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STUDY OF PORTUGUESE HANDBALL PLAYERS OF DIFFERENT PLAYING STATUS. A MORPHOLOGICAL AND BIOSOCIAL PERSPECTIVE

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ABSTRACT: The development of sport has guided sports sciences researchers to the study of excellence in sport performance. In accordance, this study aims to evaluate the relation between some morphological and biosocial factors and sport level and tactical position in handball players of Portuguese leagues. A total of 187 male handball athletes (age, 23.48±5.12 years) participated in this study. The sample was divided into five groups (Top elite, Moderate elite, Sub-elite, Moderate trained, Junior elite) for comparison. Morphological evaluation of participants comprised the study of 11 anthropometric measures, adipose mass and fat-free mass. To evaluate biosocial dimensions, participants completed the Portuguese Biosocial RAPIL questionnaire (adapted to handball athletes). Results showed that top elite athletes were taller, heavier, had higher fat-free mass, less fat mass, higher socio-economic status and higher weekly energy expenditure. These findings can be a useful tool to promote real changes in training methods, specifically in relation to the weekly energy expenditure in training (i.e., training volume).

KEY WORDS: biosocial profile, handball, morphology, playing status

INTRODUCTION

The development of sports has guided sport sciences researchers to the study of excellence, in particular to the study of the specific characteristics and requirements of each sport. At present, it is known that every sport requires a certain kind of athlete and that sport participation is possible only when a set of features is present. Among this set of features, necessarily multivariate, the most studied are undoubtedly the anthropometric characteristics.

Handball (an Olympic game since 1972) has increased in status (as a sport) and popularity (as an elite competitive handball game) and its spectacular development (as regards athletic performance) turned the study of morphological attributes and characteristics of successful athletes into a special issue.

Body composition and body mass contribute among other factors to optimal exercise and performance. Body mass can influence an athlete's speed, endurance, and power, whereas body composition can affect strength and agility. For example, lean body mass is often related in sports such as handball with speed.

In handball, the majority of studies analysing excellence consider the morphological differences between athletes who play in teams with different levels of performance [28] or between athletes with the same game position and with different levels of performance [9]. However, morphological profile should not be the sole criterion to choose a handball player, and athletic performance cannot be accurately predicted based solely on body mass and composition [12]. Other specific topics such as (1) the relationship between energy balance and body composition (i.e., energy balance and athletic performance), and (2) the importance of specific energy consumption can also help to achieve optimal athletic performance (training) [23].

Energy spent in different types of exercise is dependent on the duration, frequency, intensity and type of activity [13]. Fitness level, prior nutrient intake and energy stores determine when the crossover from primarily aerobic to anaerobic pathways occurs [19]. However, training affects the total amount of energy expenditure independently of the proportion of energy derived from carbohydrates and fat, although aerobic training increases fat oxidation.

Moreover, according to Gordon-Larsen et al. [7] the socio-economic status (SES) can influence participation in organized sports, i.e., a low SES (in youth samples) may be a disadvantage regarding the ability to participate in organized sports (because of financial and logistical barriers that athletes and their families have to face). In fact, most of the studies on SES considered education as a discriminating factor of physical activity choices [17].

In this context, and in addition to morphological characteristics, although the lack of data about biosocial characteristics of Portuguese male handball players (European) is a reality, the importance of the environment and living conditions on the success of an athlete seems to be irrefutable.

In accordance with the above, the present study aims to evaluate the impact of morphological and biosocial factors on sport level and also on tactical position in male handball players of Portuguese leagues.

MATERIALS AND METHODS

Study procedure and subjects. The experimental protocol was in accordance with the Declaration of Helsinki and was approved by the Scientific and Ethical Committees of the Faculty of Human Kinetics (Technical University of Lisbon, Portugal). Before inclusion in the study, the goals and procedures were explained to subjects, and written informed consent was obtained.

