Body Type and Performance of Elite Cuban Baseball Players

Wiliam Carvajal, MS, Andrés Ríos, MD, Ivis Echevarría, Miriam Martínez, Julio Miñoso, MD, Dialvis Rodríguez, MS

ABSTRACT

Introduction Appropriate stature and adequate somatotype are not the only attributes determining athletic performance, but they are important prerequisites for sports participation and success. However, there is scant literature on baseball players' kinanthropometric profiles and their association with performance. Given that Cuban baseball players have been among the world's top performers in recent decades, characterization of their morphological features linked to their performance may contribute to developing the evidence base in this area.

Objective Describe the kinanthropometric profile related to sports performance of elite Cuban baseball players, classified by playing position.

Methods Body composition, somatotype, proportionality, and performance were measured in 100 elite baseball players grouped by playing position and performance. Data from the 2002–2003 baseball season was gathered for players participating in the 43rd Cuban National Baseball Series (November 2003–May 2004). Slugging percentage (SLG) was used to measure performance of all players except pitchers, whose performance was measured as end-of-season win-loss record. Mean and standard deviation values were calculated for anthropometric and performance results, presented in tables for comparison. ANOVA and MANOVA analyses were applied to determine magnitudes of difference between the variables studied, as well as statistical significance of the differences established ($p \leq 0.05$ and $p \leq 0.01$).

Results Performance and body type varied by playing position, and statistically significant differences were found in performance, body composition and somatotype variables between some positions. No significant differences in proportionality were found. First basemen and outfielders (center, left, and right fielders) were the best offensive players with the highest mean SLG, body weight and muscle mass values. Infielders (second basemen, shortstops, and third basemen) had the lowest mean body weight and adipose tissue mass values, as well as the lowest mean SLG. Catchers had similar mean weight, height, muscle mass, and adipose tissue mass values as first basemen, outfielders and infielders, but a low mean SLG similar to that of infielders. Pitchers were morphologically similar to players in all positions, but significant morphological differences were found among pitchers with different performance levels. Better-performing pitchers (≥.600 winning percentage (Wpct)) were significantly heavier and more mesomorphic than lower-performing pitchers (<.600 Wpct). All players were predominantly mesoendomorphic, but mean somatotype values varied between players in different positions, and between pitchers with different performance levels.

Conclusions The kinanthropometric profile of high-performance baseball players described in this study generally coincides with the available literature. Further research on comparative samples is needed to validate the relationship between players' body type and performance. Nevertheless, the results of this study may be applied to criteria for selection and training of high-performance baseball players in Cuba.

Key words: Body composition, somatotypes, anthropometry, sports, baseball, athletic performance, sports performance

INTRODUCTION

Kinanthropometry—the study of body composition, somatotype and proportionality—has become a key tool for athletic training and talent selection.[1,2] Together, these three characteristics describe an individual's morphological profile, which serves as a basis for planning and monitoring athletic training. Although sports performance depends on multiple factors, and winning requires much more than an individual player's build and physical fitness, the anthropometric characteristics of the most successful athletes may also serve as guides for talent selection.[3,4]

Body composition refers to the characterization of body weight in terms of absolute and relative amounts of fat mass and fat-free mass. Measurement and evaluation of these characteristics is a vital aspect of health, nutritional status and physical fitness assessment.[5,6] Somatotype is a classification of the human body according to three essential elements: endomorphy, or relative adiposity; mesomorphy, relative musculoskeletal development; and ectomorphy, relative human linearity.[7] Human proportionality describes the relationship between different body dimensions and stature. This is a very important consideration for anyone wishing to practice sports, since this relationship is associated with a person's physical ability to meet the biomechanical demands of a particular sport or playing position within a given sport. Athletic ability and performance, as well as aptitude for a particular sport, depend greatly on proportionality.[8]

