Apunts Med Esport. 2018;**53(200)**:129–137

apunts
MEDICINA DE L'ESPORT
www.apunts/org

ORIGINAL

Anthropometrical characteristics of Cuban sporting population: Reference data from a high performance national teams, 1992–2014

Wiliam Carvajal Veitía[a,*], Sofía León Perez[b], María Elena González Revuelta[c], Yanel Deturnel Campo[d], Ibis Echavarría García[d]

[a] *University of Sport Science, Havana, Cuba*
[b] *Provincial Sports Medicine Center, Havana, Cuba*
[c] *Research Department, Sports Medicine Institute, Havana, Cuba*
[d] *Kinanthropometry Department, Sports Medicine Institute, Havana, Cuba*

Received 9 January 2018; accepted 3 July 2018
Available online 25 September 2018

KEYWORDS
Body composition;
Kinanthropometry;
Somatotype

Abstract Physical structures in Cuban sporting population have changed according to secular trend, sport morphological adaptation, more qualified international championship and changes within the game. The purpose of this study was to provide new anthropometrical references data for many sporting disciplines in a form that may be readily utilized to practice the medical management of athletic training. Primary information source was the Anthropological Project database ''Morphological Evolution of Cuban Sporting Population, 1970–2014'', available through the Sports Medicine Institute's Kinanthropometry Department. Forty subjects were selected for each team sport, while 10 subjects were selected for each individual sport or positions and roles within sports. Using all the data, a set of references tables have been obtained based on Whithers et al. equation to estimate percentage body fat, Heath-Carter somatotyping, the sum of six skinfolds, and Fat Free Mass Index. This knowledge offers support to practice the medical management of athletic training, can also offer practical assistance to coaches in the suitable selection for the correct sporting modalities and physical development of elite athletes, by means of diet and training, in accordance with the model anthropomeric characteristics of an elite sporting population. On the other hand, we estimated Whiters et al. six-site skinfold equations, which were derived from high-performance athletes data set.
Published by Elsevier España, S.L.U. on behalf of FC Barcelona.

* Corresponding author.
E-mail addresses: wiliam.carvajal@hotmail.com, wiliamcarvajal790@gmail.com (W. Carvajal Veitía).

https://doi.org/10.1016/j.apunts.2018.07.001
1886-6581/Published by Elsevier España, S.L.U. on behalf of FC Barcelona.

PALABRAS CLAVE
Composición corporal;
Cineantropometría;
Somatotipo

Características antropométricas de la población deportiva cubana. Datos de referencia de equipos nacionales de alto rendimiento, 1992—2014

Resumen La estructura física de la población deportiva cubana ha cambiado de acuerdo a la evolución secular, la adaptación morfológica al deporte, campeonatos internacionales más calificados y cambios dentro del deporte. La propuesta de este estudio es proveer nuevos datos antropométricos de referencias para las disciplinas deportivas que puedan ser utilizados para el control médico del entrenamiento deportivo. La fuente de información primaria fue la base de datos del Proyecto Antropológico ''Evolución Morfológica en población deportiva cubana, 1970—2014'', disponible en el departamento de Cineantropometría del Instituto de Medicina del Deporte. Para cada deporte de equipo fueron seleccionados cuarenta sujetos, mientras que diez fueron seleccionados para cada deporte individual. Usando todos estos datos, fueron obtenidas tablas de referencia con estimados de la grasa por Withers y colaboradores, el somatotipo de Heath-Carter, la suma de seis panículos y el índice de Masa Corporal Activa. Este conocimiento ofrece un soporte para la práctica del control médico del entrenamiento deportivo, también ofrece asistencia práctica para entrenadores en lo que respecta a la selección de la modalidad deportiva adecuada, y en correspondencia con las características antropométricas ideales de una población deportiva de elite. Por otra parte, nosotros introducimos estimados de grasa corporal a través de las ecuaciones de Withers y colaboradores, las cuales fueron obtenidas de una base de datos de deportistas de alto rendimiento.

Introduction

Knowledge of a successful athlete's physical structure is a necessary point of departure for talent selection, the basis for the phenomenon known as morphological optimization, which aims to achieve optimal physical structure, body composition and somatotype for most efficient athletic performance in any sport. Morphological optimization is a gradual process, the evolution of which has been described for many sports population.[1]

The processes of ''sport morphological optimization'' occur within and across generations. In these circumstances, the final body shape and composition in a given sport results in the new morphological conceptual model in order to practice the medical management of athletic training.[2]

Morphological conceptual models always have changes, many times in professional as well as amateur sport. For example, Olds[3] reported that shape and composition of rugby union players have changed since 1975; as a result, the mean somatotype of rugby players changed from 3.8—4.8—2.0 for 1975 to 3.2—7.2—1.2 for 1995—1999. Ackland et al.[4] found that the morphology of canoe paddlers evolved between 1975 and 2000 toward a more compact build. Cŭk et al.[5] showed that there was a significant difference in the width of the shoulders and pelvis of the gymnasts in 1933 and those in 2000, the contemporary athletes were wider in their shoulders and narrower in their pelvis. Lozovina et al.[6] also found that the body structure of Croatian water polo players changed as a result of morphological optimization between 1980 and 2008, in terms of greater height and more elongated limbs, with thinner waist and broader shoulders. Sands et al.,[7] on the other hand, demonstrated that women Olympic gymnasts were getting smaller through approximately the 1980s and early 1990s. Since then, the size of these female gymnasts has increased and a more mesomorphic somatotype may have an advantage. Sedeaud et al.[8] found a secular increase in weight, height and body mass index of the four major US sports players (football, basketball, baseball and hockey) following a multi-exponential function pattern.

The last contribution to morphological profile of Cuban sporting population took place in the Olympic cycle 1976—1980.[9] Thirty years after, Carvajal et al.[10] demonstrated that body composition and physical structure in Cuban sporting population have changed according to secular trend, differential selection for body size, sport morphological adaptation, more qualified international championship and changes within the game. These authors[10] found significant changes in weight, height and somatotype in a group of Cuban athletes that included volleyball players, rhythmic gymnasts and artistic gymnasts between 1976 and 2008.

Considering that Cuba has figured as a sporting power in the international context since 1970s, the purpose of this study was to provide new anthropometrical references data for many sporting disciplines in a form that may be readily utilized to practice the medical management of athletic training.

