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The body composition of the elite Cuban baseball player

[La composición corporal de la beisbolista cubana de élite]

[A composição corporal do jogador de beisebol cubano de elite]

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ABSTRACT

Introduction: Body composition is defined as the combination of chemical and/or structural components that comprise the entire organism; chemically they can be discriminated in terms of water, lipids, proteins and minerals; structurally in terms of tissue, masses, organs or organic subsystems.

Objective: To establish reference values for the body composition of elite Cuban female baseball players, average and by playing position.

Materials and methods: The 21 female baseball players were evaluated using the Fractionation method. All were members of the national teams that participated in the first Caribbean Cup, 2022. The baseball players had average chronological and sporting ages of 26.8 and 12.4 years respectively.

Results: The baseball players were divided into four groups: pitchers, outfielders, infielders, and first basemen and catchers. Among the main results, it can be seen that the baseball players presented average values of body mass: 64.3 kg; height: 163.9 cm; $\sum 6P = 97.5$ mm; body fat: 20.0%; adipose mass=20.6 kg; muscle mass=27.7 kg and muscle -bone ratio =5.13

Conclusions: The average female baseball player has approximately 80% active body mass, high adiposity, and high values in the muscle-bone ratio.

Keywords: baseball, body composition, constitution.

RESUMEN

Introducción: la composición corporal se define como la combinación de los componentes químicos y/o estructurales que comprenden la totalidad del organismo; químicamente pueden discriminarse en términos de agua, lípidos, proteínas y minerales; estructuralmente en términos de tejido, masas, órganos o subsistemas orgánicos.

Objetivo: establecer valores de referencia para la composición corporal de la beisbolista cubana de élite, promedio y por posiciones de juego.

Materiales y métodos: las 21 beisbolistas fueron evaluadas a través del método de Fraccionamiento. Todas fueron miembros de las selecciones nacionales que participaron en la primera Copa del Caribe, 2022. Las beisbolistas contaban con edades cronológicas y deportivas promedio de 26,8 y 12,4 años respectivamente.

Resultados: las beisbolistas se dividieron en cuatro grupos: lanzadoras, jardineras, jugadoras de cuadro y primera + receptoras. Entre los principales resultados se aprecia que

las beisbolistas presentan valores promedio de masa corporal: 64,3 kg; estatura: 163,9 cm; $\sum 6P = 97,5$ mm; grasa corporal: 20,0%; masa adiposa=20,6 kg; masa muscular=27,7 kg y cociente músculo-hueso=5,13

Conclusiones: la beisbolista promedio posee alrededor de un 80% de masa corporal activa, adiposidad elevada y altos valores en la relación músculo-hueso.

Palabras clave: béisbol, composición corporal, constitución.

RESUMO

Introdução: A composição corporal é definida como a combinação de componentes químicos e/ou estruturais que compõem todo o organismo; quimicamente, podem ser distinguidos em termos de água, lipídios, proteínas e minerais; estruturalmente, em termos de tecido, massa, órgãos ou subsistemas orgânicos.

Objetivo: Estabelecer valores de referência para a composição corporal da jogadora média de beisebol feminina cubana de elite e por posições de jogo.

Materiais e métodos: As 21 jogadoras de beisebol foram avaliadas pelo método de fracionamento. Todas eram integrantes das seleções nacionais que participaram da primeira Copa do Caribe em 2022. As jogadoras de beisebol tinham idades cronológicas e esportivas médias de 26,8 e 12,4 anos, respectivamente.

Resultados: As jogadoras de beisebol foram divididas em quatro grupos: arremessadoras, defensoras externas, defensoras internas e primeira base + receptoras. Os principais resultados mostraram que as jogadoras de beisebol tinham valores médios de massa corporal: 64,3 kg; altura: 163,9 cm; $\sum 6P = 97,5$ mm; gordura corporal: 20,0%; massa adiposa = 20,6 kg; massa muscular = 27,7 kg; e relação músculo-osso = 5,13.