A total of 187 Portuguese (European) male handball athletes (age, 23.48±5.12 years) participated in this study. The sample was divided into five groups for comparison, namely: (1) Professional Handball Championship – LPA (Top elite, n=24; age, 26.38±4.08 years); (2) 1st Portuguese Handball Division – Portuguese Handball Federation, PO.01 (Moderate elite, n=53; age, 26.38±4.90 years); (3) 2nd or 3rd Portuguese Handball Division – Portuguese Handball Federation, PO.02 and PO.03 (Sub-elite, n=31; age, 23.81±3.70 years); (4) Regional (1st division, Lisbon Handball Association) and Academic level (Moderate trained, n=32; age, 24.22±5.11 years); (5) 1st Portuguese Junior Handball Division – Portuguese Handball Federation, PO.04 (Junior elite, n=47; age, 18.13±0.88 years). The group of top elite players included in this study were National Champions and Vice-Champions of Portugal. The traditional classification of handball positions was also recorded for each participant (goalkeeper, n=33; wing, n=58; left/right back, n=36; centre back, n=34; pivot, n=26). All participants were tested during the 2008-2009 Portuguese handball season (2009, February and March).

Anthropometric profiling. The measures most used in studies of handball players (cited in the literature) and the results of our previous academic studies (using discriminant analysis) allowed us to select 11 anthropometric measures. These dimensions included two basic measures and nine skinfolds. The basic measures were stature (cm) and body mass (kg). The nine skinfolds (mm) were subscapular, triceps, biceps, chest, iliac crest, supraspinale, abdominal, front thigh and medial calf. Measurements included in the anthropometric profile were obtained following the protocol in Marfell-Jones et al. [16], with the exception of chest skinfold (the skinfold measurement taken with the fold running obliquely in the mean distance between the breast nipple and the axilla fold).

Anthropometric measurements were obtained using portable measurement devices. Stature was measured without shoes and headcovers, using a portable Anthropometer (Anthropometric Kit Siber-Hegner Machines SA GPM, 2008) calibrated to the nearest 0.1 cm. Body mass was measured with subjects wearing light clothing and without shoes, to the nearest 0.5 kg, using a scale (Body Mass Scale Vogel & Halke – Germany - Secca model 761 7019009, 2006) calibrated with known weights. Skinfold thicknesses were obtained using a calliper (Skinfold caliper Rosscraft Slim Guide 2001).

All measures were taken by four subjects accredited by the International Society for the Advancement of Kinanthropometry (ISAK), under the supervision of an ISAK Level 4 anthropometrist. The intra-observer TEM were well below the accepted maximum for stature ($R \geq 0.98$), 5% for skinfolds (R = [0.90 - 0.98]) and 1% for breadths and girths (R = [0.92 – 0.98]).

Assessment of body composition. The study of body composition (in this work) considered adipose and fat-free masses. To provide a more valid estimate of body fat, confirmed in healthy young men and women by Eston et al. [5], Reilly et al. [22] suggested the use of the equation proposed by Durnin and Womersley [4] as described by Hasan et al. [9]. Nevertheless, Durnin and Womersley [4] and Jackson and Pollock [14] equations predict the body density, and to convert it to relative body fat the formula of Siri [25] was chosen. Moreover, in previous studies with adult male handball athletes, the relative body fat was also estimated using the equations proposed by Yuhasz [29], or derived from the equation proposed by Jackson and Pollock [14], as observed in the studies of Gorostiaga et al. [8] and Vasques et al. [28].

Predicting fat tissue mass is obviously important but also problematic. In fact, numerous methodological assumptions and sample specificities govern the conversion of linear surface measurements into tissue masses, and for this reason we used in this study all the equations mentioned above and the relative fat-free mass was also calculated.

Biosocial profiling. Usually, large epidemiological studies are dependent on physical activity questionnaires [15] and the Portuguese biosocial questionnaire – Biosocial RAPIL questionnaire (from the Faculty of Human Kinetics, Technical University of Lisbon) has been used by Fragoso et al. [6] and Varela-Silva et al. [27] to measure biosocial variables and the lifestyle of Portuguese samples. This instrument provides a measure of socio-economic status (SES), parent height and weight recall measures, frequency of food ingestion, and time spent in different type of activities.

