⌾ open acess

RBFEx

Brazilian Journal of Exercise Physiology

Original Article

Anthropometric characteristics vary by game position and demonstrate correlation with motor performance in handball

Características antropométricas variam em função da posição de jogo e demonstram correlação com o desempenho motor no handebol

Lucas de Paula Oliveira[1]* ⏺, Vitor Luiz de Andrade[2] ⏺, Luiz Henrique Palucci Vieira[2] ⏺, Rodrigo Leal de Queiroz Thomaz de Aquino[3] ⏺, Luiz Guilherme Cruz Gonçalves[1] ⏺, Rafael Pombo Menezes[1] ⏺, Enrico Fuini Puggina[1] ⏺.

1. School of physical education and sport of Ribeirao Preto, University of São Paulo, Ribeirão Preto, São Paulo, Brazil.
2. Bauru Faculty of Science, Paulista State University Julio Mesquita Filho, Bauru, São Paulo, Brazil.
3. Federal University of Espírito Santo, Vitoria, Espirito Santo, Brazil.

ABSTRACT

Aim: The aims of this study were to describe and compare anthropometric variables and motor performance between playing positions, and to test the correlations between these variables in adult handball players.
Methods: Twenty-three handball players (20,78 ± 3,83 years) participated in the study, being subdivided by position into backs (n = 9), wings (n = 9) and pivots (n = 5). Two assessment batteries were carried out, with an interval of 72 h. In the first battery the anthropometric (height, body mass, lean mass, fat mass, and fat mass percentage) and performance variables were analyzed in the squat jump, counter movement jump, and standing broad jump. In the second battery, the performance in the 10 m sprint test and agility were evaluated.
Results: The pivots showed higher body mass, fat mass and fat mass percentage when compared to backs and wings, with pivots and backs being the tallest players in the team (p < 0.05). The performance of the pivots in the T-Test was lower than the backs. Correlations were found between high fat mass and low performance in the T-test, squat jump, counter movement jump and standing broad jump, and between high fat mass percentage and low performance in the T-test, squat jump, and counter movement jump.
Conclusion: Anthropometric characteristics and motor performance vary depending on playing position. In addition, moderate correlations were found between high fat indices and low performance on agility and vertical and horizontal jumping tests.

Key-words: Exercise, Physical functional performance, Velocity measurement.

RESUMO

Objetivo: Os objetivos do presente estudo foram descrever e comparar variáveis antropométricas e o desempenho em testes motores entre as posições de jogo, e testar a correlação entre estas variáveis em jogadores de handebol adultos.
Métodos: Participaram do estudo 23 jogadores (20,78 ± 3,83 anos), sendo subdivididos por posição em armadores (n = 9), pontas (n = 9) e pivôs (n = 5). Foram realizadas duas baterias de avaliações, com 72h de intervalo entre elas, e analisados na primeira bateria variáveis antropométricas (estatura, massa corporal, massa magra, massa gorda, e percentual de gordura), e o desempenho nos testes *squat jump*, *counter movement jump* e salto horizontal, e na segunda o desempenho nos testes *sprint* de 10 m e teste-T.
Resultados: Os pivôs apresentaram maior massa corporal, massa gorda e percentual de gordura em comparação aos armadores e pontas, sendo pivôs e armadores os jogadores de maior estatura da equipe (p < 0,05). O desempenho no teste-T dos pivôs foi menor em comparação aos de armadores. Foram encontradas correlações entre maior massa gorda com menor desempenho em teste-T, *squat jump*, *counter movement jump* e salto horizontal, e entre maior percentual de gordura com menor desempenho em teste-T, *squat jump* e *counter movement jump*.
Conclusão: As características antropométricas e o desempenho motor variam em função da posição de jogo. Além disso, foram evidenciadas correlações moderadas entre maiores índices de gordura e menor desempenho em testes de agilidade e salto vertical e horizontal.

Palavras-chave: Exercício físico, Desempenho físico funcional, Medição de velocidade.

Correspondemce: Lucas de Paula Oliveira. Avenida Bandeirantes, 3900, 14040-900 Ribeirão Preto SP. lucasdepaulausp@gmail.com

Oliveira LP et al.
Anthropometry and motor performance in handball

360

Introduction

The anthropometric characterization of handball players has been an object of interest in several studies in the sports sciences and training areas [1-7]. The relevance of this knowledge is the possibility of; 1) collaborating with technical staff in the search for "talents" in this sport, due to the adequacy of athletes with respect to the desired to anthropometric profiles, and; 2) To assisting professionals, such as fitness coaches to better outline their training programs in order to achieve the intended body profile for a player in this sport modality.