Conclusões: A jogadora de beisebol feminina média apresenta aproximadamente 80% de massa corporal ativa, adiposidade elevada e valores elevados de relação músculo-osso.

Palavras-chave: Beisebol, Composição corporal, Constituição

INTRODUCTION

Applied sciences play an important role in the development of sport, particularly regarding the selection and monitoring of athletes' adaptations and/or optimization status during training (Zaldivar *et al.*, 2021). Kinanthropometry, the science that studies the size, shape, proportionality, composition, biological maturation, and bodily function of humans in motion, is one of the areas where the greatest interest has been shown in the study of sports, including baseball.

Conceptual models of the physical characteristics of male baseball players have changed over the decades. This could also be a trend for female players, but due to a lack of research in this sport, it has not been confirmed. Women's baseball is one of the sports that has received the least attention in research.

In a recent review, only three publications related to women's baseball were found, out of a total of 4195 in the database of the United States National Library of Health (Quintero *et al.*, 2022).

Recent studies such as those by (Crespo *et al.*, 2021; Pérez *et al.*, 2021; Ríos Garit *et al.*, 2021; Pons *et al.*, 2023; Reyes, 2023) have addressed the sports training of male baseball players from different perspectives of applied sports science, through psychological, biomechanical, and physiological studies, dedicated to both pitching mechanics and the improvement of pitcher and batter preparation. Studies by Quintero *et al.* (2023) revealed the somatotype characteristics of Cuban female baseball players on the national team, an important pillar, along with body composition and proportionality, for the study of kinanthropometry.

Body composition is defined as the combination of chemical and/or structural components that comprise the entire organism. Chemically, these components can be categorized as water, lipids, proteins, and minerals; structurally, they can be categorized as tissues, masses, organs, or organ subsystems. Other models simplify body composition into two components: lean mass and fat mass. Therefore, the study of body composition involves breaking down an individual's weight into its components, which is crucial for assessing a person's physical and nutritional status.

Internationally, research by (Sada, *et al.*, 2020; Manzi *et al.*, 2022; Nose *et al.*, 2022) have studied the pitcher, his mineral, bone, and muscle composition, as well as the mechanics of his pitches. Other studies have focused on the study of adaptations to training loads using dual-energy X-ray absorptiometry (Czeck. *et al.*, 2019; Dobrosielski *et al.*, 2021).

More recent publications on body composition refer to those by (McFadden) *et al.*, 2023; Domaszewski *et al.*, 2023; Zouita *et al.*, 2023; Juckett *et al.*, 2023), who studied female athletes relating body composition values to athletic performance.

Body composition allows us to determine the relationship between skeleton, muscle, and fat tissue, fundamental elements in the biomedical monitoring of athletes during sports training. It has been observed that there is a lack of research on this pillar of kinanthropometry in women's baseball at the international level. To the best of our knowledge, no reports describing the body composition characteristics of these players were found in the specialized literature. The objective of this study is to establish reference values for the body composition of elite Cuban female baseball players, both average and by playing position.

MATERIALS AND METHODS

Twenty-one baseball players participating in the first Caribbean Cup in 2022 were evaluated through a descriptive and prospective study conducted during the pre-competitive training phase. The study population, categorized by playing position, consisted of six pitchers, seven outfielders, and eight infielders (including one first baseman and three catchers). The catchers and first baseman were grouped together for the study, forming the first baseman + catchers group. The mean chronological age was 26.8 ± 4.8 years, and the mean playing age was 14.2 ± 4.6 years. Of the sample, 33% were of mixed race, 22% were Black, and the remaining 45% were White.

The study complies with internationally established bioethical standards (World Medical Association, 2013). The athletes involved in the study gave their consent for the anthropometric tests to be performed, as well as for the use of the data to improve the quality of medical monitoring of sports training.