TABLE 1. SCORES RANGES FOR SOCIO-ECONOMIC STATUS

Score ranges	Class		SES
17 a 20	V (5)	High	Very good
14 a 16	IV (4)	Medium-high	Good
11 a 13	III (3)	Medium	Reasonable
8 a 10	II (2)	Medium-low	Poor
4 a 7	I (1)	Low	Very poor

TABLE 2. NORMATIVE DATA OF PHYSICAL ACTIVITIES, ACTIVITY CODES AND METS (in kcal/kg/h) FOR ACTIVITIES USED IN THE PRESENT STUDY. ADAPTED FROM AINSWORTH *et al.* [2].

2000 Code	METS	Heading	Description
Organised physical activity			
15320	12.0	Sports	Handball, general (Taylor Code 520).
Occasional physical activity			
1009	8.5	Bicycling	Bicycling, BMX or mountain.
2050	6.0	Conditioning exercise	Weight lifting (free weight, nautilus or universal-type), power lifting or body building, vigorous effort (Taylor Code 210).
2060	5.5	Conditioning exercise	Health club exercise, general (Taylor Code 160).
3025	4.5	Dancing	General, Greek, Middle Eastern, hula, flamenco, belly, and swing dancing.
12020	7.0	Running	Jogging, general.
15040	8.0	Sports	Basketball, game (Taylor Code 490).
15300	4.0	Sports	Gymnastics, general.
15430	10.0	Sports	Judo, jujitsu, karate, kick boxing, taekwondo.
15580	5.0	Sports	Skateboarding.
15610	7.0	Sports	Soccer, casual, general (Taylor Code 540).
15650	12.0	Sports	Squash (Taylor Code 530).
15675	7.0	Sports	Tennis, general.
15710	4.0	Sports	Volleyball (Taylor Code 400).
15732	4.0	Sports	Track and field (shot, discus, hammer throw).
15734	10.0	Sports	Track and field (steeplechase, hurdles).
18220	3.0	Water activities	Surfing, body or board.
18240	7.0	Water activities	Swimming laps, freestyle, slow, moderate or light effort.
Sedentary			
7020	1.0	Inactivity quiet	Sitting quietly and watching television.
9030	1.3	Miscellaneous	Sitting - reading, book, newspaper, etc.
9040	1.8	Miscellaneous	Sitting – writing, desk work, typing.
Habits of sleep			
7030	0.9	Inactivity, quiet	Sleeping.

All participants completed the "Biosocial RAPIL" questionnaire (adapted to handball players). In accordance, the SES was determined using Graffar's modified method, which takes into account the years of formal education, profession, type of housing and neighbourhood. The final scores range from 4 to 17, and this method allows the athlete to be assigned to one of five SES classes (where higher scores indicate high SES class; see Table 1).

The physical activity and lifestyle variables considered in this study were the weekly time spent on regular and non-regular activities, sedentary activities (TV, PC and reading) and sleeping habits. These measures were supported by the studies of Ainsworth et al. [1, 2] and data were managed according to the specific activity (see Table 2). The metabolic equivalent intensity level (MET) was used; it should be understood as the ratio of work metabolic rate to a standard resting metabolic rate of 1.0 (4.184 kJ)$\cdot$kg$^{-1}\cdot$h^{-1} (or 3.5 ml $O_2\cdot$kg$^{-1}\cdot$min^{-1}), i.e., 1 MET is considered a resting metabolic rate obtained during quiet sitting [2, pp.S498]. Participants recorded the weekly frequency and duration of the different expressed activities and the rate of energy expenditure for each activity was estimated [Frequency x Time = Total time (minutes$\cdot$week^{-1}); (Total time / 60) x Intensity (METs) = Energy spent (kcal/kg/week)].

