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PARÂMETROS DESCRITIVOS PRELIMINARES PARA COMPOSIÇÃO CORPORAL E ÂNGULO DE FASE EM ATLETAS DE ATLETISMO DA AMAZÔNIA BRASILEIRA: UM ESTUDO TRANSVERSAL

PRELIMINARY DESCRIPTIVE PARAMETERS FOR BODY COMPOSITION AND PHASE ANGLE IN TRACK-AND-FIELD ATHLETES FROM THE BRAZILIAN AMAZON: A CROSS-SECTIONAL STUDY

PARÁMETROS DESCRIPTIVOS PRELIMINARES DE COMPOSICIÓN CORPORAL Y ÁNGULO DE FASE EN ATLETAS DE ATLETISMO DE LA AMAZONÍA BRASILEÑA: UN ESTUDIO TRANSVERSAL

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Resumo

A avaliação da composição corporal e a determinação do ângulo de fase (AF) têm sido amplamente reconhecidas como ferramentas fisiologicamente significativas para a análise do rendimento esportivo e da condição de saúde. Entretanto, dados descritivos específicos por modalidade para atletas de atletismo da Amazônia brasileira permanecem escassos. **Objetivo:** Descrever e comparar parâmetros descritivos preliminares de composição corporal e ângulo de fase em atletas de velocidade e resistência do estado do Amapá, Brasil, estratificados por faixa etária e categoria de prova. **Métodos:** Estudo observacional transversal com 46 atletas (≥14 anos) filiados à Federação de Atletismo do Amapá. Foram obtidas medidas antropométricas (massa corporal, estatura), composição corporal mensurada por meio de dobras cutâneas em oito sítios anatômicos (subescapular, tríceps, bíceps, axilar média, supra-ilíaca, abdominal, coxa e panturrilha)e bioimpedância elétrica octapolar multifrequência com equações preditivas específicas por idade para massa livre de gordura aplicadas automaticamente pelo software do equipamento conforme a idade cronológica do participante — Gonzalez et al. (2019) para adultos (≥19 anos) e Costa et al. (2022) para adolescentes (14–18 anos), ambas validadas para a população brasileira, e AF, todas obtidas por protocolos padronizados. Os participantes foram estratificados em duas faixas etárias (14–18 anos; ≥19 anos) e duas categorias de prova (velocidade; resistência). A análise estatística compreendeu medidas descritivas (Q1, Q2, Q3, média ± DP), teste de normalidade de Shapiro-Wilk,

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e testes t de Student para amostras independentes (α = 0,05). **Resultados:** Atletas adultos de velocidade apresentaram maior percentual de massa magra (LM%) e menor percentual de gordura corporal (BF%) que atletas de resistência (p = 0,013). O índice de massa corporal (IMC) foi maior em adultos do que em adolescentes em ambas as categorias de prova (p ≤ 0,006). Atletas adultos de velocidade apresentaram AF total, AF de membros superiores (ULPA) e AF de membros inferiores (LLPA) maiores que atletas de resistência (p ≤ 0,003). **Conclusões:** Estes parâmetros descritivos preliminares podem subsidiar a identificação de talentos, a prescrição individualizada do treinamento e o monitoramento longitudinal da saúde de atletas regionais, embora sua utilização como referências normativas exija amostras maiores e estratificadas por sexo.

Palavras-chave: Antropometria, Desempenho Atlético, Impedância Bioelétrica, Ângulo de Fase, Atletismo.