It is documented in the scientific literature that elite level professional handball players have greater height (H) and body mass (BM) when compared to amateurs [6] and non-elite professional [7] players, and that these differences also exist between the best and worst teams ranked teams in renowned world championships [8]. Similarly, it has also been identified that elite professional players have higher absolute lean mass (LM), and lower amounts of absolute fat mass (FM) and body fat mass (BFM) [7].

The comparison of motor skills has also been a target of interest in studies in this field [6,7]. Differences have been shown in motor tests applied to these players, with special emphasis on the 10, 20, and 30 m [7,9] sprint time, absolute power of the lower limbs in the squat jump (SJ) and counter movement jump (CMJ) [7], and ball speed in the throw [6,9]. In this context, more recent studies also point out that the physical characteristics depend on the specific game position of the player, subdividing them into backs, wings, pivots, and goalkeepers [10-13].

Although anthropometric variables have already been the target of research that found differences between game positions [11-14], and that some motor tests were not sensitive to detect differences in physical performance [12], little is known about the real influences of anthropometrics variables on motor tests in handball players taking into account the game positions.

Thus, the main objectives of this study were 1) to describe and compare anthropometric characteristics and motor performance between game positions; 2) to test correlations between anthropometric variables and motor performance in adult handball players.

Additionally, the main hypothesis of the present investigation was the possibility of motor performance varying by position according to the higher or lower requirement of certain motor skills (e.g., force, velocity, and resistance), as well as that anthropometric variables could be sensitive to explain differences in motor performance.

Methods

Participants

Twenty-three adult handball players (20.78 ± 3.83 years; 86.98 ± 15.95 kg; 182.69 ± 6.75 cm; 16.19 ± 7.39%) were considered as the sample population, of amateur level, belonging to a team that disputes the first division of the Paulista championship. The inclusion and exclusion criteria were having at least one year of uninterrupted training in the modality, and not presenting musculoskeletal injuries or health problems. For the analyses between the game positions, the players were subdivided into backs (n = 9), wings (n = 9), and pivots (n = 5).

The effect size of the sample size used in the present study (n = 23) was 0.53, calculated using G*Power software (v. 3.1.9.4), assuming α = 0.05 and β = 0.89, based

on a previous study with handball players [15] using as a parameter for the calculation the level of correlation between body mass and performance in the throwing test (r = 0.53).

The collections were carried out at the beginning of the preparatory stage (February/2014) for the Paulista championship, a period in which athletes trained with a frequency of three sessions per week, lasting approximately two hours per session. This study was approved by the Research Ethics Committee of the Clinical Hospital of Ribeirão Preto (Protocol 775.212), Faculty of Medicine of Ribeirão Preto, and was conducted in accordance with the principles established by the declaration of Helsinki.

Experimental design

After being informed about the procedures adopted in the research and signing the Free and Informed Consent Term, the individuals were submitted to two batteries of assessments, carried out on an official handball court, on two assessment days, with a 72 h interval between them. The test days were divided into (I) anthropometry (H, BM, LM, FM, and BFM), and motor tests (CMJ, SJ, and SBJ), and (II) motor tests (10 m sprint and T-test).

Anthropometry

The variables BM and H were assessed using a digital scale (DLK Sports, SB-623, Brazil) and digital laser measuring tape (Bosch, DLE-40, Germany), with precisions of 0.1 kg and 1.5 mm, respectively.

To estimate the BFM and the amount of LM and FM, first, the body density (BD) was estimated using the equation proposed by Jackson and Pollock [16], based on the sum of three skin folds, chest, abdomen, and thigh (X_2) and age in years (X_3) (**Equation 1**). A scientific adipometer (Sanny, AD1010, Brazil) with a precision of 0.1 mm was used for the measurements, following the procedures proposed by Harrison *et al.* [17].

$$DC = [1.1093800 - 0.0008267 \times (X_2) + 0.0000016 \times (X_2)^2 - 0.0002574 \times (X_3)]$$
(Equation 1)

To estimate BFM based on body density, the equation proposed by Siri [18] (**Equation 2**) was used. Subsequently, from the BFM and total BM, the values of LM and FM were calculated.

$$\%G = [(4.95 / DC) - 4.5) \times 100]$$
(Equation 2)

Velocity test

For the velocity test, the participants were positioned behind the start mark and, after a sound signal, they covered the distance of ten meters in a straight line in the shortest time possible. To record the time taken in the test, one evaluator was positioned at the starting point, and another at the end of the ten meter distance, the first being responsible for signaling the start of the test and the second for marking the time spent using a stopwatch (DLK Sports, WT-038, Brazil), accurate to 1/100 seconds.

