Kinanthropometric Assessment of Individual, Collective and Fight Sport Players from the Spanish National Sport Technification Program

Evaluación Cineantropométrica en Deportistas Individuales, Colectivos y de Lucha, del Programa Nacional Español de Tecnificación Deportiva

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SUMMARY: Nowadays, the study of kinanthropometric parameters is an important tool for both early talent selection and for evaluating the efficacy of a training program. This study aimed to determine the anthropometric characteristics, body composition indicators and somatotype components of individual (athletics, swimming and triathlon), collective (handball and volleyball) and fight (karate and taekwondo) sportsmen and sportswomen from the Valencian Sports Technification Centre. This study involved a total of 62 men and 56 women, they were divided in three subgroups, including individual (athletics, swimming and triathlon), collective (handball and volleyball) and fight (karate and taekwondo) sports. The assessment was carried out according to the one established by the International Society for Advancement of Kinanthropometry (ISAK). For men, the highest value of femur breath, ectomorphy and medial calf and front thigh skinfolds are obtained for triathletes, athletics, volleyball and karate, respectively. The highest values of triceps, biceps and abdominal skinfolds, relaxed arm girth, endomorphy and body fat percentage are shown for taekwondo, while the other highest values are obtained with handball. For women, the highest value of ectomorphy is obtained for athletics. The identified kinanthropometric parameters are useful when comparing between sports and sports subgroups for the selection of subjects and to help in their performance assessment.

KEY WORDS: Kinanthropometric assessment; Handball; Volleyball; Athletics, Swimming, Triathlon, Karate, Taekwondo.

INTRODUCTION

Several studies, have demonstrated that it is possible to select potential athletes based on their anthropometric characteristics, body composition and somatotype, and that the ability can be improved with training and specific techniques (Williams & Reily, 2000; Pieter & Falcó, 2011). The Sports Technification Centers in Spain, as well as in other countries, are an adequate tool to promote excellence in sports, from the detection of a sporting talent all the way through to the highest sports level. Nowadays, the kinanthropometric assessment in these centers is a useful tool for both early talent selection and for evaluating the efficacy of a training program. A good number of investigators agree on the importance of early discovering the most capacitated subjects, selecting them and carrying out a monitoring process to promote maximal development of young persons in any sport. The aim of the present study was to describe the anthropometric characteristics, body composition indicators and somatotype components of individual (athletics, swimming and triathlon), collective (handball and volleyball) and fight (karate and taekwondo) sportsmen and sportswomen, according to the Pino's classification (Pino, 1999), from the Sports Technification Centre in Cheste (Spain), thus providing a useful tool for future studies.

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MATERIAL AND METHOD

A total of 62 and 56 sportsmen and sportswomen, respectively, participated in this study that was carried out in the Sports Medical Centre in Cheste (Valencia, Spain).

All the athletes assigned to the technification program trained from Monday to Friday, carrying out a double training session two days a week. The subjects were grouped into sports with a predominance of aerobic and cyclic efforts (middle athletics, swimming and triathlon), collective sports with aero-anaerobic efforts and a large number of actions with jumps (handball and volleyball) and wrestling sports, with many actions involving the support on one leg and the kick as a technical element of relevance (karate and taekwondo). The study protocol was approved by the Ethics Review Committee of the Faculty of Sports of the Catholic University of Valencia (Spain). Procedures followed were in accordance with the Ethics standards for human studies. Written, informed consent was obtained from the teen's parent or legal guardian, thereafter they were given, in writing, a full explanation of the aims of the study, its possible hazards, discomfort, and inconveniences. In addition, teens had all the procedures verbally explained to them, together with any possible discomfort they might encounter, using terms and language that they find easy to understand.