Methods

Study type and universe

A descriptive and retrospective study was conducted to develop the kinanthropometric profile of the Cuban sporting population. The 1255 athletes (male = 845, female = 410), having consented to participate in this investigation, were all members of national sports teams in Cuba during the 1992—2014 years. The Study was not multicenter.

Forty subjects were selected for each team sport, while 10 subjects were selected for each individual sport or positions and roles within sports (from 24 sports and 57 sporting modalities). In all team sport, 20 was the maximum number of athletes selected in each period between 1992–2002 and 2004–2014 (more than 85% of athletes of national team in each period). In all, individuals sport were selected five athletes in each period. The sample consisted of 50% Centro-Americam champions, 40% Pan-American champions, 14.7% Olympic medalists (including 6% Olympic champions), 15% World champions and 75% international medalists in others competitions. Mean participant age was 21.6 ± 4.8 years; mean athletic experience was 8.6 ± 4.1 years. The age range was 16–35 years for male and 15–23 years for female. The ethnic distribution of the sample was 53.0% African ($n = 665$), 31.0% mixed Caucasian with African ($n = 389$) and 16.0% Caucasian ($n = 201$).

Inclusion criteria

In all sports were selected athletes who participated as a member of national team in at least one official international competition during the Olympic cycle in which they were active athletes.

Compilation of data

Primary information source was the Anthropological Project database ''Morphological Evolution of Cuban Sporting Population, 1970–2014'', available through the Sports Medicine Institute's Kinanthropometry Department.

All anthropometric measures were taken according to the recommendations of the International Society for the Advancement of Kinanthropometry[11]: weight, height, biepicondylar humerus and biepicondylar femur breadth, flexed arm and calf girths, biceps skinfold, triceps skinfold, subscapular skinfold, abdominal skinfold, front thigh, medial calf and supraspinale skinfolds.

With the information derivative from these measures, it was obtained the Heath–Carter anthropomorphic somatotype, while somatopoint was placed in the somatochart according Heath-Carter procedures,[12] sum of six skinfolds (S6skf, triceps, subscapular, supraspinal, abdominal, anterior thigh and medial calf), body density (BD) was determined using the Whiters et al. six-site skinfold equations, which were derived from 1987 dataset,[13,14] but not published in the original study (Lindsay Carter, personal communication, Jun 27, 2013), where

Female	Male
$BD = 1.07878 - 0.00035(S6skf) + 0.00032(Age)$ Determination coefficient = 0.841, standard error = 0.00624 g/cc, and 2.8% BF Age range: 11–41 years	$BD = 1.10326 - 0.00031(Age) - 0.000036(S6skf)$ Determination coefficient = 0.738, standard error = 0 .00579, and 2.5% BF Age range: 15–39 years

Body density was converted into an estimate of percentage body fat using the Siri[15] equation: $\%\,BF = 495/BD - 450$. Fat Free Mass Index (FFMI) determined using Tittel & Wutscherk formula as Fat Free Mass: Height^3 ratio (g/cm^3).[16]

Data analysis

Anthropological Project database data were compiled in an Excel spreadsheet, and calculations made to determine body fat, somatotype, S6skf and Lean Mass Index. Mean and standard deviation (SD) were calculated and expressed as $X \pm SD$.

Results

Descriptive data on physical characteristics of 1255 Cuban athletes are presented in Table 1 as mean values for each sporting modalities as well as the associated standard deviations ($X \pm SD$).

In general, male athletes involved in sports where a weight class has to be made to compete, such as boxing, wrestling, judo and weight lifting, events such as the artistic gymnastics and diving, and track and jump athletics (long jump, high jump, 110 m hurdle and 100, 200, 400, 800, >800 m) demonstrated lower % fat (<8%) and endomorphy (<2.5) than in the mean population.

In female athletes involved in sports where a weight class has to be made to compete, such as judo, athletic events such as the 100 m hurdle, 100, 200, 400, 800 and >800 m, esthetic sports such as the artistic gymnastics and rhythmic gymnasts, and sports such as volleyball, fencing and cycling (road and track) demonstrated lower % fat (<14.3%) and endomorphy (<2.9) than in the mean population.

On the other hand, male athletes involved in sports where body size is a definite advantage, such as baseball, athletics throwing (shot put, javelin and discus), judo >100, weight lifting >105, and sports where a weight class has to be made to compete such as wrestling, judo and weight lifting tended to have a larger FFMI (>1.30 g/cm^3) and mesomorphy (>6.2) than in the mean population.

In female athletes involved in sports where body size is a definite advantage, such as athletics throwing (shot put and discus) and judo >78, sports where a weight class has to be made to compete such as judo, and track and road cyclists tended to have a larger FFMI (>1.19 g/cm^3) and mesomorphy (>4.0) than in the mean population.

The somatocharts illustrate the physical distributions for male and female Cuban athletes. In general, male and female athletes involved in sports where a weight class has to be made to compete, such as wrestling, judo and weight lifting, and events such as athletics throwing (shot put, javelin and discus) were more mesomorphic, than other sporting modalities. In contrast, male and female athletes involved in sports such as volleyball, basketball, rhythmic gymnasts and athletic modalities such as 400, 800, >800 m were more ectomorphic than others.

(Figs. 1–3)

Discussion

Anthropometry in Cuba has the same classical base used in certification programs.[17] Therefore, the prototypes of

Table 1 Body size, somatotype and body composition statistics by sporting modalities and sex.