Oliveira LP et al.
Anthropometry and motor performance in handball

362

Agility test

For the agility T-test, adapted by Moreira, Souza and Oliveira [19], the participants started the test positioned behind the start mark and after a sound signal, they covered ten meters in a straight line, until the first cone (central cone). After touching the cone with their hand, they changed direction to the left, towards the next cone (positioned at five meters in relation to the central cone). The participants then returned in the opposite direction, moving to the other cone of the "T", covering another ten meters. Finally, the subjects returned to the central cone, covering five more meters, and then finished the test by covering another ten meters towards the finish mark, totaling 40 m in the test (Figure 1).

To determine the time taken to perform the adapted T-test, a stopwatch (DLK Sports, WT-038, Brazil) was used, with an accuracy of 1/100 seconds.
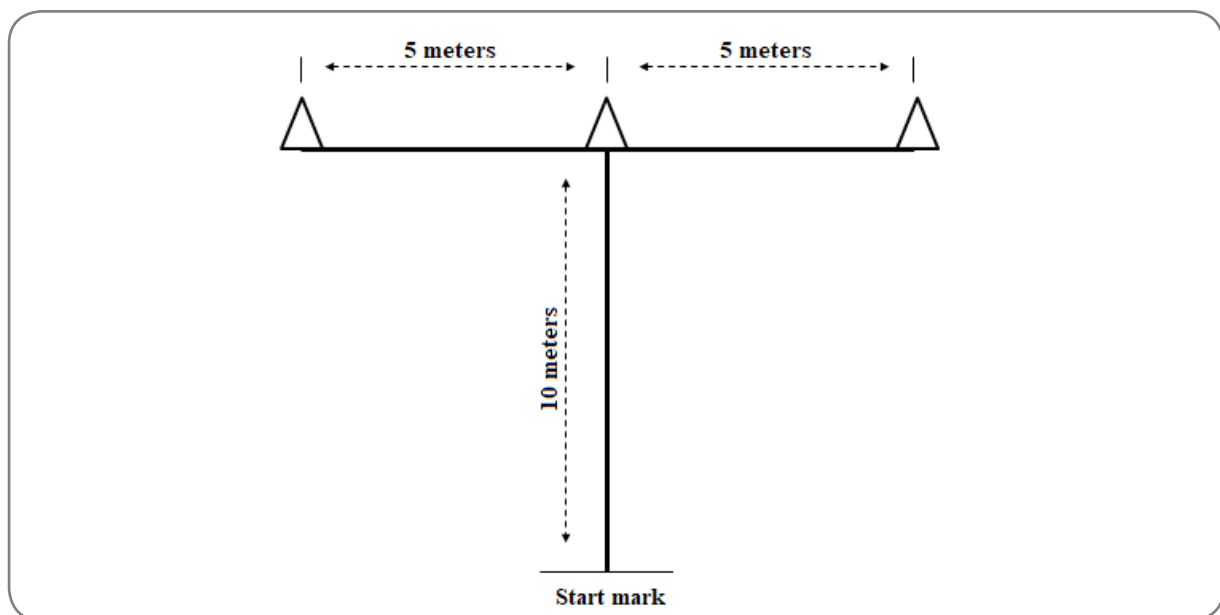

Figure 1 - Illustration of the agility test (adapted T-test by Moreira *et al.* [19]).

Vertical jump test

The vertical jump test was conducted on Ergo Jump equipment (Cefise®, Brazil) associated with the Jump System Pro software (Cefise®, Brazil), version 1.0. The mat is composed of electronic circuits which enable the estimation of vertical jump height and power of the lower limbs based on the flight time and acceleration due to gravity [20].

During the test, participants performed two execution techniques: Squat Jump (SJ) and Counter Movement Jump (CMJ). For SJ, the participants positioned themselves on the mat in a standing position, with their feet parallel, and their hands on the hips, in order to neutralize the action of the upper limbs. The individuals were instructed to start with a 90º knee flexion and perform a vertical jump to the highest possible height. For the CMJ, the positioning of the feet followed the same procedure adopted for the SJ. For the jump, a flexion movement was performed followed by knee extension, starting from an upright position [21].