Abstract

The assessment of body composition and the determination of phase angle (PA) have been widely acknowledged as physiologically meaningful tools for analysing athletic performance and health condition. However, event-specific descriptive data for track-and-field athletes in the Brazilian Amazon remain scarce. **Objective:** To describe and compare preliminary descriptive parameters of body composition and phase angle in sprint and endurance track-and-field athletes from the state of Amapá, Brazil, stratified by age group and event category. **Methods:** This cross-sectional observational study enrolled 46 athletes (≥14 years) affiliated with the Amapá Athletics Federation. Anthropometric measurements (body mass, stature), body composition measured through skinfold thickness at eight anatomical sites (subscapular, triceps, biceps, mid-axillary, supra-iliac, abdominal, thigh and calf) and octapolar multifrequency bioelectrical impedance with age-specific predictive equations for fat-free mass automatically applied by the device software according to the participant's chronological age — Gonzalez et al. (2019) for adults (≥19 years) and Costa et al. (2022) for adolescents (14–18 years), both validated for the Brazilian population, and PA were obtained using standardised protocols. Participants were stratified into two age groups (14–18 years; ≥19 years) and two event categories (sprint; endurance). Statistical analysis comprised descriptive measures (Q1, Q2, Q3, mean ± SD), Shapiro-Wilk normality testing and independent-samples Student's t-tests (α = 0.05). **Results:** Adult sprint athletes showed higher lean mass percentage (LM%) and lower body fat percentage (BF%) than endurance counterparts (p = 0.013). Body mass index (BMI) was higher in adults than adolescents in both event categories (p ≤ 0.006). Adult sprint athletes presented higher total PA, upper-limb PA (ULPA), and lower-limb PA (LLPA) than endurance athletes (p ≤ 0.003). **Conclusions:** These preliminary descriptive parameters may inform talent identification, individualised training prescription and longitudinal health monitoring of regional track-and-field athletes, although their use as normative references requires larger and sex-stratified samples. The higher PA values observed in adult sprint athletes are consistent with this parameter being associated with cellular integrity, lean mass status, and neuromuscular readiness in this exploratory sample.

Keywords: Anthropometry; Athletic Performance; Bioelectrical Impedance; Phase Angle; Track and Field.

Resumen

La evaluación de la composición corporal y la determinación del ángulo de fase (AF) han sido ampliamente reconocidas como herramientas fisiológicamente significativas para el análisis del rendimiento deportivo y de la condición de salud. Sin embargo, los datos descriptivos específicos por modalidad para atletas de atletismo en la Amazonía brasileña siguen siendo escasos. **Objetivo:** Describir y comparar parámetros descriptivos preliminares de composición corporal y ángulo de fase

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en atletas de velocidad y resistencia del estado de Amapá, Brasil, estratificados por grupo de edad y categoría de prueba. **Métodos:** Estudio observacional transversal con 46 atletas (≥14 años) afiliados a la Federación de Atletismo de Amapá. Se obtuvieron mediciones antropométricas (masa corporal, estatura), composición corporal evaluada mediante pliegues cutáneos en ocho localizaciones anatómicas (subescapular, tríceps, bíceps, axilar medio, suprailíaco, abdominal, muslo y pantorrilla) y bioimpedancia eléctrica octapolar multifrecuencia con ecuaciones predictivas específicas por edad para masa libre de grasa aplicadas automáticamente por el software del equipo según la edad cronológica del participante — Gonzalez et al. (2019) para adultos (≥19 años) y Costa et al. (2022) para adolescentes (14–18 años), ambas validadas para la población brasileña, y el AF mediante protocolos estandarizados. Los participantes fueron estratificados en dos grupos de edad (14–18 años; ≥19 años) y dos categorías de prueba (velocidad; resistencia). El análisis estadístico incluyó medidas descriptivas (Q1, Q2, Q3, media ± DE), prueba de normalidad de Shapiro-Wilk y prueba t de Student para muestras independientes (α = 0,05). **Resultados:** Los velocistas adultos presentaron mayor porcentaje de masa magra y menor porcentaje de grasa corporal que los atletas de resistencia (p = 0,013). El IMC fue mayor en adultos que en adolescentes en ambas categorías (p ≤ 0,006). Los velocistas adultos mostraron AF total, AF de miembros superiores (AFMS) y AF de miembros inferiores (AFMI) mayores que los atletas de resistencia (p ≤ 0,003). **Conclusiones:** Estos parámetros descriptivos preliminares pueden orientar la identificación de talentos, la prescripción individualizada del entrenamiento y el monitoreo longitudinal de la salud de atletas regionales, aunque su uso como referencias normativas requiere muestras mayores y estratificadas por sexo.