The ideal build of athletes in different sports and within the same sport have been described,[9-12] but little has appeared about the physical characteristics of high-performance baseball players. Most studies of baseball players refer to biomechanics, traumatology, and pitch velocity.[13-18] A few authors have suggested that morphofunctional differences among baseball players correspond to their performance role, since defensive actions—such as catching, fielding and throwing the ball—require different levels of strength, power, swiftness, balance, coordination, running speed, arm and leg movement speed, local muscle tolerance and cardiorespiratory tolerance than offensive actions—such as batting and base running.[19,20]

In Cuba, a pioneering study by Tejedor et al. described the morphological profile of players who participated in the 1986–1987 National Baseball Series and reported differences in somatotype and proportionality among players in different positions.[21] In 1986, Rodríguez et al. also published data on body composition, somatotype and proportionality of Cuban baseball players.[22]

Cuban baseball players have been among the elite of amateur baseball for almost fifty years, with three Olympic gold medals (Barcelona 1992, Atlanta 1996 and Athens 2004) and the 2006 World Baseball Classic sub-championship among their achievements. They have also won 27 World Amateur Baseball Championships, 25 World Cups, 10 Inter-Continental Cups and 12 Pan

American Games.[23] Considering this high performance record, and given the scarcity of literature on the physical characteristics of elite baseball players, details of Cuban players' morphology linked to their sports performance may contribute to developing the evidence base in this area.

This study was conducted to describe the morphological profile of elite Cuban baseball players by playing position, and to determine association between mean body type and sports performance variables for each playing position.

METHODS

Study type and sample A retrospective descriptive study was carried out February 2004 through July 2005. One hundred Cuban baseball players who participated in the 43rd Cuban National Baseball Series (November 2003–May 2004) were selected, representing the following positions: 20 first basemen (1B), 7 second basemen (2B), 7 third basemen (3B), 6 shortstops (SS), 6 center fielders (CF), 14 left and right fielders (LF and RF), 20 catchers (C) and 20 pitchers (P). Mean age was 28.56±5.2 years with 16.45±5.3 years playing baseball.

Written informed consent was obtained from all athletes participating in the study, and the study was approved by the Ethics Committee of the Cuban Sports Medicine Institute.

Performance statistics for each player were gathered from the 2002–2003 season Official Cuban Baseball Guidebook,[24] and anthropometric measurements of all players in the sample were taken during the last three months of the 43rd series (February–April 2004). These data were entered in a database created for the study and subsequently analyzed.

Inclusion criteria All active players in the 43rd Cuban National Baseball Series who had participated in at least 10 National Baseball Series and been at bat at least 1,500 times were included in the study sample. In the case of pitchers, priority was given to those who had pitched at least 1,000 innings.[24]

Classification of players by performance role Players were grouped in five categories according to their roles in the field: infielders (IF), including 2B, SS and 3B; outfielders (OF), including CF, RF and LF; catchers (C); first basemen (1B); and pitchers (P).

Classification of pitchers by performance level Given that pitching performance cannot be compared to performance in the other positions, and because defense statistics are different, pitchers were divided into two groups based on winning percentage (WPct), calculated by dividing number of games won by total number of games won and lost in the 2002–2003 season, as recorded in the Official Cuban Baseball Guidebook.[24]

Pitchers with <.600 WPct were included in Group PL1, representing lower performance, and those with ≥.600 WPct became Group PL2, representing higher performance. This classification resulted in 10 pitchers in each category.

Body composition measurement The Ross and Kerr Body Mass Fractionation protocol[25] was followed, which includes the following parameters: adipose tissue mass (ATM), muscle mass (MM), bone mass (BM), residual mass (RM), and skin mass (SM). Body weight and mass were measured in kilograms (kg), and height in centimeters (cm).

Anthropometric somatotype classification The Heath-Carter method was used to measure body shape and composition in terms of endomorphy (relative adiposity or fatness), mesomorphy (relative musculoskeletal development or robustness) and ectomorphy (relative linearity or slenderness).[7] Using this method, anthropometric measurements are converted to a rating from 0 to >7; ratings of 0–2.5 are considered low, 3–5 moderate, 5.5–7 high, and >7.5 very high.

