_{2max} and to the maximal velocity obtained in the Yo-Yo test. No relationship was found between size, BMI, % body fat and the physical abilities considered.

Concerning the effects of physical characteristics on the functional performances, we can note a positive relationship between SJ, CMJ and the maximal velocity obtained in the Yo-Yo test. No relationship was found between VJ, RSA and the physiological performances.

DISCUSSION

In this study we intended to describe the morphological characteristics of elite male handball players and

Table 1: Anthropometric characteristics, physical and physiological performances of Tunisian elite male hand ball players (n=42)

Variable	Mean (SD)	Minimum	Maximum
Age (years)	22.00 (3.21)	18	31
Size (cm)	181.83 (5.82)	170	195
Weight (kg)	82.78 (13.32)	58.4	112.3
Body mass index (kg·m ⁻²)	24.96 (3.45)	17.8	32
Body fat (%)	11.22 (4.63)	4	20.9
Fat mass (kg)	9.84 (5.26)	2.4	20.9
Thin mass (kg)	72.70 (8.9)	53.5	96.2
Squat jump (cm)	32.10 (3.14)	23.9	39.1
Countermovement jump (cm)	34.16 (4.47)	23.9	43.2
Vertical jump (cm)	38.05 (4.69)	26.1	49.9
Repeated sprint ability test (sec)	6.38 (0.86)	5.61	11.65
VO ₂ max (ml/kg/min)	50.45 (3.81)	43.6	58.3
Maximal speed (km/h)	15.01 (1.36)	12.5	17.9
Heart Rate max (bpm)	183.14 (9.41)	161	199

SD: Standard Deviation

examine the effect of these variables on the functional and physical performance. Most of the findings in the present study were the importance of the body characteristics of the Tunisian elite male handball players, and the relationship between weight, fat mass, and physical and physiological performance. In fact, referring to the study of European handball players during the world championships in 1995 in Iceland [18], the average height of the European handball players was 1.907 m and the mean value of body mass was

89.3 kg. The results of the present study showed that the mean height (181.83±5.82cm) and body mass (85.15± 20.28 kg) values were lower in the Tunisian players than are found in European handball players. Whereas, the morphological data of our handball players were near to those of West Asian players (height: 1.819±0.4m; body mass: 81.7±8.4kg) [19].

Anthropometric studies have tended to suggest that certain physical factors including body fat, body mass, muscle mass, and physique significantly influence

Table 2: Correlations between morphological characteristics, physical and physiological performance measurements of Tunisian elite male hand ball players

	SJ (cm)	CMJ (cm)	VJ (cm)	RSA (s)	VO ₂ max (ml/kg/min)	M. speed (km/h)	HR max (bpm)
AGE (years)	r = -0.30	r = -0.20	r = -0.27	r = 0.03	r = -0.34*	r = -0.34*	r = -0.17
Size (cm)	r = 0.11	r = -0.23	r = -0.08	r = -0.19	r = -0.16	r = -0.16	r = -0.09
Weight (kg)	r = 0.13	r = -0.35*	r = -0.35*	r = -0.14	r = -0.71‡	r = -0.61‡	r = 0.01
BMI (kg/m ²)	r = 0.10	r = 0.09	r = 0.19	r = -0.08	r = -0.13	r = -0.06	r = 0.06
% body fat	r = 0.16	r = 0.13	r = 0.26	r = -0.13	r = -0.11	r = -0.04	r = 0.09
Fat mass (kg)	r = 0.14	r = 0.09	r = -0.56‡	r = -0.14	r = -0.39#	r = -0.38#	r = 0.08
Thin mass (kg)	r = 0.09	r = -0.08	r = 0.06	r = -0.13	r = -0.61‡	r = -0.62‡	r = 0.02
VO ₂ max (ml/kg/min)	r = 0.33*	r = 0.32*	r = 0.25	r = 0.03	--	--	--
M speed (km/h)	r = 0.35*	r = 0.36*	r = 0.29	r = -0.005	--	--	--
HR max (bpm)	r = 0.06	r = 0.02	r = 0.21	r = -0.24	--	--	--