Palabras clave: Antropometría; Rendimiento atlético; Impedancia bioeléctrica; Ángulo de fase; Atletismo.

1. Introduction

The study of body composition has gained increasing scientific importance both in identifying health indicators across diverse populations and in understanding the factors that modulate performance in competitive sports (Bartkowiak et al., 2021; De Carvalho et al., 2019; Ezzat et al., 2016). The optimal body composition profile exhibits considerable variation depending on sex, chronological age, the specific sport practised, the assessment method employed, and habitual physical activity level (Ackland et al., 2012; Aerenhouts et al., 2015). In track-and-field athletics, each event group imposes distinct morphological and physiological requirements, rendering the establishment of descriptive parameters and reference frameworks for body composition particularly challenging (Alves Junior et al., 2021; Sedeaud et al., 2014).

It is well established that Body Mass Index (BMI) constitutes a surrogate measure of relative body mass rather than a direct index of body composition, and its application to athletic populations frequently results in the misclassification of

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highly muscular athletes as overweight or obese (Alizadeh & Rostamu, 2011; Etchison et al., 2011). The divergent morphological demands of sprint events — which favour greater muscle cross-sectional area and power output — versus endurance events — characterised by reduced absolute body mass and a predominantly ectomorphic phenotype — further underscore the inadequacy of BMI as a sole body composition indicator in this population (O'Connor et al., 2007; Sedeaud et al., 2014).

Phase angle (PA), computed from the relationship between the resistance and reactance components obtained through bioelectrical impedance analysis (BIA), has become established as a robust biophysical parameter that captures cellular membrane integrity, intracellular hydration status, and the proportion of metabolically active tissue (Cirillo et al., 2023a; Martins et al., 2022; Monteiro et al., 2018). Elevated PA values reflect greater cell membrane capacitance, a higher ratio of lean mass to fat mass, and enhanced cellular function, and have been linked to physical performance markers such as muscular strength, aerobic fitness, and recovery capacity (Hetherington-Rauth et al., 2021; Mattiello et al., 2022).

Athletes from a wide range of sport disciplines consistently exhibit PA values above those of non-athletic controls, which points to a possible association between systematic training stimuli and both cellular integrity and body composition (Trematore et al., 2023). Nevertheless, PA reference data generated from general or clinical populations may not adequately capture the physiological characteristics of competitive athletes, particularly when considering event-specific body composition profiles (Barbosa-Silva & Barros, 2005). Research investigating PA in Brazilian track-and-field athletes remains limited in scope, typically presenting aggregated analyses that do not account for the substantial inter-event variability in morphological characteristics (Cirillo et al., 2023b; Monteiro et al., 2018).

The absence of event-specific and regionally contextualised descriptive data constitutes a critical gap in the literature, particularly for the Brazilian Amazon. The state of Amapá presents singular socio-environmental conditions: hot-humid

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equatorial climate with mean annual temperatures above 27 °C, restricted access to specialised sports infrastructure compared with the major Brazilian urban centres, low population density of federated athletes, limited nutritional support for amateur athletes, and a competition calendar concentrated in regional events. Athletics is not widely promoted in the school setting in the region, which restricts the recruitment of competitive-level athletes and contributes to a small federated population. These elements justify the development of locally generated descriptive parameters as a preliminary step toward future normative frameworks. Accordingly, the present study aimed to describe and compare preliminary descriptive parameters of body composition and phase angle stratified by event category (sprint and endurance) and age group in athletes affiliated with the Amapá Athletics Federation, Brazil, providing exploratory data for future construction of regional reference values.