Body Proportionality The following ratios were used as proportionality indicators:

Relative biacromial breadth (RBAB) = biacromial breadth x 100 / height
Relative biiliocristal breadth (RBCB) = biiliocristal breadth x 100 / height
Relative wrist breadth (RWB) = wrist breadth x 100 / height
Relative upper arm length (RUAL) = upper arm Length x 100 / height
Relative arm length (RAL) = arm length x 100 / height
Relative lower leg length (RLLL) = lower leg length x 100 / height
Relative leg length (RLL) = leg length x 100 / height

All measurements were made in centimeters (cm) following the standards recommended by the International Society for the Advancement of Kinanthropometry (ISAK).[26]

Performance terminology used in data collection and analysis

GW: Number of games won by a pitcher in one season.

Wpct (winning percentage): Ratio of games won to total games won and lost by a pitcher in one season. This indicator is synonymous with pitcher efficiency. Pitchers' 2002–2003 end-of-season Wpct was obtained for this study.

SLG (slugging percentage): Total number of bases run per hit by a batter, divided by his official number of times at bat in one season. This indicator is synonymous with batter efficiency. Each batter's 2002–2003 end-of-season SLG was obtained.

Statistical Analysis Mean (X) and standard deviation (SD) values were obtained for each variable measured in the study and expressed as X±SD. For each variable, a univariate analysis of variance (ANOVA) was performed to verify the hypothesis of equal means between playing positions after the premise of variance homogeneity was verified using Levene's test.

The Brown-Forsythe mean comparison test was used to compare proportionality indexes when the equality of variance assumption was not met. Multivariate analysis of variance (MANOVA) was performed using Wilks' Lambda test to contrast the mean somatotype equality hypothesis between positions, following the method proposed by Cressie et al.[27] Tukey's post-hoc test was used to determine the magnitude of significant difference between playing positions for each variable.

Student's t-test was applied to compare the two groups of pitchers with different performance levels. NCSS-PASS-GESS and SPSS 11.5 statistical packages for Windows were used for data processing. Significance levels for the statistical tests performed were set at $p \leq 0.05$ and $p \leq 0.01$. Results were presented in tables.

Table 1: Morphological and Performance Variables of Elite Cuban Baseball Players by Playing Position (Mean and Standard Deviation)

Variable	First Basemen (1B)	Infielders (IF) (2B,3B,SS)	Catchers (C)	Outfielders (OF) (CF,RF,LF)	Pitchers (P)
Weight (kg)	98.3±5.76	82.7±5.22	90.16±5.62	88.3±5.13	87.6±4.57
Height (cm)	183.7±4.85	179.0±4.09	179.2±4.40	177.1±4.04	181.5±4.76
SLG	0.494±0.05	0.421±0.07	0.424±0.07	0.467±0.07	-
Muscle Mass (kg)	48.41±5.01	41.31±2.60	44.80±3.02	45.60±3.8	40.67±4.65
Adipose Tissue Mass (kg)	22.93±4.21	17.01±6.67	25.04±2.00	23.06±5.01	20.77±5.01
Bone Mass (kg)	11.00±3.30	8.9±2.32	8.00±1.06	7.92±2.00	10.00±1.19
Residual Mass (kg)	11.50±1.02	11.34±1.92	11.7±1.90	12.6±1.80	11.2±1.17
Skin Mass (kg)	8.00±1.60	8.12±0.30	8.20±0.19	8.09±0.15	8.31±0.28
RBAB	26.0±6.88	22.95±1.20	23.81±0.80	23.15±0.89	23.32±0.95
RBCB	20.70±0.80	15.61±0.37	15.70±0.71	15.46±1.00	15.63±0.77
RWB	4.60±1.61	4.02±0.15	4.13±0.21	4.19±0.23	4.03±0.20
RUAL	18.07±0.43	19.21±0.61	17.52±2.22	18.36±0.50	18.60±0.58
RAL	15.50±0.31	15.52±0.57	15.36±0.68	15.22±0.88	15.26±0.65
RLLL	24.82±1.00	25.00±0.69	25.09±1.11	24.97±1.00	24.73±1.00
RLL	24.67±0.62	24.00±0.40	23.92±0.20	24.57±1.36	24.89±1.14

SLG: slugging percentage; RBAB: Relative biacromial breadth; RBCB: Relative biiliocristal breadth; RWB: Relative wrist breadth; RUAL: Relative upper limb length; RAL: Relative arm length; RLLL: Relative lower limb length; RLL: Relative leg length.