The equipment used included the 0.1 scale (Detecto, USA). kg precision for taking body weight; two stadiometers (Holtain, United Kingdom) with a precision of 0.1 mm for taking height; four skinfold calipers (10 g/m³) with 0.2 precision mm (Holtain, United Kingdom); two precision thickness gauges 1 mm to determine bone diameters and three measuring tapes of 1 mm precision (Holtain, United Kingdom) to determine the circumferences.

Therefore, anthropometric measurements were taken following the ISAK protocol (Esparza-Ros *et al.*, 2019), always in the morning. The technical error of the measuring devices was less than 4.3% for skinfold thicknesses (subscapular, triceps, supraspinal, calf) and less than 1% for the remaining measurements, including diameters (humerus and femur), circumferences (flexed arm and calf), weight, and height. Body composition values were calculated using all these measurements in an Excel spreadsheet designed for this purpose.

Body composition assessment

For the study of body composition, the anthropometric fractionation method of Ross and Kerr (1991) was used, which allowed obtaining the fractions of the masses of adipose, muscle, skeletal, and residual tissue.

Fractionation methods

Equations for calculating fat, muscle, bone, residual and skin mass using the Ross and Kerr method (1991).

Adipose mass (AM)

$Spl = \sum \text{triceps fold} + \text{subscapular fold} + \text{supraspinal fold} + \text{abdominal fold} + \text{anterior thigh fold} + \text{mid-leg fold}$

$$Z1 = ((Spl * (170,8/estatura)) - 116,41) / 34,79$$

$$MA (Kg.) = ((Z1 * 5,85) + 25,6) / ((170,18/estatura) 3$$

Muscle mass (MM)

$Spm = (\text{extended arm circumference} - 3.1416 * (\text{triceps fold} / 10) + \text{forearm fold} + (\text{normal thoracic circumference} - 3.1416 * (\text{subscapular fold} / 10)) + (\text{maximum thigh circumference} - 3.1416 * (\text{thigh fold} / 10)) + (\text{leg circumference} - 3.1416 * (\text{leg fold} / 10))$

$$Z2 = ((Spm * (170.18/estatura)) - 207,21) / 13,74$$

$$MM (Kg.) = ((Z2 * 5,4) + 24,5) / (170,18/estatura) 3$$

Bone Mass of the Head (BMB)

$$Z3 = (\text{circunferencia cefálica} - 56,0) / 1,44$$

$$MOC (Kg.) = ((Z3 * 0,18)) + 1,20$$

Body Bone Mass (BBM)

$$Sdoc = (\text{bicrestal diameter} + \text{biacromial diameter} + 2 * \text{humerus diameter} + 2 * \text{femur diameter})$$

$$Z4 = (Sdoc * (170,18 / \text{estatura}) - 98,88) + 5,33$$

$$MOCU (Kg.) = ((Z4 * 1,34)) + 6,70 / (170,18 / \text{estatura})^3$$

Residual Mass (RM)

$$Smr = (\text{anteroposterior diameter of the thorax} + \text{transverse diameter of the thorax} + \text{abdominal circumference})$$

$$Z5 = ((Smr * (89,92 / \text{estatura sentada}) - 109,35) / 7,08$$

$$MR (Kg.) = ((Z5 * 0,24)) + 6,10 / (89,92 / \text{estatura sentada})$$

Skin mass (SM)

The skin mass was determined as follows:

$$FMS = SA \times Tsk \times 1,05$$

Where:

FM_s = Skin mass in kg

SA = Surface area in M.²

1.05 = Skin density (cadaver data)

T_{sk} = Skin thickness in mm (cadaver data); men 2.07 mm

To calculate SA:

$$SA = Csa \times \text{Peso Corporal} \times 0.425 \times \text{Estatura} \times 0.725$$

Where:

C_{sa} = 68.308 in males aged > 12 years; 73.074 in females aged > 12 years.