The measurements, based on the International Society for Advancement of Kinanthropometry protocol (Marfell-Jones *et al.*, 2011), were performed by one accredited technician (level 1) on the right side of the body, regardless of handedness or stance. Measurements were taken twice and variation between them was less than 1 % for body mass, stature, girths and breadths with variability of less than 5 % for skinfolds. Participants wore light clothing and were barefoot. Anthropometric measures included stature (SECA 225, Birmingham, UK), body mass [it was measured to the nearest 0.01 kg using a digital scale (SECA 770, Birmingham, UK)], skinfolds [triceps, subscapular, biceps, iliac crest, supraspinale, abdominal, front thigh and medial calf were measured using calibrated Harpenden callipers (John Bull, British Indicators, West Sussex, UK)], girths [arm flexed and tensed, waist, hip and calf were measured using an anthropometric tape (Lufkin W606PM, Cooper Hand Tools, Tyne & Wear, UK)], bone breadths [humerus and femur were measured using a Holtain anthropometer (Holtain Ltd., Dyfed, UK)]; somatotype was calculated using the Heath Carter somatotype method (Withers *et al.*, 1987). Body mass index (BMI) was calculated by dividing the body mass in kilograms by the square of stature (m). Body fat percentage values were calculated using the equation of Yuhasz (Cabañas Armesilla & Esparza Ros, 2009). The technical error of measurement was taken from studied subjects and calculated for all anthropometric measurements and was less than 3 %, which is within acceptable measurement error (Atkinson, 2003).

The statistical analysis was performed by SPSS software Version 21 (SPSS Inc., Chicago, IL, USA). All data are represented as mean ± standard deviation (SD). As the Kolmogorov-Smirnov test reported that some variables did not pass the normality assumption, non-parametric tests were used. Kruskal-Wallis test was used to study differences between sport groups, and thereafter the follow up was performed by the Mann Whitney U-test. A value of $p < 0.05$ was considered significant.

Statistical analyses were performed by means of SPSS program version 19.0 (SPSS Inc., Chicago, USA).

RESULTS

The mean and the standard deviation values for the anthropometric variables of the individual, collective and fight sports are presented in Tables I, II and III, respectively. For males, the highest values of femur breath, ectomorphy and medial calf and front thigh skinfolds are obtained for triathletes, athletes, volleyball players and karate fighters, respectively. The highest values of triceps, biceps and abdominal skinfolds, relaxed arm girth, endomorphy and body fat percentage are shown for taekwondo fighters, while the other highest values are obtained for handball players. For females, the highest value of ectomorphy is obtained for athletes.

Kruskal-Wallis test was used to establish differences between the groups. A practice effect was found in anthropometric variables between groups. The follow up was performed by Mann Whitney U-tests.

Comparison of individual and collective sports reflected that values of collective sports including BMI (U = -2.07, p<0.05, r = -0.25), humerus breadth (U = -2.34, p>0.05, r = -0.26), relaxed (U = -2.82, p<0.01, r = -0.32), and flex arm (U = -2.34, p>0.05, r = -0.26), waist (U = -2.20, p>0.05, r = -0.25), hip (U = -3.44, p<0.01, r = -0.39) and calf (U = -2.44, p>0.05, r = -0.27) girth, triceps (U = -3.32, p>0.01, r = -0.37), subscapular (U = -4.45, p>0.05, r = -0.50), biceps (U = -3.21, p>0.05, r = -0.36), iliac crest (U = -3.53, p>0.01, r = -0.40), supraespinale (U = -3.99, p>0.05, r = -0.45), abdominal (U = -3.72, p>0.01, r = -0.42), front thigh (U = -3.10, p>0.01, r = -0.35) and medial calf (U = -4.44, p>0.01, r = -0.50) skinfolds, body fat (U = -2.35, p<0.05, r = -0.15) and endomorphy (U = -3.77, p>0.05, r = -0.42) than those of studied individual sports.

Comparison of individual and fight sports shown that values of fight sports including triceps (U = -3.54, p>0.001, r = -0.40), biceps (U = -3.29, p>0.005, r = -0.37), iliac crest (U = -2.59, p>0.05, r = -0.30), supraespinale (U = -2.75, p>0.005, r = -0.31), abdominal (U = -2.38, p>0.05, r = -0.27), front thigh (U = -3.03, p>0.005, r = -0.35) and medial calf (U = -3.06, p>0.005, r = -0.35) and endomorphy (U = -3.52, p>0.001, r = -0.40) were significantly higher values than those of studied individual sports, while only humerus breadth values (U = -2.15, p<0.05, r=-0.25) in individual sports were significantly higher than those of fight sports.