RESULTS

Performance, body composition and proportionality of elite Cuban baseball players Mean values in Table 1 show that first basemen were the tallest and heaviest players with the largest muscle and bone mass, and had the highest slugging percentages. At the opposite end of the spectrum, infielders (2B, 3B and SS) were lighter and leaner than other players, with the lowest SLG values and slightly larger muscle mass than pitchers, whose muscle mass was the smallest. Outfielders and catchers had the lowest bone mass value, while catchers had the highest mean fat mass value, followed by outfielders. Proportionality values were statistically similar across all playing positions.

Statistical analysis found highly significant differences ($p \leq 0.01$) in mean weight, height, SLG, bone mass, muscle mass and residual mass between some playing positions. No significant differences were found for the other variables (Table 2).

Tukey's post hoc test revealed that first basemen and catchers were significantly heavier than infielders; first basemen and pitchers were significantly taller than outfielders; and first basemen and outfielders had significantly higher SLG values than catchers and infielders. Infielders, on the other hand, had significantly smaller muscle and fat mass than outfielders and first basemen; significantly smaller bone mass than pitchers and first basemen; and significantly smaller residual mass than catchers, outfielders and first basemen. Pitchers also had significantly smaller bone mass than first basemen.

Somatotype Players in all positions presented a mesoendomorphic somatotype, reflecting predominant musculoskeletal development and greater adiposity than leanness. Infielders were the most ectomorphic, followed by pitchers (Table 3).

MANOVA results showed significant differences between the vectors that make up the somatotypes for each position. ANOVA results (F Test) showed that each somatotype component contributed significantly to differences between vectors. Tukey's post hoc test revealed that catchers were significantly more endomorphic than infielders and outfielders, catchers and infielders were significantly more mesomorphic than pitchers, and infielders and pitchers were significantly more ectomorphic than catchers and outfielders (Table 4).

Morphological comparison of pitchers with different performance levels Table 5 shows the mean values of the variables for the two groups of Pitchers studied: PL1 (lower performance) and PL2 (higher performance). All values except ectomorphy and relative leg length (RLL) were higher in the PL2 group, and significant differences were found in games won, body weight, bone mass and residual mass values. The mean somatotype of pitchers in both groups was mesoendomorphic, although the PL2 group was significantly more mesomorphic than the PL1 group. No significant differences were found for the remaining variables.

Table 2: Morphological and Performance Variables of Elite Cuban Baseball Players by Playing Position

Variable	ANOVA p	Tukey's post hoc test
Weight (kg)	0.00*	1B, C vs IF
Height (cm)	0.00*	1B, P vs OF
SLG	0.00*	1B, OF vs IF, C
Muscle Mass (kg)	0.00*	IF vs 1B, OF
Adipose Tissue Mass (kg)	0.00*	IF vs 1B, OF
Bone Mass (kg)	0.00*	IF vs P, 1B; P vs 1B
Residual Mass (kg)	0.00*	IF vs C, OF, 1B
Skin Mass (kg)	ns	-
RBAB	ns	-
RBCB	ns	-
RWB	ns	-
RUAL	ns	-
RAL	ns	-
RLLL	ns	-
RLL	ns	-

* $p \leq 0.01$, highly significant ns: not significant
1B: First basemen; IF: Infielders; OF: Outfielders; C: Catchers; P: Pitchers; SLG: slugging percentage; RBAB: Relative biacromial breadth; RBCB: Relative biiliocristal breadth; RWB: Relative wrist breadth; RUAL: Relative upper limb length; RAL: Relative arm length; RLLL: Relative lower limb length; RLL: Relative leg length.