Sport	Mod	Sex	Age	Weight	Height	End	Mes.	Ect.	S6skf	% BF	FFMI
Athletics	400/800 m	M	22.6 ± 4.5	74.0 ± 6.0	185.0 ± 6.8	1.8 ± 0.7	4.2 ± 0.5	3.6 ± 0.5	34.0 ± 4.3	7.0 ± 0.6	1.09 ± 0.05
		F	22.4 ± 6.1	55.0 ± 4.1	167.9 ± 3.2	1.0 ± 0.5	3.2 ± 0.7	3.7 ± 0.4	43.2 ± 10.9	12.1 ± 1.8	1.02 ± 0.04
	>800 m	M	24.6 ± 3.2	58.5 ± 2.4	170.0 ± 3.6	1.9 ± 0.8	4.0 ± 0.8	3.7 ± 0.6	36.5 ± 4.4	7.3 ± 0.6	1.08 ± 0.06
		F	24.2 ± 6.1	56.4 ± 6.4	164.4 ± 2.7	1.9 ± 0.3	3.4 ± 1.1	3.4 ± 0.9	42.8 ± 6.6	9.5 ± 2.5	1.14 ± 0.08
	110 m h	M	24.3 ± 5.1	76.0 ± 3.4	186.0 ± 4.0	1.8 ± 0.4	5.9 ± 0.8	2.7 ± 0.8	38.0 ± 6.9	7.4 ± 1.3	1.09 ± 0.09
	100 m h	F	22.3 ± 4.1	61.8 ± 5.2	167.9 ± 3.1	2.2 ± 0.8	3.5 ± 0.9	2.8 ± 1.0	48.6 ± 16.1	11.3 ± 3.4	1.15 ± 1.10
	100–200 m	M	22.8 ± 3.0	76.0 ± 9.0	179.0 ± 6.4	1.4 ± 0.3	5.3 ± 1.3	2.7 ± 1.1	34.9 ± 3.7	6.8 ± 0.6	1.23 ± 0.12
		F	22.0 ± 3.7	58.5 ± 2.0	168.8 ± 3.3	2.9 ± 1.7	4.2 ± 0.9	2.7 ± 0.7	45.2 ± 25.4	11.3 ± 3.3	1.07 ± 0.08
	Shot put	M	22.5 ± 3.4	101.0 ± 4.0	190.0 ± 2.0	2.4 ± 0.8	6.6 ± 1.4	1.4 ± 0.6	70.5 ± 9.4	12.6 ± 1.5	1.40 ± 0.6
		F	23.5 ± 4.0	87.6 ± 7.2	178.7 ± 4.6	4.5 ± 0.6	6.2 ± 0.9	0.9 ± 0.5	120.0 ± 28.1	23.3 ± 4.1	1.24 ± 0.08
	Discus	M	23.9 ± 4.5	100.0 ± 5.2	188.0 ± 2.2	2.4 ± 0.8	6.6 ± 1.4	1.5 ± 0.8	52.0 ± 32.4	9.7 ± 5.1	1.50 ± 0.8
		F	23.0 ± 2.3	84.5 ± 4.2	180.0 ± 1.7	5.5 ± 0.6	4.7 ± 0.5	1.3 ± 0.5	105.2 ± 25.9	20.1 ± 4.4	1.19 ± 0.05
	Javelin	M	24.2 ± 3.1	100.0 ± 2.0	185.0 ± 2.7	2.1 ± 0.5	6.5 ± 0.9	1.8 ± 0.7	47.1 ± 11.0	8.9 ± 1.9	1.43 ± 0.1
		F	24.2 ± 1.9	77.0 ± 4.0	178.0 ± 3.0	3.5 ± 2.1	5.6 ± 1.8	1.7 ± 0.7	77.0 ± 18.9	17.1 ± 3.0	1.13 ± 0.07
	High jump	M	22.2 ± 5.0	76.0 ± 3.2	198.0 ± 1.2	1.5 ± 0.3	4.1 ± 0.8	4.2 ± 0.9	34.6 ± 5.2	7.0 ± 1.0	0.91 ± 0.08
	Long jump	M	21.6 ± 2.9	75.0 ± 4.2	177.0 ± 4.3	1.5 ± 0.3	5.2 ± 1.1	2.7 ± 0.8	33.3 ± 5.3	6.4 ± 0.8	1.12 ± 0.1
	Triple jump	M	23.5 ± 2.6	75.0 ± 3.7	186.0 ± 7.0	2.2 ± 0.3	5.2 ± 0.7	2.9 ± 0.6	45.4 ± 4.8	8.5 ± 0.8	1.06 ± 0.06
Basketball		M	24.3 ± 2.5	86 ± 9.3	194.3 ± 7.4	1.9 ± 0.6	4.1 ± 1.2	3.7 ± 1.1	42.4 ± 12.2	8.2 ± 2.0	1.07 ± 0.11
		F	23.1 ± 4.3	76.6 ± 9.0	181.5 ± 8.0	2.5 ± 0.7	2.9 ± 1.1	3.1 ± 1.0	64.0 ± 19.5	14.4 ± 3.9	1.09 ± 0.09
Handball		M	22.5 ± 6.1	87.8 ± 7.3	190.4 ± 6.9	2.1 ± 0.5	5.6 ± 1.0	2.4 ± 0.9	46.2 ± 20.4	8.3 ± 3.4	1.16 ± 0.09
		F	22.9 ± 3.5	69.5 ± 10.0	173.0 ± 5.1	2.8 ± 0.6	4.4 ± 1.0	2.4 ± 0.9	74.1 ± 18.8	15.5 ± 4.1	1.13 ± 0.09
Soccer		M	21.8 ± 4.3	73.9 ± 5.2	176.5 ± 6.6	1.8 ± 0.5	5.1 ± 1.0	2.6 ± 0.8	42.2 ± 10.3	7.7 ± 1.7	1.24 ± 0.09
Hockey		M	21.2 ± 3.9	72.8 ± 8.2	175.8 ± 7.2	1.9 ± 0.5	5.1 ± 1.0	2.6 ± 0.9	44.3 ± 12.2	8.0 ± 2.1	1.23 ± 0.09
		F	22.2 ± 3.6	59.4 ± 7.0	163.4 ± 5.9	3.1 ± 0.5	3.7 ± 0.8	2.2 ± 0.8	75.6 ± 15.3	15.6 ± 3.5	1.14 ± 0.08
Table tennis		M	19.7 ± 3.8	67.2 ± 10.7	174.6 ± 7.7	1.9 ± 0.5	4.4 ± 1.3	3.1 ± 1.2	43.5 ± 10.0	7.9 ± 1.7	1.16 ± 0.13
Volleyball		M	21.8 ± 4.9	85.7 ± 8.5	196.0 ± 5.3	1.6 ± 0.9	3.8 ± 1.1	3.9 ± 1.1	40.2 ± 14.2	7.6 ± 2.3	1.05 ± 0.11
		F	19.2 ± 5.2	73.8 ± 8.8	182.4 ± 4.1	2.4 ± 1.0	3.3 ± 1.2	3.7 ± 1.0	62.0 ± 16.0	11.1 ± 3.5	1.08 ± 0.1
Water polo		M	22.3 ± 4.7	86.8 ± 8.2	186.5 ± 3.5	2.7 ± 1.0	5.8 ± 0.9	2.4 ± 1.1	57.2 ± 20.5	9.6 ± 3.5	1.21 ± 0.09
Baseball		M	24.1 ± 4.9	92.9 ± 11.9	179.7 ± 6.0	2.7 ± 1.1	6.0 ± 1.1	1.2 ± 0.8	66 ± 22.8	12.1 ± 3.6	1.40 ± 0.11
Tennis		M	20.7 ± 2.3	75.3 ± 6.5	176.0 ± 9.0	2.2 ± 1.0	4.7 ± 1.3	2.2 ± 0.9	46.4 ± 25.8	8.4 ± 4.0	1.26 ± 0.07
		F	24.5 ± 9.9	61.0 ± 5.0	169.5 ± 3.8	3.8 ± 0.5	4.9 ± 0.3	2.5 ± 1.5	76.7 ± 10.3	14.8 ± 1.1	1.06 ± 0.15