Statistical analyses. All calculations were performed using Microsoft Excel (Microsoft, Seattle, Washington, USA) and the SPSS statistical package (Statistical Package for the Social Sciences Inc., version 17.0, Chicago, Illinois). Descriptive and comparative data (of significant variables) were presented. Three different sets of analyses were undertaken. First, the dataset was analysed using a univariate analysis of variance (one-way ANOVA) in which playing status was the between-participant variable. Second, playing position groups were compared (individually) for differences across playing status and the non-parametric Kruskal-Wallis one-way analysis of variance on ranks was employed. Third, stepwise discriminant function analysis was used to determine which combination of measures best discriminated the playing status groups (in the whole sample and in individual playing position groups). For all analyses, 5% was adopted as the significance level.

TABLE 3. DESCRIPTIVE STATISTICS (MEAN±SE) OF MORPHOLOGICAL AND BIOSOCIAL VARIABLES, FOR ALL PLAYING STATUSES (N=187), AND ANOVA TEST RESULTS

	Playing status groups					ANOVA		
	Junior elite	Moderate trainded	Sub elite	Moderate elite	Top elite	$F_{4,182}$	Sig.	
Body mass (kg)	80.53±12.21	78.28±15.52	79.37±11.08	82.35±11.22	86.88±9.46	2.119	0.080	NS
Stature (cm)	179.49±16.50	178.47±6.60	179.67±6.50	182.20±6.55	188.11±5.36	4.158	0.003	**
% Fat mass [29]	13.83±4.47	15.61±5.90	14.30±4.00	13.44±3.49	11.56±2.31	3.380	0.011	*
% Fat mass [14]	10.91±5.61	15.03±7.86	13.26±5.67	12.43±5.14	8.90±3.65	4.797	0.001	**
% Fat mass [4]	15.68±5.21	17.74±7.02	16.07±5.68	15.39±5.44	12.69±3.76	2.918	0.023	*
% Fat-free mass [29]	86.17±4.47	84.39±5.90	85.70±4.00	86.56±3.49	88.44±2.31	3.380	0.011	*
% Fat-free mass [14]	83.44±7.48	75.82±10.30	79.46±6.34	81.67±6.99	88.23±3.95	11.085	0.000	***
% Fat-free mass [4]	75.74±6.39	71.06±8.42	74.94±5.17	77.23±7.57	83.11±4.66	11.455	0.000	***
Socioeconomic status (class)	3.87±0.77	3.78±0.61	3.84±0.78	4.12±0.68	4.63±0.65	6.610	0.000	***
Energy expedicture ….								
Organised physical activity (kcal/kg/week)	95.57±21.51	42.08±13.56	59.35±14.37	85.74±40.40	174.75±38.45	82.741	0.000	***
Occasional physical activity (kcal/kg/week)	9.18±19.06	14.27±25.33	4.53±8.54	4.90±9.82	5.73±12.28	2.215	0.069	NS
Watch TV (kcal/kg/week)	12.06±7.66	9.52±6.02	10.71±5.89	10.63±6.87	13.48±7.65	1.445	0.221	NS
Computer Games (kcal/kg/week)	13.01±12.74	8.33±10.03	10.48±11.48	10.14±12.76	13.09±11.69	0.996	0.411	NS
Read (kcal/kg/week)	3.90±6.14	5.45±4.56	3.35±4.47	3.29±3.74	3.85±4.07	1.154	0.333	NS
Total of inactivity (kcal/kg/week)	28.98±18.49	23.12±15.02	24.55±12.57	24.06±16.41	30.41±16.57	1.348	0.254	NS
Habits of sleep (kcal/kg/week)	48.04±3.92	47.42±3.49	46.34±6.62	47.38±5.21	50.42±4.81	2.597	0.038	*

Note: Sig.: *, p<0.05; **, p<0.01; ***, p<0.001; NS, not significant;

TABLE 4. MEAN RANK OF SIGNIFICANT MORPHOLOGICAL AND BIOSOCIAL VARIABLES (BY PLAYING STATUS) IN ALL PLAYING POSITION GROUPS.