Finally, comparison of collective sports and fight sports indicated that values of collective sports including BMI (U = -2.01, p<0.05, r = -0.23), humerus (U = -3.95, p<0.001, r = -0.44) and femur (U = -2.55, p<0.05, r = -0.29) breadth, relaxed (U = -3.27, p<0.005, r = -0.37), and flex arm (U = -3.38, p<0.005, r = -0.38), waist (U = -2.70, p<0.05, r = -0.30), hip (U = -2.29, p<0.05, r = -0.26) and calf (U = -2.85, p<0.05, r = -0.32) girths, subscapular (U = -2.90, p<0.005, r = -0.33) and medial calf (U = -2.09, p<0.05, r = -0.23) skinfolds and mesomorphy (U = -1.98, p<0.05, r = -0.22) were significantly higher than those of the studied fight sports.

Table I. Skill and anthropometric variables of individual sports subgroups (mean±SD).

Measure Professional	Athletics		Swimming		Triathlon	
	Female (n=6)	Male (n=6)	Female (n=5)	Male (n=8)	Female (n=4)	Male (n=9)
Body mass (kg)	51.1 ± 6.1	56.5 ± 14.6	57.0 ± 2.9	60.0 ± 5.1	51.1 ± 7.1	64.9 ± 10.8
Stature (cm)	161.8 ± 4.2	170.5 ± 16.1	160.7 ± 6.0	172.4 ± 4.0	159.4 ± 4.9	174.0 ± 8.3
Body mass index (BMI)	19.5 ± 1.9	19.1 ± 2.3	22.1 ± 1.9	20.2 ± 1.1	20.1 ± 2.2	21.3 ± 2.4
Triceps skinfold (mm)	11.7 ± 2.9	7.9 ± 1.0	13.7 ± 5.3	8.3 ± 1.4	13.4 ± 4.7	7.5 ± 2.9
Subscapular skinfold (mm)	7.8 ± 1.7	6.3 ± 1.4	10.4 ± 3.7	8.7 ± 3.0	9.4 ± 4.1	8.2 ± 2.6
Biceps skinfold (mm)	4.2 ± 0.7	3.1 ± 0.2	6.0 ± 1.7	4.7 ± 2.0	5.8 ± 2.2	4.1 ± 0.7
Iliac crest skinfold (mm)	11.8 ± 2.9	6.9 ± 1.5	17.2 ± 8.1	10.4 ± 3.5	16.2 ± 5.6	11.5 ± 4.7
Supraspinale skinfold (mm)	8.3 ± 2.1	4.9 ± 0.7	12.1 ± 6.0	7.2 ± 2.4	10.4 ± 3.0	7.2 ± 2.9
Abdominal skinfold (mm)	13.7 ± 3.4	7.4 ± 1.6	14.9 ± 6.3	9.8 ± 3.5	16.1 ± 4.9	9.7 ± 3.4
Front thigh skinfold (mm)	16.6 ± 2.2	10.6 ± 3.7	20.4 ± 7.3	11.5 ± 1.8	21.4 ± 5.8	11.7 ± 2.5
Medial calf skinfold (mm)	11.0 ± 2.8	7.1 ± 2.2	10.3 ± 3.0	9.4 ± 2.0	10.9 ± 4.4	8.4 ± 2.0
Relaxed arm girth (cm)	24.0 ± 1.7	24.7 ± 3.0	27.1 ± 2.8	26.4 ± 1.3	24.5 ± 2.0	26.9 ± 3.1
Flexed arm girth (cm)	24.7 ± 1.7	25.9 ± 3.4	27.8 ± 2.1	28.3 ± 1.2	25.1 ± 1.5	28.8 ± 3.3
Waist girth (cm)	66.2 ± 3.6	70.2 ± 6.4	69.5 ± 5.0	72.8 ± 4.0	66.8 ± 4.6	72.6 ± 5.6
Gluteal girth (cm)	89.9 ± 4.7	88.4 ± 8.9	90.3 ± 6.8	86.1 ± 4.3	91.2 ± 7.4	90.3 ± 7.3
Calf girth (cm)	29.0 ± 1.4	28.7 ± 3.2	33.2 ± 1.5	34.0 ± 1.1	32.5 ± 1.7	34.7 ± 3.5
Humerus breadth (cm)	5.6 ± 0.3	6.6 ± 0.5	5.8 ± 0.2	6.6 ± 0.4	5.5 ± 0.3	6.3 ± 0.6
Femur breadth (cm)	8.8 ± 0.4	9.7 ± 0.6	9.0 ± 0.6	9.9 ± 0.6	8.8 ± 0.7	10.5 ± 2.3
Endomorphy	2.9 ± 0.7	1.8 ± 0.2	3.8 ± 1.7	2.3 ± 0.7	3.6 ± 1.2	2.2 ± 0.9
Mesomorphy	2.3 ± 0.7	2.9 ± 0.9	4.0 ± 1.3	4.0 ± 0.9	3.1 ± 0.9	4.1 ± 2.0
Ectomorphy	3.4 ± 1.0	4.2 ± 1.2	2.0 ± 1.1	3.7 ± 0.6	2.9 ± 1.2	3.2 ± 1.1
Sum of six skinfolds (mm)	69.3 ± 10.3	44.3 ± 5.5	81.8 ± 29.9	54.9 ± 12.1	81.5 ± 21.6	52.7 ± 14.7
Body fat percentage	29.8 ± 0.7	29.0 ± 1.2	30.8 ± 1.1	29.2 ± 0.5	30.2 ± 0.8	29.6 ± 1.0