Standing broad jump test

The standing broad jump test was performed on the court where the athletes habitually train. The participants started the test behind the exit mark, with their feet slightly apart, and were instructed to perform a semi-flexion of the knees to-

gether with oscillatory movements of the arms and to jump to the greatest possible horizontal distance [22]. The jump distance was measured using a measuring tape (Stanley, 34-263, United States) fixed to the floor of the court. The longest distance was measured between the starting line and the heel closest to the starting mark.

For all tests in the study, three attempts were performed, and the best attempt was considered for statistical analysis. The recovery time between tests was five minutes and one minute between attempts in the same test [21].

Statistical analysis

Initially all the data passed the Shapiro Wilk normality test, which allowed parametric statistical analysis. After confirmation of the normality of distribution, one-way ANOVA analysis was adopted, followed by the Tukey post hoc to compare anthropometric variables and motor performance between positions (i.e., backs, wings, and pivots). Possible correlations between the variables were tested using Pearson's correlation coefficient. The values obtained in the correlation tests were classified as very weak (0.0 – 0.20), weak (0.21 – 0.40), moderate (0.41 – 0.70), strong (0.71 – 0.90) and very strong (0.91 – 1.0) [23]. All analysis was performed using SPSS software version 20.0 (SPSS Inc. Chicago, USA), with a significance criterion of $p < 0.05$.

Results

Table I presents the mean values of the anthropometric variables and motor performance, as well as the comparisons between the game positions. The pivots demonstrated greater BM, FM and BFM compared to the backs and wings, and the pivots together with the backs were the tallest in the team ($p < 0.05$). Regarding motor performance variables, the pivots presented a worse time in the T-test compared to the backs ($p < 0.05$). In contrast, no significant differences were found in the 10 m, SBJ, SJ, CMJ, and absolute mean power (MP) and relative power (RP) of the lower limbs for both SJ and CMJ techniques.

Considering the total sample (n = 23), Table II presents the correlation values between the anthropometric variables and motor performance. A positive correlation was observed between BM and T-test time and, an inverse correlation with the SBJ, SJ, and CMJ. The FM presented a positive correlation with the T-test, and inverse correlation with the SBJ, RP in the CMJ, and vertical heigth in the SJ and CMJ. For the BFM the same behavior was observed, a positive correlation with the T-test, and inverse correlation with the RP in the CMJ, and vertical heigth in the SJ and CMJ, highlighting an association between lower values for these variables (i.e., BM, FM, and BFM) and better performance.

Oliveira LP et al.
Anthropometry and motor performance in handball

364

Table I - Description of anthropometric variables and motor performance of adult handball players.

Position	Backs (n = 9)	Wings (n = 9)	Pivots (n = 5)	Total (n = 23)
H (cm)	185.03 ± 6.22	177.44 ± 5.08^a	187.94 ± 3.67c	182.69 ± 6.75
BM (kg)	83.59 ± 10.85	80.14 ± 10.32	105.42 ± 19.86$^{b.c}$	86.98 ± 15.95
LM (kg)	72.96 ± 9.45	67.92 ± 7.55	78.63 ± 13.64	72.22 ± 10.21
FM (kg)	10.63 ± 4.10	12.22 ± 4.78	26.79 ± 12.45$^{b.c}$	14.76 ± 9.23
BFM (%)	12.59 ± 4.41	14.91 ± 5.07	25.00 ± 9.00$^{b.c}$	16.19 ±7.39
10m (s)	1.71 ± 0.15	1.90 ± 0.42	1.84 ± 0.17	1.81 ± 0.29
T-test (s)	9.24 ± 0.47	9.64 ± 0.53	10.19 ± 0.79^b	9.60 ± 0.65
SJ (cm)	35.38 ± 3.84	34.82 ± 5.09	31.96 ± 6.18	34.42 ± 4.85
MPSJ (W)	314.64 ± 84.25	391.23 ± 136.51	451.84 ± 161.14	374.43 ± 130.46
RP$_{SJ}$ (W.kg^{-1})	3.80 ± 0.92	4.86 ± 1.64	4.34 ± 1.98	4.33 ± 1.49
CMJ (cm)	35.17 ± 4.10	36.31 ± 6.30	32.66 ± 6.04	35.07 ± 5.40
MP$_{CMJ}$ (W)	456.24 ± 97.24	382.62 ± 144.90	416.70 ± 61.71	418.84 ± 113.47
RP$_{CMJ}$ (W.kg^{-1})	5.56 ± 1.46	4.81 ± 1.82	4.03 ± 0.74	4.93 ± 1.56
SBJ (cm)	233.78 ± 18.10	225.67 ± 20.39	216.60 ± 23.90	226.87 ± 20.45