RESULTS AND DISCUSSION

Table 1 shows the results of the body composition of the Cuban baseball players. When performing the Wilcoxon test to evaluate the evolution of these athletes, the characteristics of the average baseball player had a slightly higher significance in the percentage of kilograms of fat mass and adiposity ($\Sigma 6P$).

The components of active body mass, the percentages of residual mass and skin, and the active body substance index showed a slightly significant decrease ($p < 0.05$). In evaluating the application of the fractionation model, the average error was below 5% (+3.5%), highlighting the usefulness of the method, which overestimated by 2.5% kg of weight the actual mass (Table 1).

Table 1. - Body composition and anthropometric indices of Cuban female baseball players

	Assessment	
	X	OF
Adipose mass		
kg	20.6	5.3
%	31.8	4.5
Z	-0.43	0.97
Muscle mass		
kg	27.7	6.0

%	43.1	6.2
Z	1.17	0.99
Total bone mass		
kg	6.7	1.7
%	10.2	1.3
Z	-0.29	1.21
Residual mass		
kg	6.8	2.0
%	10.4	1.9
Z	-0.07	1.53
Skin mass		
kg	5.01	0.46
%	7.9	0.7
Mistake		
kg	+2.5	5.4
%	+3.5	7.5
Indexes		
$\sum 6P$	97.5	31.8
Muscle-Bone	5.13	1.21

Table 2 presents the results of the body composition fractionation estimation from a qualitative perspective. The method generally yielded normal estimates in half of the evaluated group. Overall, the method overestimates more than it underestimates. It overestimated in 36.4% of the sample and underestimated in only 9.1% of the evaluated sample (Table 2).

Table 2. - Qualitative results of body composition estimates by body mass fractionation in female baseball players

		Assessment
Normal	No	12
	%	54.5
Overestimates	No	8
	%	36.4
Underestimation	No	2
	%	9.1

Proportionally, the average female baseball player had greater muscle mass (1.17) than the reference Phantom (Figure 1). Residual mass was proportionally similar to the Phantom, while bone and fat masses were proportionally lower than those of the Phantom, the anatomical reference subject for fractionation.

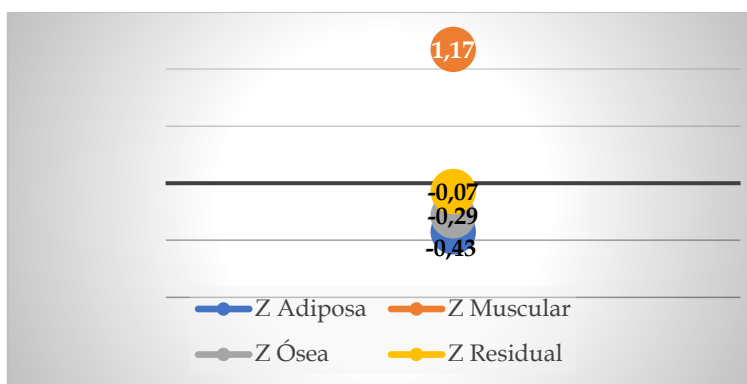


Fig. 1. - Phantom proportionality scores of body mass fractionation in Cuban female baseball players

The Ross and Kerr (1991) model constitutes the reference fractionation model for the Cuban sports population. Therefore, from a comparative standpoint, the average values of adipose tissue mass, muscle mass, and skeletal mass of the Cuban female baseball players studied will be compared with those of athletes from 12 sports previously studied by Carvajal during the validation of the model in the Cuban sports population.

Compared to the rest of the Cuban sports population, female baseball players have among those with the highest adipose tissue mass (adipose mass = 31.8%), surpassed only by female speed skaters ($X = 32.6\%$) and sailors ($X = 32.10\%$), with whom they share similarities. In absolute terms, female baseball players (adipose mass = 20.6%) have the highest percentage of body fat. kg) have a higher average value than the rest of the sports where collective sports such as basketball appear ($X=20.39$ kg), handball ($X=17.39$ kg), hockey ($X=15.35$ kg), volleyball ($X=19.69$ kg).