DISCUSSION

No major differences exist for individual sports between the anthropometrical values herein (Table I) and formerly published reports for males (Ackland *et al.*, 1998; Silva *et al.*, 2012) and females (Ackland *et al.*; Lentini *et al.*, 2004; Silva *et al.*). Our study reflected similar values in the somatotype and body composition among swimmers and

athletes as those published in the study by Leake & Carter (2007) that evaluated triathletes, swimmers and athletes. Male and female swimmers are characterized as mesomorphic-ectomorph and mesomorphic-endomorph, respectively (Table I). Similar results to other reports were obtained for weight, stature and BMI for male and female

Table II. Skill and anthropometric variables of collective sports subgroups (mean±SD).

Measure Professional	Handball		Volleyball	
	Female (n=6)	Male (n=11)	Female (n=15)	Male (n=9)
Body mass (kg)	63.0 ± 8.2	71.2 ± 12.7	58.5 ± 7.4	65.5 ± 11.8
Stature (cm)	166.6 ± 5.8	179.5 ± 6.5	164.9 ± 4.2	173.5 ± 14.1
Body mass index (BMI)	22.7 ± 2.9	22.0 ± 3.5	21.5 ± 2.5	21.6 ± 2.1
Triceps skinfold (mm)	16.4 ± 4.8	10.9 ± 5.2	15.2 ± 5.1	11.5 ± 3.8
Subscapular skinfold (mm)	13.6 ± 4.0	10.3 ± 4.2	13.4 ± 5.6	9.8 ± 2.7
Biceps skinfold (mm)	7.5 ± 1.5	5.2 ± 2.3	8.3 ± 5.3	4.6 ± 1.2
Iliac crest skinfold (mm)	22.3 ± 3.2	15.7 ± 8.3	20.9 ± 8.6	12.1 ± 5.1
Supraspinale skinfold (mm)	16.4 ± 5.5	10.6 ± 6.5	15.9 ± 7.2	9.8 ± 4.7
Abdominal skinfold (mm)	22.7 ± 4.8	13.6 ± 7.4	21.9 ± 8.2	12.8 ± 4.8
Front thigh skinfold (mm)	26.7 ± 4.9	13.2 ± 4.7	23.3 ± 5.7	14.8 ± 2.5
Medial calf skinfold (mm)	17.9 ± 1.8	8.9 ± 2.4	19.1 ± 6.6	12.1 ± 2.8
Relaxed arm girth (cm)	27.5 ± 2.4	28.6 ± 3.0	27.2 ± 2.6	27.1 ± 2.3
Flexed arm girth (cm)	28.1 ± 2.1	30.1 ± 2.9	27.4 ± 2.1	28.9 ± 2.5
Waist girth (cm)	73.9 ± 7.2	78.5 ± 8.0	71.8 ± 6.8	71.5 ± 7.0
Gluteal girth (cm)	95.8 ± 6.7	96.0 ± 7.3	96.0 ± 5.1	91.8 ± 8.3
Calf girth (cm)	34.3 ± 3.4	35.4 ± 4.2	34.0 ± 1.6	32.6 ± 3.2
Humerus breadth (cm)	6.1 ± 0.6	7.0 ± 0.6	6.1 ± 0.6	6.8 ± 0.4
Femur breadth (cm)	9.4 ± 0.5	10.2 ± 1.2	9.4 ± 0.6	10.0 ± 0.7
Endomorphy	4.7 ± 1.2	3.0 ± 1.4	4.5 ± 1.5	3.0 ± 0.9
Mesomorphy	3.8 ± 1.2	4.2 ± 1.6	3.8 ± 1.1	3.8 ± 1.5
Ectomorphy	2.2 ± 1.3	3.3 ± 1.4	2.7 ± 1.1	3.0 ± 1.3
Sum of six skinfolds (mm)	113.7 ± 20.7	67.5 ± 27.8	108.9 ± 34.8	70.8 ± 16.2
Body fat percentage	30.6 ± 1.3	29.5 ± 1.6	30.3 ± 1.0	29.8 ± 1.3