H = Height; BM = Body mass; LM = Lean body mass; FM = Fat mass; BFM = Body fat mass; 10m = ten meters sprint time; Teste-T = T-teste time; SJ = Squat Jump; CMJ = Counter Movement Jump; MP = Mean power; RP = Relative power; SBJ = Standing broad jump; (p < 0.05): ^{a}backs x wings; ^{b}backs x pivots; ^{c}wings x pivots.

Table II - Correlation matrix between anthropometric variables and motor performance (r).

	H (cm)	BM (kg)	LM (kg)	FM (kg)	BFM (%)
10 m (s)	0.00	0.26	0.30	0.11	0.07
T-Test (s)	-0.01	0.49*	0.15	0.68**	0.63**
SJ (cm)	-0.13	-0.54**	-0.34	-0.55**	-0.43*
MP$_{SJ}$ (W)	-0.18	0.11	0.04	0.15	0.24
RP$_{SJ}$ (W.kg^{-1})	-0.47*	-0.30	-0.29	-0.20	-0.08
CMJ (cm)	-0.16	-0.60**	-0.39	-0.60**	-0.52*
MP$_{CMJ}$ (W)	0.40	0.15	0.32	-0.10	-0.20
RP$_{CMJ}$ (W.kg^{-1})	0.06	-0.35	-0.13	-0.46*	-0.49*
SBJ (cm)	0.12	-0.44*	-0.26	-0.47*	-0.36

H = Height; BM = Body mass; LM = Lean body mass; FM = Fat mass; BFM = Body fat mass; 10m = ten meters sprint time; Teste-T = T-teste time; SJ = Squat Jump; CMJ = Counter Movement Jump; MP = Mean power; RP = Relative power; SBJ = Standing broad jump; *represents p < 0.05; **represents p < 0.01.

Discussion

The main findings of this study were the diferences in antropometric variables between the positions of backs, wings, and pivots and also in agility test performance between backs and pivots. In addition, significant correlations were found between anthropometric variables and motor performance.

Sporis et al. [11] evaluated 92 handball players of elite level, and observed significant differences between the positions for H (backs [196.7 ± 5.4 cm], wings

[183.9 ± 5.7 cm], and pivots [196.3 ± 9.3 cm]), BM (backs [96.7 ± 5.4 kg], wings [89.1 ± 6.5 kg], and pivots [107.6 ± 7.9 kg]), and BFM (backs [8.7 ± 2.0%], wings [13.2 ± 3.3%], and pivots [13.3 ± 6.2%]), similar to the finding of the present study. Differences were also observed in the studies of Hermassi, Laudner and Schwesig [13], Chaouachi et al. [12], and Llic et al. [14].

Players occupy different positions on the court, in which they are required to perform functions directly related to the model and game system adopted by the coach. The backs, for example, are positioned in more distant places from the opponent's goal, allowing displacements in different directions of the court and greater distance in relation to their direct and/or indirect markers. The backs can also use the greatest number of technical-tactical elements (such as crossings, feints, and changes of direction) in an attempt to obtain advantageous situations to attack and allow infiltrations or finishings of medium or long distance by other backs [24]. The wings are players who act close to the right and left side lines of the court (usually close to the end lines or nine meters lines on the court). These players perform the functions of initiating the movement of the ball and finishing after that movement (in a positional attack), developing different collective technical-tactical elements (such as crossings, changing of specific positions, and curtains), participating in changing of offensive systems (when they occupy the pivot post - or second pivot), and also initiating counterattacks that provoke defensive imbalances [24]. The pivot is the striker positioned closest to the opponent's goal and among the defenders, whose body position is usually lateral to or their back to the opposing team's goal [25]. Despite the apparently fixed positioning, the pivot performs actions such as blocking, which make it difficult for defenders to move and makes it possible for infiltration by back players, and to clear them, so that they can receive the ball and perform the spin for the throw, which requires high strength levels of this player [25].