2. Materials and Methods

2.1 Study Design

This cross-sectional observational study employed a quantitative approach to characterise body composition and PA in competitive track-and-field athletes. Given the exploratory and descriptive nature of the investigation, no formal a priori sample-size calculation was performed; sample-size adequacy is addressed in section 2.4 and discussed as a study limitation. All procedures followed the Declaration of Helsinki and Brazilian National Health Council Resolution 466/2012. The study was approved by the Ethics Committee for Research Involving Human Subjects of the Federal University of Amapá (CEPSH-UNIFAP; Protocol No. 6.454.711, 24 October 2023). Written informed consent was obtained from adult participants, and written assent plus parental/guardian consent for participants under 18 years.

2.2 Participants

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A non-probabilistic convenience sample of 46 athletes registered with the Amapá Athletics Federation was recruited between October and December 2023. This recruitment strategy reflects the limited pool of federated athletes in the state, given the geographic isolation of the Brazilian Amazon, the low popularity of track-and-field in regional schools and the consequent difficulty of attracting and retaining young athletes in the modality. Eligibility criteria comprised: (i) minimum chronological age of 14 years; (ii) at least 12 months of systematic athletics training with a minimum of two weekly sessions; (iii) participation in at least two state-level competitions within the preceding 12 months; (iv) absence of pharmacological treatment with known effects on body composition or fluid balance. Event categorisation followed the official IAAF/World Athletics distance criteria: sprint athletes were those competing in events of ≤400 m, and endurance athletes were those competing in events of ≥800 m, including road racing classified within distance running. Athletes specialising in jumps and throws were excluded from inferential analyses owing to insufficient subgroup sample sizes. Data on weekly training volume (hours), training intensity, current periodisation phase, biological maturation indicators and detailed competitive history were not systematically collected, and this limitation is acknowledged in section 6. The institutional affiliations and coaches of participating clubs granted formal written authorisation for the study.

2.3 Anthropometric and Body Composition Assessments

All measurements were performed by a single trained evaluator following standardised protocols to minimise intra-rater variability. Body mass was recorded to the nearest 0.1 kg using a calibrated portable digital scale (Model P150, Líder®, Brazil), with participants wearing minimal clothing and no footwear. Stature was measured to the nearest 0.1 cm using a portable stadiometer (Alturexata®, Brazil). BMI was calculated as body mass (kg) divided by the square of stature (m^2).

Body composition was evaluated using two complementary approaches. First, skinfold thickness was recorded at eight standardised anatomical locations —

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subscapular, triceps, biceps, mid-axillary, supra-iliac, abdominal, thigh, and calf — using a Lange-type scientific calliper (Sanny®, Brazil). Skinfold values are reported as descriptive measurements alongside the bioimpedance-derived variables. Second, octapolar multifrequency bioelectrical impedance analysis (BIA) was carried out with the BioSanny® Model 1012-8S device (BioSanny, Brazil). Fat-free mass and, by subtraction, fat mass were estimated using age-specific predictive equations validated for the Brazilian population, automatically applied by the device software according to each participant's chronological age. For adult participants (≥19 years), the equation developed and validated by Gonzalez et al. (2019), which combines height² / resistance, age, weight and waist circumference for adults from a middle-income country, was used. For adolescent participants (14–18 years), the equation developed and cross-validated by Costa et al. (2022) for Brazilian adolescents aged 10–19 years was used, derived from a dual-energy X-ray absorptiometry (DXA) criterion sample of 257 boys and girls. The variables body-fat percentage (BF%) and lean-mass percentage (LM%) reported in the tables therefore derive from octapolar BIA (using the Gonzalez equation in adults and the Costa equation in adolescents) and not from skinfolds. The BIA pre-assessment protocol required: 24-hour abstention from strenuous exercise, a minimum 4-hour overnight fast, 24-hour abstention from diuretics and alcohol, and voiding of the bladder immediately before assessment. PA was derived directly from the impedance device as the arctangent of the reactance-to-resistance ratio (Xc/R) at a frequency of 50 kHz, expressed in degrees. Regional PA values for the upper limbs (ULPA) and lower limbs (LLPA) were derived from segmental impedance measurements. Android and gynoid body fat distribution indices were extracted from the BIA output. Maturational stage (Tanner staging or peak height velocity using Mirwald et al., 2002) was not assessed in adolescent participants, and this is recognised as a methodological limitation (section 6).