Table 1 (*Continued*)

Sport	Mod	Sex	Age	Weight	Height	End	Mes	Ect	S6skf	% BF	FFMI
Canoe/Kayak		M	25.1 ± 4.6	80.5 ± 5.4	178.4 ± 5.4	1.8 ± 0.4	6.4 ± 0.7	1.9 ± 0.8	44.6 ± 12.4	8.1 ± 2.0	1.30 ± 0.09
		F	21.3 ± 4.5	63.6 ± 6.0	167.3 ± 4.1	2.9 ± 0.5	5.2 ± 0.6	1.9 ± 0.7	74.6 ± 15.5	14.4 ± 3.7	1.16 ± 0.10
Sailing		M	24.0 ± 5.1	70.8 ± 8.1	175.0 ± 6.2	1.9 ± 0.5	4.9 ± 0.6	2.3 ± 1.0	50.1 ± 15.3	9.5 ± 2.5	1.19 ± 0.10
Swimming		M	20.1 ± 2.4	75.0 ± 3.3	181.6 ± 3.6	2.3 ± 0.2	5.5 ± 0.2	2.8 ± 0.5	50.2 ± 10.6	8.3 ± 1.6	1.15 ± 0.05
		F	16.7 ± 3.8	59.4 ± 2.9	169.8 ± 3.7	2.4 ± 0.3	4.4 ± 0.2	3.3 ± 0.4	72.4 ± 11.8	18.1 ± 3.2	1.00 ± 0.05
Cycling	Road	M	23.5 ± 5.4	68.5 ± 5.8	173.8 ± 5.6	1.9 ± 0.3	5.3 ± 0.9	2.7 ± 0.7	39.4 ± 7.7	7.7 ± 1.2	1.20 ± 0.08
		F	23.0 ± 4.4	61.5 ± 7.8	165.3 ± 5.0	2.9 ± 0.7	4.6 ± 0.9	2.3 ± 0.7	70.4 ± 16.3	12.5 ± 2.7	1.19 ± 0.06
	Track	M	22.6 ± 5.4	71.8 ± 7.1	176.4 ± 5.4	2.1 ± 0.5	5.7 ± 0.8	2.2 ± 0.7	46.3 ± 14.1	8.5 ± 2.3	1.19 ± 0.09
		F	19.7 ± 2.7	64.3 ± 2.5	167.0 ± 3.0	2.9 ± 1.1	3.8 ± 0.7	1.9 ± 0.7	73.7 ± 18.0	12.2 ± 4.9	1.22 ± 0.13
Rowing	Lightweight	M	26.7 ± 2.8	82.0 ± 17.7	179.7 ± 3.4	1.6 ± 0.3	4.9 ± 1.0	1.7 ± 0.8	41.2 ± 12.5	7.5 ± 2.0	1.16 ± 0.23
	Heavyweight	M	23.2 ± 2.3	91.0 ± 10.8	188.5 ± 7.0	2.0 ± 0.8	5.1 ± 0.7	2.4 ± 0.7	45.4 ± 17.9	8.2 ± 3.7	1.14 ± 0.08
	Lightweight	F	24.5 ± 3.7	60.6 ± 2.5	170.4 ± 3.5	2.3 ± 0.6	3.3 ± 0.8	3.3 ± 0.6	64.5 ± 16.9	16.0 ± 4.1	1.02 ± 0.07
Artistic gymnastics		M	21.0 ± 2.9	62.3 ± 4.4	166 ± 3.3	1.4 ± 0.2	6.4 ± 0.8	2.0 ± 0.6	32.0 ± 4.4	5.9 ± 0.0	1.28 ± 0.07
		F	15.7 ± 3.2	42.7 ± 6.0	151.2 ± 6.0	1.5 ± 0.5	3.8 ± 0.8	3.3 ± 0.1	37.3 ± 71.2	7.6 ± 3.6	1.14 ± 0.09
Diving		M	21.6 ± 3.6	66.0 ± 4.6	169.7 ± 3.2	2.0 ± 0.2	6.1 ± 0.6	1.8 ± 0.4	41.6 ± 13.8	7.7 ± 2.2	1.26 ± 0.05
		F	21.1 ± 5.2	49.7 ± 3.2	157.0 ± 5.7	3.2 ± 1.0	4.9 ± 1.1	1.9 ± 0.6	77.7 ± 24.1	15.4 ± 5.0	1.08 ± 0.09
Rhythmic gymnasts		F	17.2 ± 3.4	46.2 ± 4.2	162 ± 5.0	1.7 ± 0.5	2.4 ± 0.5	4.1 ± 0.8	45.4 ± 10.7	12.0 ± 3.7	0.95 ± 0.06
Synchronized swimming		F	17.0 ± 3.0	56.3 ± 5.0	163.9 ± 4.3	3.4 ± 0.9	3.6 ± 0.7	3.0 ± 0.9	73.0 ± 16.2	15.7 ± 3.6	1.07 ± 0.07
Fencing		M	21.7 ± 4.5	74.1 ± 6.5	179 ± 5.6	2.3 ± 0.8	4.6 ± 0.9	2.5 ± 0.8	44.7 ± 13.9	8.2 ± 2.2	1.18 ± 0.08
		F	21.4 ± 4.1	59.8 ± 3.4	167.3 ± 4.0	2.1 ± 0.5	3.6 ± 0.6	3.0 ± 0.5	64.5 ± 11.9	11.2 ± 1.9	1.11 ± 0.05