When analyzing the demands of the game and the functions mentioned above, it is possible to suggest that in handball each position occupied on the court requires certain anthropometric characteristics of the players. For example, the physical attributes of the pivots, such as the greater H and BM found in this study, may be favorable in offensive situations, such as in blocking actions, to facilitate infiltration and finishing for backs and wings. On the other hand, the greater agility (i.e, better T-test time) of the backs and the lower BM and BFM of the backs and wings, when compared with pivots, could facilitate feints, changes of direction, and quick offensive actions, which can be developed together with other players such as the pivots.

Regarding the performance in motor tests, the main hypotheses were the possibility of performance varying according to the higher or lower requirement for a certain motor skill in the position, and that the anthropometric variables could be sensitive to explain differences in performance. In this sense, significant differences were found in the agility test, with the pivots presenting a worse time in the T-test compared to the backs. In addition, negative correlations were found between BFM, FM, and performance in the T-test, SBJ, SJ, and CMJ.

Unlike anthropometric aspects, few studies in the literature have investigated motor performance taking into account game positions [12,13,26]. Chaouachi et al. [12] analyzed 21 professional handball players of elite level and pointed out that there were no significant differences in motor performance (i.e., jumping, sprint, upper and lower limbs strength, throw speed and aerobic power) between goalkeepers, backs, pivots and wings. On the other hand, Massuça et al. [26] recently demonstrated, in a sample composed of 161 handball players, including professionals and non-professionals subdivided by position, significant differences in the 30 m

Oliveira LP et al.
Anthropometry and motor performance in handball

366

sprint test, MP of the lower limbs, and handgrip strength. Therefore, according to the authors, motor performance may also vary depending on the game position. Thus, it is possible that in the present study the reduced sample number may have provided a low statistical power to observe significant differences between the game positions for the other variables (10 m, SBJ, CMJ, SJ, MP, and RP).

Regarding the correlation data, Dellagrana *et al.* [27] and Mota and Virtuoso Junior [28] found results similar to those of the current study, but in young handball players and university students, respectively. Dellagrana *et al.* [26] identified an inverse relationship between the BFM and SBJ (r = -0.42), and a positive relationship between the BFM and time in the Shuttle run test (r = 0.61). Mota and Virtuoso Junior [27] found an inverse relationship between BFM and maximum oxygen consumption (r = -0.55), estimated from the Balke test performed on a bicycle. Thus, the correlation of the results of this study with the data available in the literature shows that anthropometric variables have an influence on motor performance, and that the magnitude seems to be dependent on the test employed.

Muscle tissue produces strength actively during the process of muscle contraction, through the cross bridges (formed by the myofibrils actin and myosin), contributing to the performance of motor gestures. Adipose tissue, on the other hand, is not able to produce strength actively, therefore, it is possible that the excess body fat from the pivots may have prejudice the physical performance during the T-test, mainly due to the significant correlations found for FM and BFM, and the fact that the pivots demonstrated higher values than the other positions in these two variables. In addition, the fact that there are no significant differences in RP between positions, suggests that even players with higher levels of FM and BFM, such as pivots, maintained a good rate of muscle power/body weight, allowing similar performances in tests with high demands on motor strength and velocity (e.g., 10 m sprint, vertical jump, and standing broad jump).

In summary, based on the results found and on the aforementioned studies, although only specific differences were found in the performance for the agility test, there is the possibility that performance may be altered depending on the game position. In addition, the influence of anthropometric variables on motor performance was identified, with the magnitude appearing to be dependent on the motor test used.

As a limitation of the study, our experimental design involved only analyses using motor tests, which has few implications for the actions that occur during the context of the game, especially with respect to the movements of the SBJ, CMJ, and SJ tests, which can be considered as general and not specific in relation to the sport modality. In addition, the measurement instruments used (e.g., jumping mat, stopwatch) despite having low methodological complexity and high practical application for athletes and coaches, present large systematic measurement errors. Therefore, it is suggested that more robust analyses of physical and tactical performance by game position should be performed, using better measurement instruments and that include the analysis of displacement patterns during a handball game.

Conclusion

The findings of this study suggest that for adult handball players of amateur level, anthropometric characteristics vary depending on the game position. The results showed that the pivots have higher BM, FM, and BFM when compared to backs and wings, and that pivots and backs are the tallest players on the team. Motor per-

formance also varied between positions, and it was found that backs achieved better T-test performance when compared to pivots, while no significant differences were observed in the other motor tests (10 m, SBJ, CMJ, SJ, MP, and RP). Finally, moderate correlations were found between FM and BFM with performance in the T-test, SJ, CMJ, and SBJ, which suggests that these factors influence, even if in a small measure, motor performance.