It is important to clarify that the percentage of fat and adipose tissue mass appear on two different scales; while adipose tissue mass generates higher values because it measures anatomically defined adipose mass, with its adipocytes, lipids, water, electrolytes and proteins (Ross and Kerr, 1991).

Regarding muscle mass, baseball players are among those with the highest muscle mass (muscle mass = 43.1%), surpassed only by kayak-canoe athletes ($X = 43.50\%$) and volleyball players ($X = 44.85\%$). In absolute terms, baseball players (muscle mass = 27.7%) kg) only showed average values lower than team sports such as basketball ($X=28.08$ kg) and volleyball ($X=33.45$ kg).

The skeletal weight of the Cuban baseball players studied has the same proportion as the rest of the athletes in the Cuban sports population studied; however, from an absolute point of view, the handball athletes ($X=7.16$ kg), kayak-canoe ($X=7.44$ kg) and basketball ($X=7.57$ kg) have a greater skeletal weight than baseball players.

The impact of residual mass and skin is not significant for performance; they are two components of active tissue, but rather their value in estimating fractionation, for this analysis, is to know if the method is acceptable for this specific population, and to what extent it is superior when compared to the benefits of this method in other sports of the same sex.

In this population, the model underestimated body mass by only 3.5%, within the permissible range of $\pm 5\%$, as proposed by Ross and Kerr (1988) for a normal assessment. From a comparative standpoint, the baseball players (Sum of percentage of masses = 103.4%) showed qualitatively superior estimates to those of most women's sports in Cuba, similar to those of canoe-kayak ($X = 98.0\%$), volleyball ($X = 98.0\%$), and sailing ($X = 97.0\%$), all within the $\pm 5\%$ body mass estimation range.

Based on the muscle mass/bone mass ratio, the muscle-bone index (MBI) has emerged. It's a kind of motor/chassis ratio and describes the development of muscle mass in relation to one of its limiting factors: bone or skeletal mass. If a muscle attaches to bony surfaces via tendons and ligaments, the size of this surface determines the force that this tendon attachment can exert. As a safety measure, biology would not allow a muscle to have a force that exceeds the musculotendinous junctions, which would cause detachment and injury. Inhibitory mechanisms such as the Golgi apparatus exist to prevent this.

The values found for the Cuban athletes studied (5.13) are above what the aforementioned author has defined as the normal range for this index ($3.0 < \text{IMO} \leq 4.2$). Holway (2008) has suggested that values above the normal limit may raise suspicions of anabolic substance use or of athletes with exceptional genetics, or in athletes where measurement errors have been made that underestimate bone mass.

In this case, the authors consider that the reference values of Holway (2008) were obtained from a population very different from the Cuban one and that studies on this index are lacking to assess whether ethnicity can be a limiting factor in interpreting the optimal value of this index for the sport in question.

Another important finding in this research is that the Cuban baseball player is characterized by having higher relative adiposity values than the average of the Cuban sports population, since only the super heavyweight categories of judo ($X=6.5$) and the shot putters ($X=4.5$) showed greater adiposity than the baseball players, when they were descriptively compared with 34 sports modalities studied by Carvajal et al. (2018) in the characterization of Cuban sport.

Descriptive analysis of the target population: profile by playing positions

In evaluating the application of the fractionation model (Table 3), it can be seen that pitchers stood out for having higher average values for adipose, muscle, and bone mass; on the other

hand, first and second catchers showed the highest absolute values for residual mass and skin. Regarding the muscle-bone ratio associated with this body composition estimate, outfielders (5.65) and infielders (5.07) showed greater potential than the other positions, which showed more modest values.