2.4 Statistical Analysis

Statistical analyses were performed using IBM SPSS Statistics, version 29.0

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(IBM Corp., Armonk, NY, USA). Continuous variables were characterised using descriptive statistics: arithmetic mean, standard deviation (SD), and percentile values corresponding to the first (Q1), second (Q2, median), and third (Q3) quartiles. Data distribution normality was assessed via the Shapiro-Wilk test ($\alpha = 0.05$). Given that normality was confirmed within all age-group and event-category strata via the Shapiro-Wilk test, between-group comparisons were performed using independent-samples Student's t-tests. Because the study is positioned as exploratory and descriptive, and given the small subgroup sample sizes ($n = 7–10$ in some cells), the magnitude of differences is reported and discussed in absolute terms — using the actual mean differences in physiologically meaningful units and comparing them with published reference ranges — rather than through standardised effect-size estimators, whose precision (95% confidence intervals) would be substantially limited by sample size. No correction for multiple comparisons was applied, and the family-wise type-I error risk is acknowledged and discussed as a limitation. Statistical inference is therefore interpreted with caution, alongside descriptive characterisation. A two-tailed significance level of $\alpha = 0.05$ was adopted for all inferential analyses.

2.5 Ethical Considerations

This study was approved by the Ethics Committee of the Federal University of Amapá (approval number 6.454.711, October 24, 2023) and conducted in accordance with the National Health Council Resolution 466/2012. All adult participants and parents/guardians of minor participants provided written informed consent. The Amapá Athletics Federation and affiliated clubs granted permission for the study.

3. Results

3.1 Sample Characteristics

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The final sample comprised 46 athletes distributed across two event categories: endurance (n = 29; 63.1%) and sprint (n = 17; 36.9%). The total sample comprised 26 male (56.5%) and 20 female (43.5%) athletes; sex distribution differed between categories, with a higher proportion of females in the endurance group (15/29; 51.7%) and a higher proportion of males in the sprint group (12/17; 70.6%). This unbalanced sex distribution is addressed in the Discussion and Limitations sections, as it may act as a confounder of event-category comparisons. Adults (>18 years) represented 69.5% of the sample. Mean body mass was 68.3 ± 12.3 kg, mean height 164.5 ± 8.6 cm, and mean BMI 23.0 ± 3.7 kg/m². Descriptive characteristics by event category are presented in Table 1.

Table 1. Descriptive characterisation of the sample (sex, age, body mass and height) by event category (n = 46).

Variable	Statistic	Endurance (n = 29)	Sprint (n = 17)
Sex	Female n (%)	15 (51.7)	5 (29.4)
	Male n (%)	14 (48.3)	12 (70.6)
Age group	14–18 y, n (%)	7 (24.1)	7 (41.2)
	>18 y, n (%)	22 (75.9)	10 (58.8)
Age (y)	Q1 | Q2 | Q3	19.0 | 28.0 | 35.0	18.0 | 21.0 | 24.0
	Mean (SD)	29.1 (12.7)	21.7 (6.0)
Body mass (kg)	Q1 | Q2 | Q3	49.1 | 57.2 | 67.1	58.7 | 66.5 | 67.7
	Mean (SD)	59.5 (10.9)	63.3 (7.7)
Height (cm)	Q1 | Q2 | Q3	153.1 | 163.0 | 170.0	163.0 | 166.0 | 173.0
	Mean (SD)	161.7 (9.6)	166.8 (6.8)

Note: Q1, first quartile; Q2, median; Q3, third quartile; SD, standard deviation. Data presented as n (%) for categorical variables and as quartiles and mean (SD) for continuous variables.