Table III. Skill and anthropometric variables of fight sports subgroup (mean±SD)

Item	Karate		Taekwondo	
	Female (n=7)	Male (n=13)	Female (n=13)	Male (n=6)
Body mass (kg)	59.2 ± 10.9	54.2 ± 12.2	51.7 ± 6.7	61.4 ± 17.4
Stature (cm)	163.6 ± 10.1	162.9 ± 10.6	160.2 ± 6.8	167.9 ± 13.1
Body mass index (BMI)	21.9 ± 2.1	20.2 ± 2.9	20.1 ± 1.3	21.3 ± 3.5
Triceps skinfold (mm)	14.9 ± 3.9	11.5 ± 4.2	13.2 ± 3.7	13.9 ± 6.7
Subscapular skinfold (mm)	13.3 ± 6.3	9.1 ± 4.1	8.4 ± 2.2	9.4 ± 3.8
Biceps skinfold (mm)	7.7 ± 0.9	5.8 ± 3.4	5.1 ± 0.8	6.1 ± 3.7
Iliac crest skinfold (mm)	21.7 ± 6.0	14.3 ± 5.5	15.2 ± 6.1	13.2 ± 9.4
Supraspinale skinfold (mm)	15.4 ± 7.1	9.3 ± 5.3	10.4 ± 3.8	10.1 ± 6.9
Abdominal skinfold (mm)	20.0 ± 6.9	12.7 ± 5.3	13.3 ± 4.0	13.8 ± 7.7
Front thigh skinfold (mm)	25.7 ± 5.4	15.4 ± 4.1	19.5 ± 4.6	14.1 ± 6.4
Medial calf skinfold (mm)	15.1 ± 4.4	11.5 ± 3.0	10.9 ± 2.5	10.9 ± 3.3
Relaxed arm girth (cm)	26.6 ± 2.5	25.5 ± 2.7	24.6 ± 1.6	29.9 ± 4.0
Flexed arm girth (cm)	27.1 ± 2.2	26.9 ± 2.9	25.3 ± 1.6	28.4 ± 4.1
Waist girth (cm)	72.3 ± 5.7	68.9 ± 5.9	66.1 ± 3.8	73.9 ± 7.8
Gluteal girth (cm)	97.3 ± 7.1	89.5 ± 7.3	90.1 ± 4.9	90.8 ± 10.3
Calf girth (cm)	35.6 ± 1.6	32.0 ± 4.1	30.7 ± 2.7	30.2 ± 3.3
Humerus breadth (cm)	5.2 ± 0.4	5.9 ± 1.0	5.7 ± 0.4	6.4 ± 0.5
Femur breadth (cm)	9.3 ± 0.9	9.6 ± 1.3	8.7 ± 0.5	9.8 ± 0.9
Endomorphy	4.5 ± 1.3	3.1 ± 1.2	3.4 ± 1.0	3.3 ± 1.6
Mesomorphy	3.4 ± 1.3	3.9 ± 1.9	2.9 ± 0.7	3.6 ± 0.8
Ectomorphy	2.3 ± 0.9	3.1 ± 1.0	2.9 ± 0.6	2.9 ± 1.1
Sum of six skinfolds (mm)	104.4 ± 28.6	69.5 ± 23.1	75.8 ± 17.8	72.3 ± 35.5
Body fat percentage	30.6 ± 1.0	30.0 ± 1.1	30.1 ± 0.6	30.2 ± 0.9