In the studies by Carvajal *et al.* (2018) and Czeck *et al.* (2019), athletes grouped as first base catchers and outfielders were among those who showed the highest levels of lean body mass. In this study, outfielders and infielders revealed higher values for muscle mass; in turn, infielders showed higher values for fat mass.

The aforementioned authors have suggested that infield positions, specifically second base and shortstop, require a high degree of power, agility, and balance. Therefore, these players commonly exhibit lower weight, height, and overall body fat profiles. However, for female receivers, greater weight, height, and lean body mass are beneficial for their protection due to the high probability of physical contact during defensive plays (Esparza, *et al.*, 2019) (Table 3).

Table 3. - Body composition and anthropometric indices of Cuban female baseball players by playing position

	Launchers		Planters		First+ Receptors		Paintings		p
	X	OF	X	OF	X	OF	X	OF	
Adipose mass									
kg	22.8	6.4	18.3	4.0	21.3	4.5	20.7	6.4	0.644
%	33.5	4.5	30.3	3.1	29.6	4.5	33.8	5.9	0.279
Z	-0.43	1.06	-0.64	0.54	-0.61	1.11	0.02	1.34	
Muscle mass									
kg	28.8	8.4	27.4	5.5	28.3	5.4	26.1	5.4	0.787
%	42.7	8.9	45.3	2.5	40.0	9.4	43.0	3.1	0.761
Z	0.83	1.38	1.51	0.63	0.75	0.39	1.45	1.16	
Total bone mass									
kg	7.5	2.4	5.9	1.3	7.3	1.0	6.2	1.5	0.153
%	10.9	1.9	9.7	0.9	10.1	0.9	10.2	1.2	0.318
Z	-0.14	1.54	-0.59	0.88	-0.19	1.37	-0.12	1.39	

Residual mass									
kg	7.3	2.9	6.1	1.8	7.8	1.6	6.4	1.1	0.464
%	10.4	2.9	10.0	1.7	10.8	1.7	10.7	1.0	0.893
Z	-1.02	1.53	0.09	1.12	0.09	1.91	0.70	1.59	
Skin mass									
kg	5.2	0.5	4.8	0.4	5.4	0.1	4.8	0.3	0.06
%	7.9	1.1	8.0	0.5	7.5	0.5	8.0	0.7	0.396
Mistake									
kg	-2.5	4.2	-2.7	4.4	0.9	4.3	-4.3	4.8	0.479
%	3.5	6.3	3.9	6.9	1.2	6.0	6.4	6.5	0.419
Indexes									
Σ6P	102.6	37.7	89.4	18.7	94.8	36.0	110.1	42.9	
Muscle-Bone	4.84	1.68	5.65	0.84	4.77	1.62	5.07	0.62	0.543

Figure 2 shows the relative fractionation of body mass according to the Ross and Kerr (1991) anthropometric model. It can be seen that pitchers and infielders share the highest average values for adipose tissue mass and skeletal mass. Infielders and outfielders have similar skin mass values and exhibit the highest percentage values for muscle mass. Catchers and first basemen show the lowest percentage values for adipose tissue and muscle mass (Figure 2).