	Junior elite		Moderate trained		Sub elite		Moderate elite		Top elite		Test Statistics[a,b]			
	N	Rank	N	Rank	N	Rank	N	Rank	N	Rank	Chi-Square	df	Sig.	
Goalkeeper group (n=33)														
Stature (cm)	10	13.85	4	7.13	3	19.67	10	17.75	6	26.25	11.016	4	0.026	*
% Fat-free mass [14]	10	18.30	4	11.00	3	11.00	10	13.30	6	28.00	12.105	4	0.017	*
% Fat-free mass [4]	10	16.30	4	10.50	3	10.33	10	15.70	6	28.00	11.231	4	0.024	*
Organised physical activity (kcal/kg/week)	10	18.10	4	6.00	3	12.83	10	13.80	6	29.92	17.998	4	0.001	**
Wing group (n=58)														
% Fat-free mass [14]	14	33.86	12	23.33	13	21.92	13	30.62	6	45.67	10.705	4	0.030	*
% Fat-free mass [4]	14	29.71	12	22.42	13	25.35	13	31.96	6	46.83	9.498	4	0.050	*
Organised physical activity (kcal/kg/week)	14	38.11	12	10.08	13	20.42	13	35.81	6	54.25	38.581	4	0.000	***
Occasional physical activity (kcal/kg/week)	14	30.86	12	42.29	13	23.42	13	22.73	6	28.58	14.153	4	0.007	**
Backward Left/Right group (n=36)														
Stature (cm)	9	20.94	7	12.57	5	10.70	10	19.55	5	28.10	9.697	4	0.046	*
% Fat-free mass [14]	9	22.89	7	7.71	5	16.00	10	19.20	5	26.80	12.327	4	0.015	*
Organised physical activity (kcal/kg/week)	9	25.50	7	4.50	5	11.70	10	18.85	5	31.60	26.658	4	0.000	***
Backward Center group (n=34)														
Body mass (kg)	8	10.25	3	7.50	7	21.86	11	19.36	5	24.90	11.777	4	0.019	*
% Fat-free mass [14]	8	18.75	3	5.67	7	13.57	11	17.82	5	27.40	10.405	4	0.034	*
% Fat-free mass [4]	8	14.63	3	3.33	7	15.43	11	20.45	5	27.00	12.560	4	0.014	*
Organised physical activity (kcal/kg/week)	8	21.25	3	4.67	7	8.14	11	18.09	5	31.00	21.852	4	0.000	***
Pivot group (n=26)														
% Fat-free mass [4]	6	9.67	6	8.50	3	17.00	9	15.67	2	25.00	9.943	4	0.041	*
Organised physical activity (kcal/kg/week)	6	19.50	6	4.17	3	8.33	9	14.78	2	25.50	19.483	4	0.001	**

Note: [a.] Kruskal Wallis Test; [b.] Grouping Variable: Playing status; Sig.: *, p<0.05; **, p<0.01; ***, p<0.001;

TABLE 5. STANDARDIZED CANONICAL DISCRIMINANT FUNCTION COEFFICIENTS, EIGENVALUES AND VARIANCE.

	Goalkeeper	Wing	Left/Right Back	Centre Back		Pivot		All sample			
	1[a]	1[b]	1[c]	1[d]	2[e]	1[f]	2[g]	1[h]	2[i]	3[j]	4[k]
Body mass (kg)				0.479	0.884						
% Fat mass [29]						-0.683	0.913				
% Fat-free mass [14]								0.354	-1.398	0.517	0.836
% Fat-free mass [4]								-0.119	1.544	0.504	-0.678
Socioeconomic status (class)								0.221	0.444	-0.121	0.871
Organised physical activity (kcal/kg/week)	1.000	1.000	1.000	0.930	-0.382	1.128	0.161	0.920	-0.163	-0.321	-0.276
Eigenvalue	2.493	1.419	2.686	1.459	0.465	11.633	0.132	2.028	0.130	0.009	0.001
% of Variance	100.0	100.0	100.0	75.9	24.1	98.9	1.1	93.6	6.0	0.4	0.1
Cumulative %	100.0	100.0	100.0	75.9	100.0	98.9	100.0	93.6	99.5	99.9	100.0