Table 3: Somatotype of Elite Cuban Baseball Players by Playing Position (Mean and Standard Deviation)

Position	Endomorphy	Mesomorphy	Ectomorphy
First Base (1B)	3.38±0.41	6.83±0.42	0.60±0.39
Infield (IF)	2.86±0.24	5.91±0.24	1.54±0.23
Catcher (C)	4.08±0.31	6.84±0.21	0.32±0.29
Outfield (OF)	2.96±1.31	6.66±0.23	0.66±1.07
Pitcher (P)	3.26±0.16	5.66±0.17	1.47±1.16

Table 4: Mean Somatotypes and Somatotype Components among Elite Cuban Baseball Players by Playing Position

Analysis	Somatotype	Value	p	Tukey's post hoc test
MANOVA	Mean somatotype	0.67	0.00*	-
ANOVA	Endomorphy	0.66	0.02†	C vs IF, OF
ANOVA	Mesomorphy	0.72	0.00*	C, IF vs P
ANOVA	Ectomorphy	8.88	0.00*	IF, P vs C, OF

*p≤0.01 †p ≤0.05.
1B: First basemen; IF: Infielders (2B,3B,SS); OF: Outfielders (CF,RF,LF); C: Catchers; P: Pitchers.

Table 5: Morphology and Performance of Elite Cuban Baseball Pitchers, by Performance Level

Variable	PL1	PL2	p
GW	8.82±0.59	10.51±0.24	0.00*
Weight (kg)	84.45±4.02	93.72±4.04	0.00*
Height (cm)	180.45±4.92	182.37±3.98	0.24
Muscle Mass (kg)	41.25±5.85	44.94±2.63	0.08
Adipose Tissue Mass (kg)	21.35±5.19	24.02±4.26	0.22
Bone Mass (kg)	9.67±1.12	10.80±1.18	0.04†
Residual Mass (kg)	11.36±1.56	12.71±0.66	0.02†
Skin Tissue (kg)	8.25±0.37	8.35±0.37	0.55
Endomorphy	3.18±1.12	3.50±0.92	0.49
Mesomorphy	4.23±1.01	6.20±1.03	0.00*
Ectomorphy	1.67±0.98	1.08±1.00	0.19
RBAB	23.41±1.10	23.68±1.05	0.58
RBCB	15.47±0.72	16.02±0.82	0.12
RWB	4.01±0.29	4.17±0.19	0.16
RUAL	18.69±0.60	18.98±0.77	0.35
RAL	14.88±0.45	15.33±0.80	0.14
RLLL	24.19±1.04	25.04±1.12	0.09
RLL	25.60±1.21	25.41±1.36	0.74

*p≤0.01 †p≤0.05 . GW: number of games won per season; RBAB: Relative biacromial breadth; RBCB: Relative biiliocristal breadth; RWB: Relative wrist breadth; RUAL: Relative upper limb length; RAL: Relative arm length; RLLL: Relative lower limb length; RLL: Relative leg length.

DISCUSSION

Several studies have demonstrated differences in the physical build of athletes playing different sports and different positions within the same sport, as well as differences between male and female athletes playing the same sport and the same position.[4,28,29]

Various authors have observed that certain morphological types are more suited to the biomechanical and tactical demands of each playing position in team sports.[2,21,28,30] Gualdi and Russo suggested that anthropometric differences among players respond to the tactical demands of each position,[28] and Fleck showed that athletes playing roles for which absolute body height is a decisive competitive edge have greater musculoskeletal development, whereas athletes whose performance depends on speed weigh less and have a lower percentage of body fat.[31]

Other authors have also observed that body fat is inversely proportional to performance in sports or playing positions requiring swift movement.[32,33]

The impact of residual mass and bone mass on performance has not been defined in the literature, but Janssen et al. found that height and body weight explain about half of the variations in musculoskeletal tissue and therefore concluded that taller and heavier individuals generally have longer bones and muscles, and therefore a larger build.[34]

Results of this study coincide with all of these findings, as well as the mesoendomorphic somatotype of baseball players in general and the endomorphic, mesomorphic and ectomorphic variations between players in different playing positions described by other authors.[20-22,30]

First basemen and outfielders frequently play a greater offensive role in the batting lineup.[30,32] This study found that these players not only had higher SLG values than players in other positions but that their morphology—larger muscle mass and predominant mesomorphy—was also consistent with greater offensive power, although these values were not significantly higher than those of other players.