Sport	Mod	Sex	Age	Weight	Height	End	Mes	Ect	S6skf	% BF	FFMI
Boxing	49	M	22.0 ± 3.5	51.1 ± 1.5	163.5 ± 4.4	2.0 ± 0.5	4.2 ± 0.4	3.7 ± 0.7	33.4 ± 4.7	6.8 ± 0.9	1.09 ± 0.09
	52	M	20.9 ± 3.6	54.6 ± 2.0	165.0 ± 3.3	2.1 ± 0.6	5.0 ± 0.8	2.7 ± 0.8	37.0 ± 9.0	7.5 ± 1.8	1.12 ± 0.06
	54	M	21.3 ± 4.0	58.5 ± 2.5	168.0 ± 3.8	1.6 ± 0.3	4.3 ± 0.5	3.1 ± 0.8	37.3 ± 5.4	7.4 ± 1.0	1.15 ± 0.8
	56	M	23.8 ± 2.9	60.5 ± 1.6	169.5 ± 3.6	1.6 ± 0.3	4.4 ± 0.6	3.0 ± 0.4	37.6 ± 5.6	7.5 ± 1.1	1.15 ± 0.08
	60	M	22.1 ± 2.2	63.7 ± 2.8	173.9 ± 3.7	1.8 ± 0.5	4.9 ± 1.2	3.1 ± 1.0	36.4 ± 6.6	7.1 ± 1.2	1.13 ± 0.07
	64	M	23.4 ± 2.9	66.8 ± 2.0	175.2 ± 3.4	1.6 ± 0.2	4.1 ± 1.4	3.0 ± 0.6	36.4 ± 3.6	7.2 ± 0.7	1.15 ± 0.07
	69	M	22.4 ± 3.9	70.5 ± 2.6	178.3 ± 3.3	1.8 ± 0.4	4.6 ± 1.1	3.0 ± 0.7	41.3 ± 6.6	8.2 ± 1.2	1.14 ± 0.07
	75	M	23.1 ± 1.3	76.2 ± 3.5	181.1 ± 5.5	1.8 ± 0.5	5.5 ± 0.8	2.7 ± 1.0	44.7 ± 12.9	8.8 ± 2.5	1.17 ± 0.10
	81	M	21.9 ± 2.3	82.2 ± 3.5	182.1 ± 4.1	2.0 ± 0.5	6.5 ± 0.8	2.1 ± 0.4	44.8 ± 15.3	8.8 ± 2.9	1.25 ± 0.08
	91	M	23.6 ± 5.3	91.7 ± 3.4	187.6 ± 5.3	2.5 ± 0.8	5.7 ± 1.2	2.0 ± 0.8	53.8 ± 14.6	10.4 ± 2.7	1.25 ± 0.09
	>91	M	23.8 ± 4.0	98.3 ± 8.7	189.9 ± 6.5	3.6 ± 1.3	6.3 ± 1.8	1.7 ± 1.2	65.8 ± 24.7	12.9 ± 4.7	1.25 ± 0.08
Wrestling	54	M	22.0 ± 2.0	59.7 ± 1.5	160.9 ± 3.1	1.7 ± 0.2	5.9 ± 0.7	1.6 ± 0.4	34.2 ± 4.4	6.4 ± 1.0	1.34 ± 0.05
	58	M	21.6 ± 2.8	64.1 ± 1.8	162.4 ± 3.4	1.9 ± 0.2	6.4 ± 0.9	1.1 ± 0.5	40.0 ± 6.4	7.0 ± 0.9	1.39 ± 0.08
	63	M	25.7 ± 5.0	69.5 ± 1.8	170.1 ± 2.7	1.7 ± 0.3	6.1 ± 0.7	1.7 ± 0.4	35.9 ± 4.0	7.1 ± 0.6	1.31 ± 0.05
	69	M	23.0 ± 4.1	74.6 ± 1.8	170.5 ± 3.0	1.9 ± 0.3	6.5 ± 0.6	1.1 ± 0.5	39.7 ± 5.8	7.2 ± 0.6	1.40 ± 0.08
	76	M	23.7 ± 2.3	80.5 ± 2.5	177.5 ± 3.1	1.7 ± 0.1	7.0 ± 1.0	1.5 ± 0.5	35.5 ± 3.5	6.8 ± 0.3	1.34 ± 0.07
	85	M	23.9 ± 1.9	92.0 ± 2.9	180.2 ± 3.2	2.0 ± 0.5	7.5 ± 0.8	0.7 ± 0.5	44.6 ± 12.6	8.0 ± 1.8	1.45 ± 0.07
	97	M	24.7 ± 4.3	99.8 ± 5.3	185.5 ± 5.3	2.9 ± 0.3	6.8 ± 0.7	0.7 ± 0.4	65.0 ± 8.9	10.8 ± 1.8	1.39 ± 0.07
	130	M	24.3 ± 4.5	120.4 ± 9.5	188.0 ± 2.9	3.0 ± 0.2	7.0 ± 0.5	2.4 ± 0.7	79.6 ± 12.0	11.7 ± 2.7	1.59 ± 0.05

Table 1 (*Continued*)