Note: Functions: [a], Wilks' Lambda=0.286; $\chi^2(4)=36.270$, $p<0.05$; [b], Wilks' Lambda=0.413; $\chi^2(4)=45.932$, $p<0.05$; [c], Wilks' Lambda=0.271; $\chi^2(4)=41.746$, $p<0.05$; [d], Wilks' Lambda=0.278; $\chi^2(8)=37.804$, $p<0.05$; [e], Wilks' Lambda=0.683; $\chi^2(3)=11.256$, $p<0.05$; [f], Wilks' Lambda=0.070; $\chi^2(8)=57.200$, $p<0.05$; [g], Wilks' Lambda=0.883; $\chi^2(3)=2.670$, $p>0.05$; [h], Wilks' Lambda=0.289; $\chi^2(16)=222.546$, $p<0.05$; [i], Wilks' Lambda=0.877; $\chi^2(9)=23.648$, $p<0.05$; [j], Wilks' Lambda=0.990; $\chi^2(4)=1.762$, $p>0.05$; [k], Wilks' Lambda=0.999; $\chi^2(1)=0.230$, $p>0.05$.

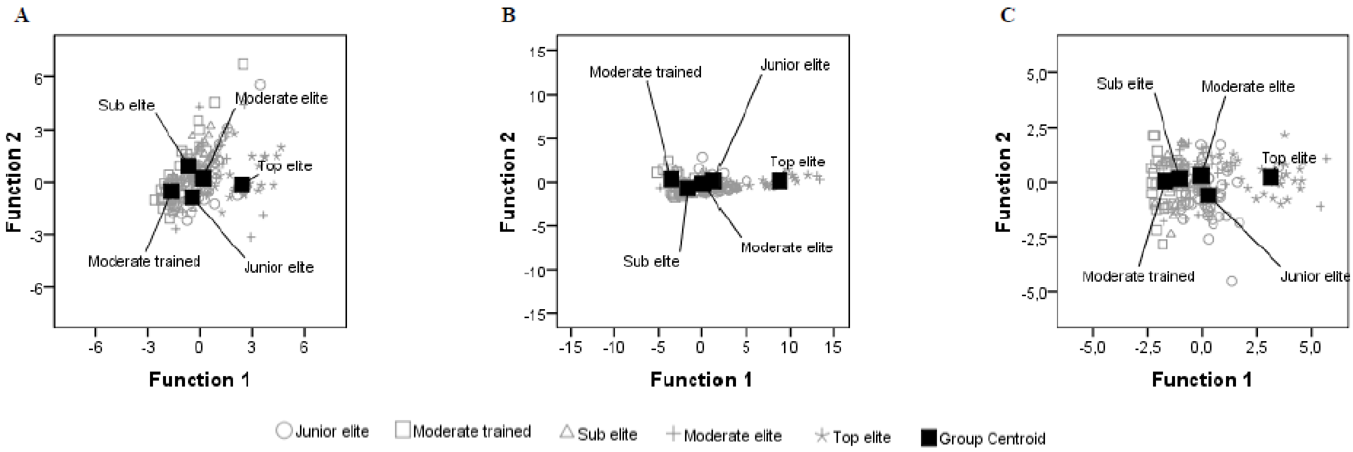

FIG. 1. CANONICAL DISCRIMINANT FUNCTIONS (SCATTER-PLOT) OF CENTRE BACK (A), PIVOT (B) AND FOR ALL FIVE PLAYING POSITION GROUPS (C).