3.2 Body Composition by Age and Event Category

Comparisons of skinfold-derived classification, BIA-derived body composition and body-fat distribution by age group and event category are presented in Table 2. In adult athletes, sprint athletes showed lower BF% and higher LM% than endurance athletes (p = 0.013; mean difference of approximately 7 percentage points in BF% and 7 percentage points in LM%), and

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lower android and gynoid fat distribution (p = 0.031 and p = 0.014, respectively). BMI was higher in adults than adolescents within both event categories (endurance: p = 0.006, mean difference 3.8 kg/m²; sprint: p < 0.001, mean difference 3.7 kg/m²).

Table 2. Body composition variables (BF%, LM%, BMI, android%, gynoid%) by age group and event category.

Variable	Subgroup (n)	Q1 | Q2 | Q3	Mean (SD)	p-value
BF%	Endurance, 14–18 y (n = 7)	10.8 | 14.6 | 23.0	16.3 (6.4)	
	Endurance, >18 y (n = 22)	9.6 | 15.4 | 21.4	16.1 (9.7)	0.449 (age)
	Sprint, 14–18 y (n = 7)	12.6 | 14.5 | 20.8	16.9 (7.1)	
	Sprint, >18 y (n = 10)	6.6 | 8.6 | 10.3	9.5 (5.2)	**0.013 (age)**
	Endur. vs Sprint, adults	—	—	**0.013 (category)**
LM%	Endurance, 14–18 y (n = 7)	77.0 | 84.5 | 89.2	83.4 (6.3)	
	Endurance, >18 y (n = 22)	78.6 | 84.6 | 90.4	83.9 (9.7)	0.449 (age)
	Sprint, 14–18 y (n = 7)	79.2 | 85.5 | 87.4	83.1 (7.1)	
	Sprint, >18 y (n = 10)	89.7 | 91.4 | 93.4	90.5 (5.2)	**0.013 (age)**
	Endur. vs Sprint, adults	—	—	0.091 (category)
BMI (kg/m²)	Endurance, 14–18 y (n = 7)	17.3 | 19.9 | 20.8	19.8 (2.4)	
	Endurance, >18 y (n = 22)	21.5 | 22.9 | 24.6	23.6 (3.4)	**0.006 (age)**
	Sprint, 14–18 y (n = 7)	18.7 | 20.7 | 21.6	20.1 (2.1)	
	Sprint, >18 y (n = 10)	23.6 | 23.9 | 24.3	23.8 (1.3)	**<0.001 (age)**
	Endur. vs Sprint, adults	—	—	0.402 (category)
Android%	Endurance, 14–18 y (n = 7)	13.7 | 24.9 | 32.8	23.9 (9.8)	
	Endurance, >18 y (n = 22)	22.8 | 26.9 | 31.9	27.2 (9.2)	0.213 (age)
	Sprint, 14–18 y (n = 7)	17.2 | 24.6 | 32.1	24.5 (8.9)	
	Sprint, >18 y (n = 10)	18.2 | 21.6 | 24.8	21.0 (5.9)	0.174 (age)
	Endur. vs Sprint, adults	—	—	**0.031 (category)**
Gynoid%	Endurance, 14–18 y (n = 7)	18.4 | 23.5 | 36.6	27.6 (9.6)	
	Endurance, >18 y (n = 22)	21.8 | 31.7 | 38.2	30.2 (9.7)	0.269 (age)
	Sprint, 14–18 y (n = 7)	19.2 | 23.1 | 36.0	27.1 (9.7)	
	Sprint, >18 y (n = 10)	19.1 | 21.4 | 23.3	22.5 (6.1)	0.124 (age)
	Endur. vs Sprint, adults	—	—	**0.014 (category)**

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Note: BF%, body-fat percentage; LM%, lean-mass percentage; BMI, body-mass index (kg/m²); Android%, android fat distribution; Gynoid%, gynoid fat distribution. p-values from independent-samples Student's t-test. Q1, first quartile; Q2, median; Q3, third quartile; SD, standard deviation.