Judo	56	M	18.2 ± 1.5	62.2 ± 3.3	163.2 ± 1.2	1.8 ± 0.1	6.0 ± 0.3	1.6 ± 0.7	37.6 ± 3.5	6.2 ± 0.6	1.34 ± 0.08
	48	F	16.0 ± 2.0	49.7 ± 1.3	151.4 ± 2.1	1.4 ± 0.4	4.5 ± 0.8	1.4 ± 0.7	52.0 ± 10.0	13.9 ± 1.7	1.25 ± 0.06
	60	M	18.2 ± 2.0	63.9 ± 1.4	165.0 ± 2.5	1.8 ± 0.2	6.2 ± 0.8	1.7 ± 0.5	41.9 ± 5.1	6.8 ± 0.5	1.33 ± 0.08
	52	F	22.5 ± 4.3	54.0 ± 1.5	156.7 ± 3.3	1.9 ± 0.4	5.2 ± 0.9	1.8 ± 0.8	42.7 ± 6.4	12.2 ± 1.3	1.24 ± 0.09
	66	M	22.8 ± 2.5	69.2 ± 1.7	166.5 ± 1.7	1.6 ± 0.2	6.9 ± 0.6	1.1 ± 0.3	37.6 ± 3.4	6.9 ± 0.6	1.40 ± 0.04
	57	F	19.3 ± 3.4	60.0 ± 1.7	161.4 ± 5.3	2.6 ± 0.9	5.3 ± 1.1	1.6 ± 1.1	53.4 ± 11.0	14.3 ± 2.2	1.23 ± 0.12
	73	M	19.3 ± 1.2	76.8 ± 1.9	171.4 ± 3.9	1.5 ± 0.1	7.2 ± 0.9	1.0 ± 0.9	33.6 ± 2.3	5.8 ± 0.2	1.44 ± 0.13
	63	F	19.5 ± 3.2	65.1 ± 0.6	165.6 ± 6.4	1.9 ± 0.4	5.6 ± 1.5	1.6 ± 1.2	44.1 ± 8.1	12.8 ± 1.3	1.26 ± 0.14
	81	M	20.7 ± 1.2	84.5 ± 2.4	178.5 ± 0.4	2.0 ± 0.4	6.9 ± 0.4	1.2 ± 0.3	45.0 ± 7.5	7.5 ± 1.2	1.37 ± 0.04
	70	F	23.0 ± 4.6	73.5 ± 2.5	171.3 ± 7.4	2.3 ± 0.2	5.5 ± 1.0	1.4 ± 1.0	55.5 ± 4.9	14.0 ± 1.4	1.26 ± 0.14
	90	M	19.8 ± 1.3	93.9 ± 1.6	188.3 ± 2.8	1.7 ± 0.1	9.1 ± 7.1	1.8 ± 0.5	41.0 ± 3.7	6.9 ± 0.3	1.31 ± 0.07
	78	F	22.3 ± 2.5	78.5 ± 2.0	171.0 ± 3.3	3.0 ± 0.7	6.4 ± 0.7	0.7 ± 0.5	74.2 ± 13.8	17.0 ± 1.8	1.30 ± 0.05
	100	M	20.0 ± 2.3	98.9 ± 7.9	185.8 ± 2.3	2.9 ± 0.9	7.6 ± 0.9	1.0 ± 0.5	67.2 ± 22.2	10.3 ± 3.2	1.38 ± 0.06
	>78	F	23.1 ± 6.6	108.0 ± 23.5	174.4 ± 6.7	6.5 ± 2.1	7.8 ± 1.0	0.5 ± 0.7	148.9 ± 51.9	28.8 ± 7.7	1.42 ± 0.06
	>100	M	23.4 ± 3.0	130.0 ± 27.0	187.5 ± 2.2	5.0 ± 0.5	9.0 ± 0.4	0.5 ± 0.3	116.0 ± 43.0	19.8 ± 11.7	1.55 ± 0.11
Weight lifting	56	M	19.2 ± 2.2	56.4 ± 3.3	153.7 ± 3.6	2.1 ± 0.4	6.7 ± 1.3	0.9 ± 1.0	39.1 ± 8.8	6.3 ± 0.9	1.46 ± 0.14
	62	M	22.3 ± 3.2	64.1 ± 0.9	156.5 ± 2.6	2.1 ± 0.3	7.5 ± 0.4	0.5 ± 0.1	41.4 ± 9.3	6.7 ± 1.1	1.56 ± 0.08
	69	M	21.2 ± 2.3	68.9 ± 1.5	162.7 ± 3.7	2.2 ± 0.4	7.3 ± 0.6	0.7 ± 0.4	43.9 ± 7.8	7.2 ± 1.1	1.49 ± 0.08
	77	M	23.4 ± 2.3	76.5 ± 3.7	164.1 ± 4.2	2.3 ± 1.0	8.0 ± 1.6	0.7 ± 0.3	53.9 ± 18.0	8.2 ± 2.4	1.59 ± 0.16
	85	M	19.0 ± 4.0	84.4 ± 0.8	172.5 ± 6.5	2.3 ± 0.7	7.7 ± 0.7	0.8 ± 0.3	49.0 ± 11.1	7.8 ± 1.3	1.52 ± 0.14
	94	M	21.5 ± 5.3	87.0 ± 4.5	176.0 ± 3.7	2.3 ± 0.2	6.8 ± 1.4	0.9 ± 0.6	54.6 ± 2.6	8.9 ± 1.0	1.46 ± 0.15
	105	M	24.7 ± 3.4	104.0 ± 7.9	176.4 ± 3.7	3.8 ± 0.1	9.6 ± 0.7	0.5 ± 0.4	70.3 ± 8.8	14.1 ± 1.5	1.60 ± 0.12
	>105	M	23.0 ± 4.3	115.8 ± 10.6	178.7 ± 4.5	5.4 ± 0.5	9.1 ± 1.2	0.5 ± 0.3	119.0 ± 12.0	22.2 ± 2.0	1.58 ± 0.12
Total		M	22.0 ± 4.6	77.1 ± 12.7	179.8 ± 10.2	2.5 ± 0.8	5.3 ± 1.4	2.4 ± 1.2	48.3 ± 17.8	8.0 ± 2.1	1.30 ± 0.13
		F	20.9 ± 5.0	61.1 ± 12.3	168.2 ± 9.0	2.9 ± 1.2	4.0 ± 1.3	2.8 ± 1.2	67.6 ± 26.6	14.3 ± 4.9	1.19 ± 1.2

Mod, modalities; Weight, kg; Height, cm; End: endomorphy; Mes, mesomorphy; Ect, ectomorphy; S6skf, mm; %BF, %body fat; FFMI, Fat Free Mass Index, g/cm^3.

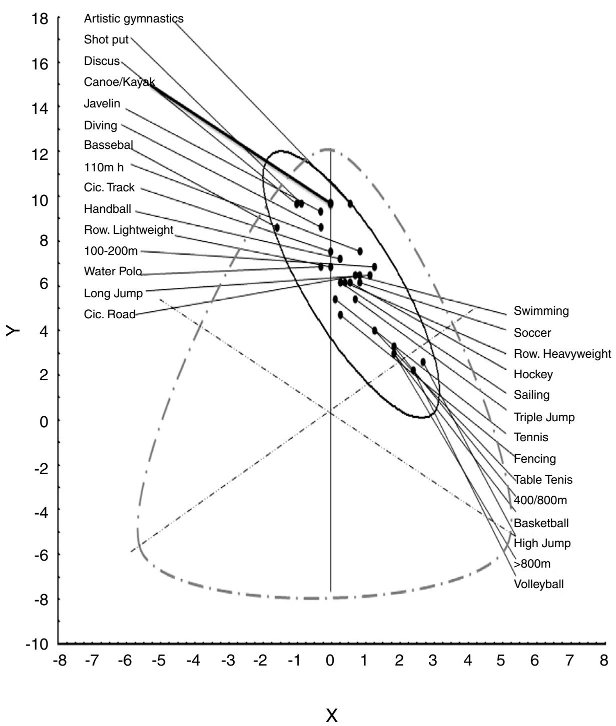

Figure 1 Somatochart showing the mean somatoplots of Cuban male sporting modalities.