swimmers (Table I) (Prestes *et al*., 2006; Pérez *et al*., 2006; Vitor & Böhme, 2010). Body fat percentage values are important since they determine the buoyancy and the amount of energy swimmers must expend to simply stay on water surface (Fernández *et al*., 2002; Cabañas Armesilla & Esparza Ros). Female and male athletes from our study were central and ectomorph somatotypes, respectively (Table I), with similar values to those of the study by Muñoz *et al*. (2008). Furthermore, no significant differences exist between the data in Table I and senior sport players of former Olympic Games, as compiled by Cabañas Armesilla & Esparza Ros.

For collective sports, handball players were taller and heavier compared to volleyball players (Table II). The results in Table II reflect that female and male handball players were characterized as endomorphic-mesomorph and mesomorphic-ectomorph, respectively, in agreement with previous reports (Fernández Paneque & Alvero Cruz, 2006; Uezu *et al*., 2008). On the other hand, female and male volleyball players were characterized as endomorphic-mesomorph and central, respectively (Table II). Our findings regarding body height and BMI of handball players are also in agreement with formerly published data (de Hoyo Lora *et al*., 2008; Cabral *et al*., 2011; Milic *et al*., 2012).

For fighting sports, weight and stature in our study were similar to those reported in the work by Pieter & Falcó. Which evaluated the same age range. Kazemi *et al*., (2006), detected that in all weight categories, the average height of championship medalists of male taekwondo was higher than the category average. Our results show that female and male taekwondo fighters had the same central somatotype while female and male karate fighters were characterized as endomorphic-mesomorph and central, respectively (Table III). For taekwondo, several studies have reported that junior male are ectomorph contrary to the endomorphy for adult male; junior and adult female are ectomorph and endomorph, respectively (Kazemi *et al*., 2006; Pieter & Falcó).

In conclusion, anthropometric variables are a useful tool to evaluate human body shape, composition and proportionality and to detect sporting talent.

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RESUMEN: En la actualidad, el estudio de los parámetros cineantropométricos es una herramienta importante tanto para la selección temprana del talento como para evaluar la eficacia de un programa de capacitación. Este estudio tuvo como objetivo determinar las características antropométricas, los indicadores de composición corporal y los componentes somatotípicos de deportistas y deportistas individuales (atletismo, natación y triatlón), colectivos (balonmano y voleibol) y de lucha (karate y taekwondo) del Centro Valenciano de Tecnificación Deportiva. Este estudio involucró a un total de 62 hombres y 56 mujeres, se dividieron en tres subgrupos, que incluyen deportes individuales (atletismo, natación y triatlón), colectivos (balonmano y voleibol) y peleas (karate y taekwondo). La evaluación se realizó de acuerdo con la establecida por la Sociedad Internacional para el Avance de la Cineantropometría (ISAK). Para los hombres, el valor más alto de la respiración del fémur, la ectomorfia y los pliegues de la pantorrilla y el muslo frontal se obtienen para triatletas, atletismo, voleibol y karate, respectivamente. Los valores más altos de tríceps, bíceps y pliegues abdominales, circunferencia relajada del brazo, endomorfia y porcentaje de grasa corporal se muestran para el taekwondo, mientras que los otros valores más altos se obtienen con balonmano. Para las mujeres, el mayor valor de la ectomorfía se obtiene para el atletismo. Los parámetros cineantropométricos identificados son útiles cuando se comparan entre deportes y subgrupos deportivos para la selección de sujetos y para ayudar en su evaluación del rendimiento.

PALABRAS CLAVE: Antropometría; Balonmano; Voleibol; Atletismo; Natación; Triatlón; Karate; Taekwondo.

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