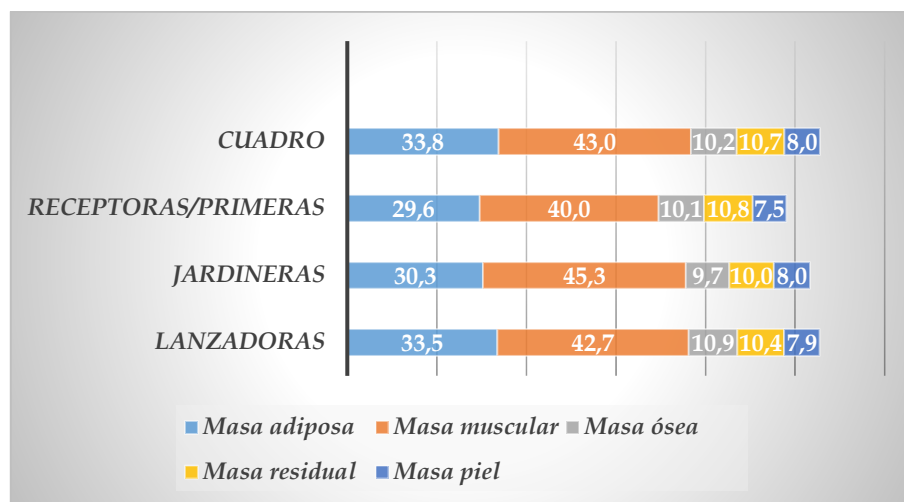


Fig. 2. - Model of body composition fractionation by playing positions in Cuban female baseball players

Body composition values of elite Cuban baseball players, average and by playing position

Based on the above, and taking into account the results described in the previous sections, the reference values for the body composition of the elite Cuban baseball player, average and by playing positions, are declared as referred to below (Table 4).

Table 4. - Reference values for the body composition of the elite Cuban baseball player, average and by playing position

POSITIONS	CHARACTERISTICS
Average player	No: 21; Chronological age: 26.8 years; Body mass: 64.3 kg; Height: 163.9 cm; $\sum 6P$ = 97.5 mm; body fat: 20.0%; adipose mass=20.6 kg; muscle mass=27.7 kg; total mass = 6.7kg; residual mass=6.8 kg; skin mass 5.01 kg ; muscle-bone ratio = 5.13.
Launchers	No: 6; Chronological age: 26.3 years; Body mass: 67.2 kg; Height: 169.5 cm; $\sum 6P$ = 102.6 mm; body fat: 20.7%; adipose mass=22.8 kg; muscle mass=28.8 kg; total bone mass= 7.5 kg; residual mass=7.3 kg; skin mass 5.2 kg ; muscle-bone ratio = 4.84.
Planters	No: 7; Chronological age: 27.8 years; Body mass: 59.9 kg; Height: 160.0 cm; $\sum 6P$ = 89.4 mm; Body fat: 18.4%; Adipose mass=18.3 kg; Muscle mass=27.4 kg; total mass = 5.9 kg; residual mass=6.1 kg; skin mass 4.8 kg ; muscle-bone ratio = 5.65.
Players of picture	No: 4; Chronological age: 26.2 years; body mass: 59.9kg; height: 158.4 cm; $\sum 6P$ = 110.1 mm; body fat: 22.1%; adipose mass=20.7kg; muscle mass=26.1kg; total bone mass= 6.2kg; residual mass=6.4kg; skin mass 4.8kg ; muscle bone ratio=5.07.
Catchers + first base	No: 4; Chronological age: 23.8 years; body mass: 71.1 kg; height: 169.3 cm; $\sum 6P$ = 94.8 mm; body fat: 19.3%; adipose mass = 21.3 kg; muscle mass = 28.3 kg; total bone mass = 7.3 kg; residual mass = 7.8 kg; skin mass = 5.4 kg ; muscle-bone ratio = 4.77.

CONCLUSIONS

This study provides reference values for theory and practice within the framework of high-performance athlete assessment. The elite Cuban female baseball player is characterized, among her most notable traits, by possessing approximately 80% active body mass, high adiposity, and high muscle-to-bone ratios. While such marked differences by playing position are not yet evident, only height and wingspan showed significant variations between positions. From a descriptive standpoint, pitchers and the first base/catcher combination had the largest absolute size, while infielders and outfielders had the highest muscle-to-bone ratios.

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Yannara Quintero Batista: Conceptualization, literature search and review. Review of the bibliographic style guidelines used.

Lianet L. Setién Boronat: Literature search and review, information gathering, translation of the abstract.

Bergelino Zaldívar Pérez: General advice on the topic. Analysis of results. Revision and final version of the article. Proofreading.



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