On the other hand, infielders and catchers—positions defined as the most defensive by some authors[19,20,30]—had the lowest SLG values. Mean muscle mass values between these two positions were not significantly different, although the mean value for catchers was higher. Other authors have found that catchers are tall with large musculoskeletal development.[21,22,30] Results of this study coincided with this profile; catchers had the highest mesomorphic values, and their height was not significantly different from that of first basemen, who were the tallest players in the sample. Infielders had the lowest weight and adipose tissue mass values, which coincide with the need for speed and agility in these positions.[20,30,32]

Winning pitchers are often distinguished by their strength, fitness, coordination, wits and adequate tactical thinking.[14,16,32] In one study, Guillén obtained highly significant correlations between pitchers' throwing speed and some anthropometric variables, including body weight, height, mesomorphy and muscle mass, suggesting that these variables influence pitchers' performance.[35] The present study makes the same correlation with pitching performance measured as total end-of-season games won. Further research applying statistical or regression methods is recommended to determine the contribution of each anthropometric variable to pitchers' success.

Some authors suggest that the body composition of many athletes has evolved toward a more compact and competitive build as part of a process known as secular acceleration, which is associated with increases in weight, height, muscle mass and other physical dimensions over time.[12,36-38] Ackland et al found that the morphology of canoe paddlers evolved between 1975 and 2000 toward a more compact build.[11] Lozovina and Pavicic also found that the body structure of Croatian water polo players changed as a result of secular acceleration between 1980 and 1995.[36] Kraemer et al showed increases in the body mass of US National League football players since 1970,[37] and Carvajal et al. also

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.[38] Norton and Olds attribute secular change in athletes' morphology to the morphofunctional demands of a particular sport, the use of specialized training methods, and new criteria for talent selection, among other aspects.[39]

There is some evidence of secular change in body composition, somatotype and the full range of anthropometric parameters in Cuban baseball players, possibly due to talent selection based on anthropometric parameters, morphological adaptation, and higher qualifying scores in international tournaments, among other elements.

In the last 20 years, the average height of elite Cuban baseball players has increased by about 3 cm, and their body weight has increased by 10–15 kg,[38] compared to measurements reported by Tejedor et al and Rodríguez et al. in the late 1980s.[21,22] In a study of Venezuelan, Cuban and Puerto Rican baseball players who participated in tournaments in the 1990s, García reported mesomorphy values of 4.7±1.0; 4.9±1.0 and 4.7±0.9 for Venezuelan, Cuban and Puerto Rican pitchers, respectively.[30] In the present study, however, pitchers' mean mesomorphy value was higher (5.66±0.17).

Results of this study coincide with the morphological profile of elite baseball players described by other authors. Further research with comparative samples is needed to validate the relationships between players' body type and performance. Nevertheless, the results of this study may be applied to criteria for selection and training of high-performance baseball players in Cuba.