RESULTS

The analysis revealed significant differences among different performance statuses regarding stature, fat mass, fat-free mass, socioeconomic status, weekly energy expenditure in organised physical activity and sleep habits. Results showed that top elite athletes were taller, heavier, had higher fat-free mass, lower fat mass, higher SES class, and higher weekly energy expenditure on organized physical activities and on sedentary activities. With respect to SES classes and weekly energy expenditure on organised physical activity, the moderate trained athletes showed lower values than all the other playing status groups. However, sub-elite athletes scored worse when considering the weekly energy expenditure on sleep habits. These results are presented in Table 3.

In addition, the five playing position groups (i.e., goalkeeper, wing, left/right back, centre back and pivot) were also studied. The results showed significant differences among playing status groups when considering the five playing positions: (1) goalkeeper group – stature, free fat mass and energy spent (per week) in organised physical activity; (2) wing group – fat-free mass, energy spent (weekly) in occasional and organised physical activity; (3) left/right back group – stature, fat-free mass and energy spent (per week) in organised physical activity; (4) centre back – body mass, fat mass, fat-free mass and energy spent (per week) during organised physical activity; (5) pivot group – fat-free mass and energy spent (per week) in organised physical activity.

As observed in Table 4, top elite goalkeepers and left/right backs were taller, centre backs were heavier, all top elite groups had higher fat-free mass and the moderate trained group had higher fat mass. With respect to significant biosocial variables, results showed that all top elite groups had higher weekly energy expenditure on organized physical activities and that in the wing group the moderate trained players had higher weekly energy expenditure on occasional physical activity.

Finally, stepwise discriminant function analysis was used to determine which combination of measures best discriminated the playing status groups (considering each playing position and the whole sample).

The discriminant analysis, when applied to the goalkeeper, wing and left/right back groups, showed that the weekly energy expenditure in organized physical activity differentiates the different playing status groups, and that 42.4%, 62.1% and 66.7% (respectively) of the original group cases and of cross-validated grouped cases could be correctly classified through this variable. In the centre back and pivot groups, the results showed that two variables successfully discriminated the playing status groups, and that 55.9% and 73.1% (respectively) of the original group cases and of cross-validated group cases were correctly classified. Finally, the five playing positions were analysed together (n=187) and a combination of four variables successfully discriminated the five playing status groups (61.3% of original grouped cases were correctly classified and 54.3% of cross-validated group cases were correctly classified). All results of stepwise discriminant analysis are presented in Table 5 and graphically in Figure 1.

DISCUSSION

As already described, the evolution of sports has determined the study of excellence in sports performance and, in particular, the study of the specific requirements of handball players. In this context, the present study showed significant differences in morphological and biosocial profile between different playing status, especially when the top elite group was considered.

Stature and body mass showed significant differences between athletes of different playing status, and these differences were all in favour of the top elite. These global results are in accordance with Reilly [21], who considered body mass and stature as very important to achieve a high level of performance in throwing. Body mass appears to be essential, especially in handball-specific skills, and for this reason most of the national athletes are very heavy.

The literature also reports that, in male handball players with the same playing position, the successful athletes were taller and had lower % body fat and less adiposity [9]. Discriminant analysis not only clarified the relation between the playing status but also confirmed what were the morphological requirements for being an elite handball athlete (see Table 5 and Figure 1). These morphological requirements although influenced by training are mostly dependent on genetic characteristics.

It is clear that in athletes, a minimal amount of body fat allows a more effective exchange of calories during metabolic processes (especially during high intensity effort), and reduces the excess weight carried during jumping and running actions. In fact, Hasan et al. [9] observed that more successful teams had lower body fat than less successful teams. In this study, it was also reported that handball athletes with higher competitive levels had (on average) a lower percentage fat mass, although the mean value of the studied groups matched, in general, the values (> 4%; < 12%) recommended in the literature [11].