Potential conflict of interest
No conflicts of interest with potential potential for this article have been reported.

Financing source
There were no external sources of funding for this study.

Authors' contributions
Conception and design of the research: Oliveira LP and Puggina EF. **Data collection:** Oliveira LP, Vieira LHP, Gonçalves LGC. **Analysis and interpretation of data:** Oliveira LP, Andrade VL. **Statistical analysis:** Oliveira LP, Aquino RLQT. **Obtaining financing:** not applicable. **Writing of the manuscript:** Oliveira LP. **Critical revision of the manuscript for important intellectual content:** Oliveira LP, Andrade VL, Vieira LHP, Aquino RLQT, Gonçalves LGC, Menezes RP, Puggina EF.

References

1. Šibila M, Pori P. Position-related differences in selected morphological body characteristics of top--level handball players. Coll Antropol 2009;33(4):1079-86.

2. Wagner H, Finkenzeller T, Würth S, Von Duvillard SP. Individual and team performance in team--handball: A review. J Sports Sci Med 2014;13(4):808. https://www.semanticscholar.org/paper/Individual-and-team-performance-in-teamhandball%3AaWagnerFinkenzeller/0620aa66d2105aaee5e-c1212e216713cf6fd8d42

3. Krüger K, Pilat C, Ückert K, Frech T, Mooren FC. Physical performance profile of handball players is related to playing position and playing class. J Strength Cond Res 2014;28(1):117-25. https://doi.org/10.1519/jsc.0b013e318291b713

4. Manchado C, Tortosa-Martínez J, Vila H, Ferragut C, Platen P. Performance factors in women's team handball: Physical and physiological aspects—A review. J Strength Cond Res 2013;27(6):1708-19. https://doi.org/10.1519/jsc.0b013e3182891535

5. Vila H, Manchado C, Rodriguez N, Abraldes JA, Alcaraz PE, Ferragut C. Anthropometric profile, vertical jump, and throwing velocity in elite female handball players by playing positions. J Strength Cond Res 2012;26(8):2146-55. https://doi.org/10.1519/jsc.0b013e31823b0a46

6. Wagner H, Buchecker M, Von Duvillard SP, Müller E. Kinematic description of elite vs. low level players in team-handball jump throw. J Sports Sci Med 2010;9(1):15. https://doi.org/10.1055/s-2004-820974

7. Massuça LM, Fragoso I, Teles J. Attributes of top elite team-handball players. J Strength Cond Res 2014;28(1):178-86. https://doi.org/10.1519/JSC.0b013e318295d50e.

8. Ghobadi H, Rajabi H, Farzad B, Bayati M, Jeffreys I. Anthropometry of world-class elite handball players according to the playing position: reports from men's handball world championship 2013. J Hum Kinet 2013;39(1):213-20. https://doi.org/10.2478/hukin-2013-0084

9. Ortega-Becerra M, Pareja-Blanco F, Jiménez-Reyes P, Cuadrado-Peñafiel V, González-Badillo JJ. Determinant factors of physical performance and specific throwing in handball players of different ages. J Strength Cond Res 2018;32(6):1778-86. https://doi.org/10.1519/JSC.0000000000002050

10. Massuça L, Fragoso I. Morphological characteristics of adult male handball players considering five levels of performance and playing position. Coll Antropol 2015;39(1):109-18. https://pdfs.semanticscho-lar.org/1ec4/438106eb68f8cc707b21c228928313ae8c96.pdf?_ga=2.127365965.1574457342.1589246067-358049433.1589246067

11. Sporiš G, Vuleta D, Vuleta Jr D, Milanović D. Fitness profiling in handball: physical and physio-logical characteristics of elite players. Coll Antropol 2010;34(3):1009-14. https://pdfs.semanticscho-lar.org/de1c/7426968f549209cdcdd734e5a2fa903d8a49.pdf?_ga=2.135173361.1574457342.1589246067-

Oliveira LP et al.
Anthropometry and motor performance in handball

368

358049433.1589246067

12. Chaouachi A, Brughelli M, Levin G, Boudhina NBB, Cronin J, Chamari K. Anthropometric, physiological and performance characteristics of elite team-handball players. J Sports Sci 2009;27(2):151-7. https://doi.org/10.1080/02640410802448731