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REFERENCES

1. Leone M, Lariviere G, Comtois AS. Discriminant analysis of anthropometric and biomotor variables among elite adolescent female athletes in four sports. J Sports Sci. 2002 Jun;20(6):443-9.
2. Carvajal W. Valoración del comportamiento de los diferentes indicadores antropométricos en el voleibol cubano elite en el periodo 1992–2000 y sus tendencias. [master's thesis]. Havana (CU): University of Havana; 2005.
3. Carter JE. Morphological factors limiting human performance. In: DH Clarke, Eckert HM, editors. Limits of Human Performance. Champaign (IL): Human Kinetics, American Academy of Physical Education Papers; 1985. p.1-7.
4. Giampietro M, Pujia A, Bertini I. Anthropometric features and body composition of young athletes practicing karate at a high and medium competitive level. Acta Diabetol. 2003;40(1 Suppl):S145-48.
5. Kim JH, Gallagher D, Song MY. Comparison of Body Composition Methods During Weight Loss in Obese Women Using Herbal Formula. AJCM. 2005;33(6):851-8.
6. Wang Z, Heshka S, Pierson RN, Heymsfield SB. Systematic organization of body composition methodology: an overview with emphasis on component-based. Am J Clin Nutr. 1995;61:457-65.
7. Carter JE, Heath BH. Somatotyping: development and applications, 1st edition. New York: Cambridge University Press; 1990.
8. Ross WD, Wilson NC. A stratagem for proportional growth assessment. Acta Paed Bel. 1974;28:169-82.
9. Young WB, Pryor L. Relationship between preseason anthropometric and fitness measures and indicators of playing performance in elite junior Australian Rules football. J Sci Med Sport. 2007 Apr;10(2):110-8. Epub 2006 Jul 18.
10. Srhoj V, Marinovic M, Rogulj N. Position specific morphological characteristics of top-level male handball players. Coll Antropol. 2002;26(1):219-27.
11. Ackland TR, Ong KB, Kerr DA, Ridge B. Morphological characteristics of Olympic sprint canoe and kayak paddlers. J Sci Med Sport. 2003;6(3):285-94.
12. Kerr DA, Ross WD, Norton K, Hume P, Kagawa M, Ackland TR. Olympic lightweight and open-class rowers possess distinctive physical and proportionality characteristics. J Sci Med Sport. 2007 Jan;25(1):43-53.
13. Escamilla R, Fleisig G, Barrentine S, Andrews J, Moorman C. Kinematic and kinetic comparisons between American and Korean professional baseball pitchers. Sports Biomech. 2002;1(2):213-28.
14. Escamilla RF, Speer KP, Fleisig GS, Barrentine SW, Andrews JR. Effects of throwing overweight and underweight baseballs on throwing velocity and accuracy. Sports Med. 2000;29(4):259-72.
15. Fleisig GS, Barrentine SW, Zheng N, Escamilla RF, Andrews JR. Kinematic and kinetic comparison of baseball pitching among various levels of development. J Biomech. 1999;32(12):1371-5.
16. Pugh SF, Kovaleski JE, Heitman RJ, Pearsall AW. Upper and lower body strength in relation to underhand pitching speed by experienced and inexperienced pitchers. Percept Mot Skills. 2001;93(3):813-8.
17. Murata A. Shoulder joint movement of the non-throwing arm during baseball pitch—comparison between skilled and unskilled pitchers. J Biomech. 2001;34(12):1643-7.
18. Escamilla RF, Fleisig GS, Zheng N, Barrentine SW, Andrews JR. Kinematic comparisons of 1996 Olympic baseball pitchers. J Sports Sci. 2001 Sep;19(9):665-76.
19. Hay JG. The Mechanics of Sports Techniques, 2nd edition. New Jersey: Prentice Hall; 1978.
20. Rivera MA. Morpho-functional profile of the Puertorican baseball players of high level performance. Apunts. 1991;(24):27-36.
21. Tejedor O, Haces O, Díaz J, Gutiérrez S. Considerations about somatotype of the national baseball players. In: Estudios de Antropología Biológica. IV Coloquio de Antropología Física José Comas. Mexico City: UNAM; 1986. p. 407-415.
22. Rodríguez CA, Sánchez G, García E, Martínez M, Cabrera T. Contribution to the study of the morphological profile of highly competitive male Cuban athletes. Boletín Científico-Técnico, INDER Cuba. 1986;1(2):6-24.
23. Bjarkman PC, editor. History of Cuban baseball, 1864-2006.1st ed. Jefferson (NC): McFarland & Company; 2007.
24. Guía Oficial del Béisbol cubano. Temporada 2002-2003. Havana: CINID-INDER; 2003.
25. Ross WD, Kerr DA. Fraccionamiento de la masa corporal: "un nuevo método para utilizar en nutrición clínica y medicina deportiva". Apunts. 1993;(18):175-87.
26. Norton K, Whittingham NO, Carter L, Kerr D, Gore C, Marfell-Jones M. Measurement techniques in anthropometry. In: Norton K, Olds T, editors. Anthropometrica. Sydney: University of New South Wales Press; 1996. p. 25-75.
27. Flores Z. La estadística en el contexto de las Investigaciones Bioantropológicas. In: García P, editor. Introducción a la investigación Bioantropológica en Actividad Física, Deporte y Salud. Caracas: FACES UCV; 2006. p. 45-75.
28. Gualdi E, Russo L. Somatotype, role and performance in elite volleyball players. J Sports Med Phys Fitness. 2001 Jun;41(2):256-62.
29. Bayios IA, Bergeles NK, Apostolidis NG, Noutsos KS, Koskolou MD. Anthropometric, body composition and somatotype differences of Greek elite female basketball, volleyball and handball players. J Sports Med Phys Fitness. 2006;46(2):271-80.
30. García P, editor. El tipo físico del jugador de béisbol aficionado: un enfoque antropológico. Temas de Antropología. Caracas: FACES UCV; 2007. p.35-45.
31. Fleck SJ. Body composition of elite American athletes. Am J Sports Med. 1983;11(6):398-403.
32. Espinosa L. Composición corporal en los jugadores de béisbol elite en Ciudad de la Habana en el periodo 1993-2002 y sus tendencias. [master's thesis]. Havana (CU): Higher Institute of Medical Sciences; 2005.
33. Claessens AL, Lefevre J, Beunen G, Malina RM. The contribution of anthropometrics to performance scores in elite female gymnasts. J Sports Med Phys Fitness. 1999;9(4):355-60.
34. Janssen I, Heismfield SB, Wang Z, Ross R. Skeletal Muscle Mass and distribution in 468 men and women aged 18-88 yr. J Appl Physiol. 2000;89:81-8.