The fat mass seems to be related to the time spent on sport and the level of fitness [24]. Our results showed that top elite athletes have low fat mass and higher weekly energy expenditure in organised handball activity (e.g., twice as much time as in moderate elite; Table 3). In fact, the weekly energy expenditure in organised handball activity is significantly different among the studied playing statuses for all playing position groups (Table 4, 5 and Figure 1).

This finding raises a general question: do they train more because they are elite, or are they elite because they train more? According to Helsen et al. [10] and Baker et al. [3] it is evident that expert performers accumulate more minutes of sport-specific practice than non-expert performers. For this reason, the amount of practice time seems to be associated with success but also with the time "needed" to learn and to improve technical and tactical skills. As described, the results of this study suggested that the individual time spent on organized activities (training) and the body composition variability (fat) of handball subjects was related to their sport success. Still, to answer the initial question we need to evaluate not only the volume of training but also the energy expenditure during training (with accelerometers), the energy intake and other factors, such as the intrinsic motivation of handball elite and non-elite players.

Regarding the association between sleep and success in sports, the literature shows a relation between sleep deprivation and physiological behaviour [18], indicating that this circumstance reduces the athlete's tolerance to prolonged efforts and is responsible for wide variation in mechanical efficiency. However, some other authors have suggested that sleep deprivation does not significantly influence physiological behaviour [26]. In this study, the elite handball athletes (top and junior) sleep longer than the athletes of other groups. Nevertheless, this variable does not appear to discriminate handball players of different playing status, which (having in consideration the uncertainty of the results reported in the literature) suggests that sleeping habits are not a priority when the challenge is to explain the success of handball players in this particular context (the Portuguese environment).

Also Ramsay et al. [20] report that health outcome is associated with socio-economic status (SES). To better understand the specific role of different SES on handball success, the association between social class (I to V) of Portuguese handball athletes and their playing status was investigated. Our results showed that (in senior groups) the SES was significantly associated with success (higher SES is related to higher playing status, as can be seen in Table 3). Moreover, when considering the individual playing positions, the sleeping habits and SES were not useful to discriminate players of different playing status (in association with morphological variables). However, the study of both social variables can give us a broad understanding of handball players' success although the uncertainty of the results reported in the literature suggests that this association (between both social and physical fitness variables) needs to be clarified in the near future.

Finally, the results of this study showed that weekly energy expenditure could be an important variable to discriminate between different playing status. To understand the meaning of this result it will be necessary to evaluate not only the energy expenditure but also the energy intake. In fact, low energy intake may result in decrease of fat-free mass (due to a loss of muscle mass), and can increase the risk of fatigue, injury, illness, and a prolonged recovery process. As Rodriguez et al. state, “meeting energy needs is a nutrition priority for athletes” [23, pp. 512] especially when we know that different levels of performance are associated with different SES, sleeping habits and energy expenditure. However, nutritional studies in the group of handball players must be conducted to determine whether appropriate nutrition may have a decisive influence on morphological profile and exercise ability. So in the near future it will be important to study training volume, energy expenditure during training, and also athletes’ nutritional intake, and to relate these factors to athletic training capacity, athletic performance, fatigue during exercise and recovery after training.

CONCLUSIONS

One of the possible strengths of the current study is the use of a large sample with a cross-sectional research design. To our knowledge, this is the first study to investigate the impact of biosocial factors on the level of performance (junior and senior handball athletes), and to study the link between morphological and biosocial factors and playing status. Marked individual differences in morphological and biosocial characteristics were found among handball athletes of different playing status (and different playing positions), i.e., top elite athletes were taller, heavier, had higher fat-free mass, lower fat mass, higher socio-economic status, and higher weekly energy expenditure.

In our opinion, these findings can be a useful tool to promote real changes in training methods, specifically concerning the weekly energy expenditure in training (i.e., training volume), and emphasize the importance of some variables rarely studied in handball, such as the energy balance and nutritional intake of athletes.

Competing interests

The authors declare that they have no competing interests.

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