* P<0.05; # P<0.01; ‡ P<0.001

BMI: Body mass index; SJ: Squat jump; CMJ: Countermovement jump; VJ: Vertical jump; RSA: Repeated sprint ability test; HR: Heart Rate; M speed: Maximal speed

athletic performance [8]. Knowledge of the physical characteristics of handball players can provide insight into those individual factors that influence the players' competition performance and, as consequence, are considered in the selection of players to a specific game plan. Indeed, it seems that there's a significant difference in morphological characteristics between the four playing positions (back court players, wings, pivots and goalkeepers) [2,20,21]. In fact, Srhoj et al [20] and Sporis et al [21] noted that Back court players and goalkeepers are superior in terms of outstanding skeletal dimensions and circumferences. Line players, i.e. wings and pivots, have somewhat lower longitudinal measures, whereas pronounced voluminosity and a slightly higher fat tissue value differentiate pivots from players in other positions. These analyses revealed also a greater homogeneity in the morphological profiles of wings and pivots than in the profiles of backs or goalkeepers. Our study didn't consider players' positions, which can be a limitation. However, our results show that the player's weight, fat and muscle mass seem to be an important factor, particularly affecting the jumping performance, $VO_2\max$ and inclusively the maximal running speed. These results are in accordance with those of Sporis et al [21] which noted a strong negative correlation between body fat and maximal running speed. It is believed that a more muscular make-up of the successful players would give them an advantage in contesting possession of the ball. whilst the greater fat free mass would imply greater economy in moving body mass vertically to jump for the ball and in running around the court [22].

However, our findings noted that muscle mass was negatively correlated to maximal oxygen consumption meaning that more muscle mass affects negatively the performance of Tunisian handball players. These findings were in accordance to those of Ekelund et al [23], which suggested that thin mass variability of subjects could be explained by inter-individual oxygen uptake differences [3]. In addition, Simone et al [7] and Parcel et al [2] showed that $VO_2\max$ was correlated to thin and fat masses. This may be due to the fact that thin mass represents the metabolism of the non fat cellular mass which can reach the major part of the body metabolism [2]. It seems that thin mass produces almost all the metabolic activity of the body and

governs the total request of oxygen which determines the cardiac flow required [1]. Our findings also noted that weight and fat mass were respectively correlated to CMJ and VJ performances. Most researchers agree that physical performance may be highly associated with body composition [24,25]. This is supported by the fact that more fat mass constitute a "dead mass" which the player must lift up [26]. Previous studies have also revealed that handball is a very complex sports activity where successful performance depends on a number of basic motor abilities, mostly on the ability of cortical regulation of movement, explosive strength (of throwing type in particular), basic strength of the trunk and psychomotor speed [27]. Situation performance is predominantly determined by explosive strength because the conditions of elite handball impose the need of maximal jumping, throwing or sprint performance.

The limitations of this study are acknowledged. Firstly, the positional differences of the studied variable and players' positions were not considered. Secondly, the three studied teams were in the North of Tunisia. Although players came from all regions of Tunisia, the findings are difficult to generalize to all Tunisian handball players. This study could be completed by studying other teams from coastal and southern regions.

CONCLUSION

This study has shown that performances in VJ, CMJ and yo-yo test were negatively correlated to the Tunisian handball player weight. Age and body compositions, notably fatty and thin masses, were additionally negatively related to the $VO_2\max$ and the maximal velocity obtained in the Yo-Yo test. No relationship was found between sizes, BMI, % body fat and the physical abilities considered.

Our findings also noted a positive relationship between SJ, CMJ and the yo-yo performance test. No relationship was found between VJ, RSA and the physiological performances.

PRACTICAL APPLICATIONS

The present study demonstrates that certain morphological characteristics can enhance handball performance. In fact, by examining a variety of body morphological characteristics and performance characteristics, which are believed to be advantageous for competition, and the conditioning training of handball players, we may be able to enhance the ability of selection of the best possible soccer players for a competitive team or to determine the physiological demands of soccer. Ideally, this would lead to enhanced conditioning, good training strategies and improved performance. Also, the morphological

characteristics of the soccer players can be studied according to their positions played on the team to plan individualized training regimens.

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Conflict of interests: None

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