35. Guillén ME. Estudio cineantropométrico para la selección de talentos en lanzadores de béisbol en Venezuela [dissertation]. Havana (CU): University of Havana; 2007.
36. Lozovina V, Pavicic L. Anthropometric changes in elite male water polo players: survey in 1980 and 1995. Croat Med J. 2004;45(2):202-5.
37. Kraemer WJ, Torine JC, Silvestre R, French DN, Ratamess A, Spiering BA, et al. Body size and composition of National Football League players. J Strength Cond Res. 2005;19(3):485-9.
38. Carvajal W, Ríos A, Echevarría I, Martínez M, Castillo ME. Tendencia secular en deportistas cubanos de alto rendimiento: periodo 1976-2008. Rev Española Antrop Biol. 2008;28:69-77.
39. Norton K, Olds T. Morphological evolution of athletes over the 20th century: causes and consequences. Sports Med. 2001;31(11):763-83.

THE AUTHORS

Wiliam Carvajal Veitía (Corresponding Author: wiliam.carvajal@infomed.sld.cu), anthropologist. Professor of kinanthropometry and biostatistics. Head of the kinanthropometry laboratory, Sports Medicine Institute, Havana, Cuba.

Andrés Ríos Hernández, specialist in sports medicine, medical management of athletic training, and traditional and bioenergetic medicine. Professor and adjunct researcher, Sports Medicine Institute, Havana, Cuba.

Ivis Echevarría García, anthropometry technician, Kinanthropometry Department, Sports Medicine Institute, Havana, Cuba.

Miriam Martínez Acosta, anthropometry technician, Kinanthropometry Department, Sports Medicine Institute, Havana, Cuba.

Julio Miñoso Molina, specialist in sports medicine. Adjunct researcher and deputy director of medical management of athletic training, Sports Medicine Institute, Havana, Cuba.

Dialvis Rodríguez Hernández, anthropologist. Adjunct researcher, Anthropology Institute, Havana, Cuba.

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