13. Hermassi S, Laudner KG, Schwesig R. Playing level and position differences in body characteristics and physical fitness performance among male team handball players. Front Bioeng Biotechnol 2019;7:149. https://doi.org/10.23736/S0022-4707.17.06938-9

14. Ilic V, Ranisavljev I, Stefanovic D, Ivanovic V, Mrdakovic V. Impact of body composition and VO-2max on the competitive success in top-level handball players. Coll Antropol 2015;39(3):535-40. https://www.semanticscholar.org/paper/Impact-of-Body-Composition-and-Vo2-Max-on-the-in-Ilic--Ranisavljev/d282a32a8742afd5b6f50fa05d9f6528961d65d9

15. Schwesig R, Hermassi S, Fieseler G, Irlenbusch L, Noack F, Delank K-S et al. Anthropometric and physical performance characteristics of professional handball players: influence of playing position. J Sports Med Phys Fitness 2017;57(11):1471. https://doi.org/10.23736/S0022-4707.16.06413-6.

16. Jackson AS, Pollock ML. Generalized equations for predicting body density of men. Br J Nutr 1978;40(3):497-504. https://doi.org/10.1079/bjn19780152

17. Harrison GG, Buskirk E, Carter JL, Johnston F, Lohman T, Pollock M et al. Skinfold thicknesses and measurement technique. In: Lohman TG, Roche AF, Martonell R editors. Anthropometric standardization reference manual. Champaign Illinois: Human Kinetics; 1988:55-80.

18. Siri WE. Body composition from fluid spaces and density: analysis of methods. Nutrition. 1961;9(5):480-91. https://escholarship.org/uc/item/6mh9f4nf

19. Moreira A, Souza M, Oliveira PR. A velocidade de deslocamento no basquetebol. Rev Bras Ciênc Esporte 2003;24(2). http://revista.cbce.org.br/index.php/RBCE/article/view/367/321

20. Bosco C, Belli A, Astrua M, Tihanyi J, Pozzo R, Kellis S et al. A dynamometer for evaluation of dynamic muscle work. Eur J Appl Physiol Occup Physiol 1995;70(5):379-86. https://doi.org/10.1007/bf00618487

21. Smirniotou A, Katsikas C, Paradisis G, Argeitaki P, Zacharogiannis E, Tziortzis S. Strength-power parameters as predictors of sprinting performance. J Sports Med Phys Fitness 2008;48(4):447. https://search.proquest.com/openview/5becbe5d75f468ba201f0e89cd9ca7e8/1?pqorigsite=gscholar&cbl=4718

22. Moreira A, Oliveira PR, Okano AH, Souza MD, Arruda MD. A dinâmica de alteração das medidas de força e o efeito posterior duradouro de treinamento em basquetebolistas submetidos ao sistema de treinamento em bloco. Rev Bras Med Esporte 2004;10(4):243-250. https://doi.org/10.1590/s1517-86922004000400002

23. Rowntree D. Statistics without tears: An introduction for non-mathematicians. London: Penguin; 1981. https://doi.org/10.2307/3617333

24. Menezes RP. Modelo de análise técnico-tática do jogo de handebol: necessidades, perspectivas e implicações de um modelo de interpretação das situações de jogo em tempo real [Tese]. Campinas (SP): Universidade Estadual de Campinas; 2011. http://repositorio.unicamp.br/bitstream/REPO-SIP/275088/1/Menezes_RafaelPombo_D.pdf

25. Menezes RP, Freire VD, Boff LC. Sistema defensivo 3: 3 no handebol mediante o jogo do pivô: possibilidades pedagógicas. Conexões 2014;12(4):69-90. https://doi.org/10.20396/conex.v12i4.1673

26. Massuca L, Branco B, Miarka B, Fragoso I. Physical fitness attributes of team-handball players are related to playing position and performance level. Asian J Sports Med 2015;6(1):1-5. https://doi.org/10.5812/asjsm.24712

27. Dellagrana RA, Silva MP, Smolarek AC, Bozza R, Stabelini Neto A, Campos WD. Composição corporal, maturação sexual e desempenho motor de jovens praticantes de handebol. Motriz 2010;16(4):880-8. https://doi.org/10.5016/1980-6574.2010v16n4p880

28. Mota IL, Virtuoso Junior JS. Consumo máximo de oxigênio e percentual de gordura em universitários. Rev Bras Fisiol Exerc 2013;12(1):13-8. https://doi.org/10.33233/rbfe.v12i1.3311