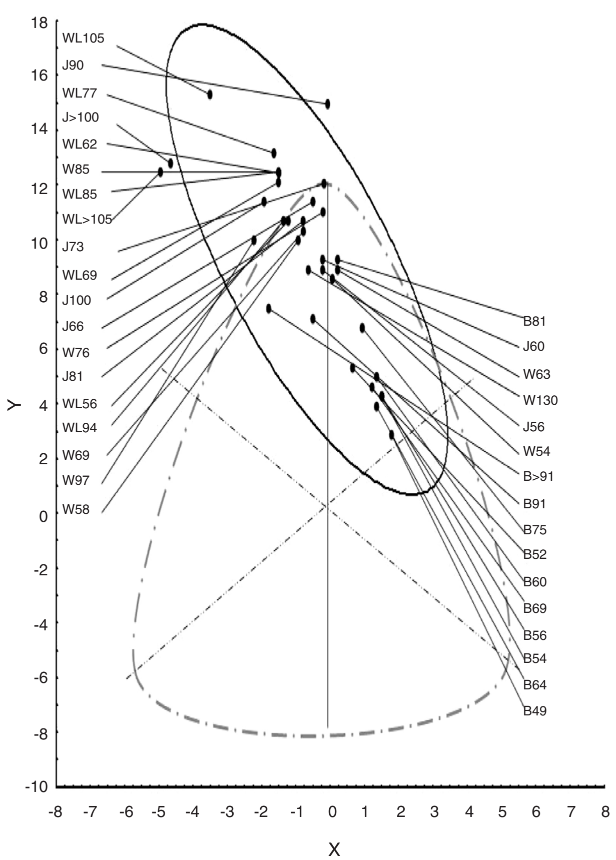

Figure 2 Somatochart showing the mean somatoplots of Cuban male sporting modalities. B#, boxing; WL#, weight lifting; J#, judo; W#, wrestling.

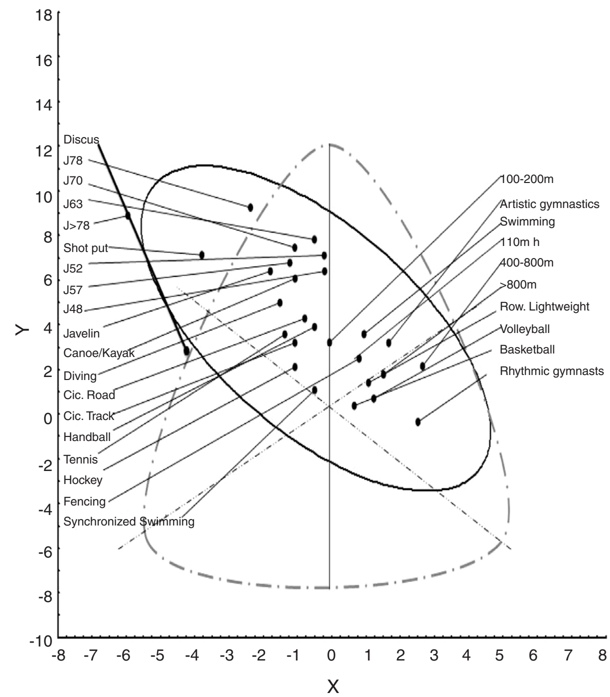

Figure 3 Somatochart showing the mean somatoplots of Cuban female sporting modalities. J#, judo.

Cuban athletes can be added to the information already available for description and comparison of elite athletes.

In this study, the Cuban athletes showed lower S6skf mean values (male, S6skf = 48.3 mm and female, S6skf = 67.6 mm) than those showed for the Spanish sporting population (male, S6skf = 53.2 mm and female = 78.97 mm)[18] and the Venezuelan sporting population (male, S6skf = 49.0 mm and female = 92.6 mm).[19] In comparison to male athletes, differences between Cuban and foreign female athletes were most pronounced. Due to the historical high-level performance achieved by the studied Cuban sample, it might be thought that body composition is in agreement with this.

In general, the Cuban sporting modalities satisfy the rules of sport morphological optimization: athletes involved in a sport where their body weight is supported, such as canoe and kayak, rowing and swimming had means % BF values. Athletes involved in sports where a weight class has to be made to compete, in athletics, all the track events, high and long jump, that are very anaerobic in nature and extremely aerobic events such as the >800 m demonstrated lower % BF values. In contrast, athletes involved in sports where body size is a definite advantage, such as baseball, athletics throwing, and heavyweight judoist >100, weight lifting >105 and wrestler had a larger FFMI.

These results were qualitatively similar to those of the Olympic athletes. Fleck conducted a study with a sample of 826 athletes participating in Olympic events and found that athletes involved in a sport where their body weight is supported, such as canoe and kayak and swimming had higher % BF values. Athletes involved in sports where a weight class has to be made to compete, such as boxing and wrestling, events such as the 100, 200 and 400 m in athletes that are very anaerobic in nature and extremely aerobic events such as the marathon demonstrated lower % BF values. Athletes involved in sports where body size is a definite advantage, such as basketball and volleyball tended to have a larger Lean Body Mass.[20]

With respect to the methodology used, in 1982, after 6 years of the Montreal Olympic Game Anthropological Project (MOGAP), Lindsay Carter introduced the Yuhasz six-site skinfold equations to estimate % BF in elite athletes of different disciplines.[2] For this reason, MOGAP and the research literature provided abundant reference values on the Yuhasz body fat estimated.[2,18,19,21] In spite of this clear difference with another equation, Whiters et al.[13,14] are the only equation that have been developed on a large number of elite adult athletes from a variety of sports.

International scientific literature show more data based on the use of Yuhasz and Faulkner[2,21–23] equations than the Whiters et al. equations and his FFMI. In Cuba, the Whiters et al. six-site skinfold equations were introduced by Carvajal et al.[24] whom noted that this method is more sensitive to monitor small changes in body fat of elite athletes. This method was also proposed by Rodriguez et al.[19] in Venezuela, while Alvero et al.[25] and Canda[18] proposed two different variants of Whithers et al. equations in Spain.

According to Tittel and Wutscherk,[16] FFMI can discriminate between different types of sporting modalities, and between competitive levels, is the most commonly used index to evaluate the effects of sport training on relative fat free mass. This method was first proposed by Tittel and Wutscherk[16]; after 1970, it was recommended by Rodriguez,[9] Pancorbo,[26] Canda[18] and Carvajal et al.[27] In this study, athletes involved in sports where body size is a definite advantage had a larger FFMI.

Conclusion

This study provides new reference values for the assessment of the body composition and the somatotype in Cuban athletes. This knowledge offers support to practice the medical management of athletic training, can also offer practical assistance to coaches in the suitable selection for the correct sporting modalities, in accordance with the model anthropometric characteristics of an elite sporting population. On the other hand, we introduced Whiters et al. six-site skinfold equation estimated of high-performance athletes, which were derived from high-performance athletes data set.

Fuente de financiación

No.

Conflicts of interest

The authors declare that they do not have any conflict of interests.

References

1. Olds T. Body composition and sports performance. In: Olympic Textbook of Science in Sport. Volume XV of the Encyclopedia of Sports Medicine. A JOC Medical Commission Publication. Garsington Road, Oxford: Wiley; 2009.
2. Carter JEL. Physical Structure of Olympic athletes. Part 1: The Montreal Olympic Games Anthropological Project. Medicine and Sports, 16. Basel: Karger; 1982.
3. Olds T. The evolution of physique in male rugby union players in the twentieth century. J Sports Sci. 2001;19:253–62.
4. Ackland TR, Ong KB, Kerr DA, Ridge B. Morphological characteristics of Olympic sprint canoe and kayak paddlers. J Sci Med Sport. 2003;6:285–94.
5. Cŭk I, Korencić T, Tomazo-Ravnik T, Pecek M, Bucar M, Hraski M. Differences in morphologic characteristics between top level gymnasts of year 1933 and 2000. Coll Antropol. 2007;31: 613–9.
6. Lozovina V, Lozovina M, Pavičić L. Morphological changes in elite male water polo players. Acta Kinesiol. 2012;6:85–90.
7. Sands WA, Slater C, McNeal JR, Murray SR, Stone MH. Historical trends in the size of US Olympic female artistic gymnasts. Int J Sports Phys Perform. 2012;7:350–6.
8. Sedeaud A, Marc A, Schipman J, Schaal K, Danial M, Guillaume M, et al. Secular trend: morphology and performance. J Sports Sci. 2014, http://dx.doi.org/10.1080/02640414.2014.88984.
9. Rodriguez CA, Sanchez G, Garcia E, Martinez M, Cabrera T. Contribution to the study of the morphological profile of highly competitive male Cuban athletes. Boletín Científico Técnico INDER. 1986;1:6–24.
10. Carvajal W, Ríos A, Echeverría I, Martínez M, Castillo ME. Tendencia secular en deportistas cubanos de alto rendimiento: periodo 1976–2008. Rev Esp Antrop Fís. 2008;28:71–9.
11. Stewart A, Marfell-Jones M, Olds T, de Ridder H. International Standards for Anthropometric Assessment ISAK. New Zealand: Lower Hutt; 2011.
12. Carter JEL, Heath BH. Somatotyping: Development and Applications. Cambridge, UK: Cambridge University Press; 1990.
13. Withers RT, Whittingham NO, Norton KI, La Forgia J, Ellis MW, Crockett A. Relative body fat and anthropometric prediction of body density of female athletes. Eur J Appl Physiol. 1987;56:169–80.
14. Withers RT, Craig NP, Bourdon PC, Norton KI. Relative body fat and anthropometric prediction of body density of male athletes. Eur J Appl Physiol. 1987;56:191–200.
15. Siri WEV. Body composition from fluid spaces and density. In: Brozek J, Henshel A, editors. Techniques for Measuring Body Composition. Washington, DC: National Academy Sciences; 1961. p. 223–4.
16. Tittel K, Wutscherk H. Sportanthopometrie. Leipzig: Johann Ambrosius Bath; 1972. p. 106–7.
17. Ross WD, Carr RV, Carter JEL. Anthropometry illustrated [CD-ROM]. The human animal series, 1. Toronto: Turnpike Electronic Publications Inc.; 1999. p. 106–7.
18. Canda AS. Variables antropométricas de la población deportista española. Ministerio de Educación y Cultura. Madrid: ICD; 2012, 239 pp.
19. Rodríguez, C.A., Siret, J.R., Carvajal., W. Evaluación de la Composición Corporal en el Control Biomédico de la Preparación de Atletas venezolanos. Proyecto de colaboración conjunta entre el INDER y el Instituto Nacional de Deportes de Venezuela. 2014.
20. Fleck S. Body composition of elite American athletes. Am J Sports Med. 1983;11:398–403.
21. Cabañas MD, Esparza F. Compendio de cineantropometría. Madrid: CTO Editorial; 2009.
22. Pons V, Riera J, Galilea PA, Drobnic F, Banquells M, Ruiz O. Características antropométricas, composición corporal y somatotipo por deportes. Datos de referencia del CAR de San Cugat, 1989–2013. Apunts Med Esport. 2015;50:65–72.
23. Fernández S, Alvero JR. La producción científica en cineantropometría: datos de referencia de composición corporal y somatotipo. Arch Med Deporte. 2006;23:17–35.

24. Carvajal W, Deturnel Y, Echevarría I, Martínez M, Castillo ME. Protocolo de valoración de la composición corporal para el control cineantropométrico del entrenamiento deportivo. Documento de consenso del departamento de Kinantropometría del Instituto de Medicina del Deporte de Cuba. Rev Cub Med Dep Cul. Fis. [Internet] 2010 [Consultado 22 Nov 2016]; 5(3) Disponible en: https://www.scribd.com/document/106156571/Protocolo-de-valoracion-de-la-composicion-corporal.
25. Alvero Cruz JR, Cabañas Armesilla MD, Herrero de Lucas A, Martínez Riaza L, Moreno Pascual C, Porta Manzañido J, et al. Protocolo de valoración de la composición corporal para el reconocimiento médico-deportivo. Documento de consenso del Grupo Español de Cineantropometría de la Federación Española de Medicina del Deporte. Arch Med Deporte. 2009;26:166–79.
26. Pancorbo AE. Medicina del Deporte y Ciencias Aplicadas al Alto Rendimiento y salud. Caxias do Sul: EDUCS; 2002.
27. Carvajal, W., Deturnel, Y. Exigencias para los indicadores de la composición corporal en deportistas cubanos de alto rendimiento: periodo 2011–2016. Folleto de consulta. Instituto de Medicina del Deporte, La Habana. 2011.