3.3 Phase Angle Measurements

Phase angle results are presented in Table 3. In the adult subgroup, total PA, ULPA and LLPA were all higher in sprint athletes than in endurance athletes ($p = 0.001$, $p = 0.001$ and $p = 0.003$, respectively), with mean differences of 0.8° for total PA, 0.9° for ULPA and 0.8° for LLPA. Within the sprint category, total PA and ULPA were higher in adults than in adolescents (mean differences of 0.6° and 0.9°, respectively; $p = 0.033$ and $p = 0.003$). No statistically significant differences were observed within the endurance category between age groups.

Table 3. Total, upper-limb and lower-limb phase angle by age group and event category.

Variable	Subgroup (n)	Q1 | Q2 | Q3	Mean (SD)	p-value
Total PA (°)	Endurance, 14–18 y (n = 7)	5.8 | 6.1 | 7.2	6.4 (0.7)	
	Endurance, >18 y (n = 22)	6.1 | 6.5 | 6.7	6.5 (0.6)	0.396 (age)
	Sprint, 14–18 y (n = 7)	6.2 | 6.9 | 7.1	6.7 (0.5)	
	Sprint, >18 y (n = 10)	6.8 | 7.1 | 7.7	7.3 (0.6)	**0.033 (age)**
	Endurance . vs Sprint, adults	—	—	**0.001 (category)**
ULPA (°)	Endurance, 14–18 y (n = 7)	4.8 | 5.4 | 6.2	5.5 (0.8)	
	Endurance, >18 y (n = 22)	5.4 | 5.8 | 6.1	5.8 (0.8)	0.212 (age)
	Sprint, 14–18 y (n = 7)	5.2 | 6.0 | 6.4	5.8 (0.6)	
	Sprint, >18 y (n = 10)	6.3 | 6.7 | 7.0	6.7 (0.5)	**0.003 (age)**
	Endurance. vs Sprint, adults	—	—	**0.001 (category)**
LLPA (°)	Endurance, 14–18 y (n = 7)	6.7 | 6.7 | 7.7	7.1 (0.6)	
	Endurance, >18 y (n = 22)	6.2 | 6.7 | 7.1	6.7 (0.7)	0.126 (age)
	Sprint, 14–18 y (n = 7)	7.2 | 7.2 | 7.8	7.3 (0.4)	
	Sprint, >18 y (n = 10)	6.9 | 7.6 | 7.8	7.5 (0.6)	0.245 (age)
	Endurance. vs Sprint, adults	—	—	**0.003 (category)**

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Note: PA, total phase angle (degrees); ULPA, mean right/left upper-limb phase angle; LLPA, mean right/left lower-limb phase angle. p-values from independent-samples Student's t-test. Q1, first quartile; Q2, median; Q3, third quartile; SD, standard deviation.

4. Discussion

The present study describes preliminary parameters of body composition and phase angle in track-and-field athletes from the Brazilian Amazon, organised across five interpretive axes: (4.1) anthropometric and body-composition profile by event category, (4.2) android/gynoid fat distribution, (4.3) phase angle as a biophysical marker, (4.4) practical relevance of effect sizes, and (4.5) regional specificity of the Amazonian context.

4.1 Anthropometric and body composition profile by event category

The sample showed a predominance of endurance athletes (63.1%), which may be associated with the recent expansion of road racing in Brazil (Thuany et al., 2021) and the migration of federated athletes towards recreational competitions offering financial prizes. This distribution differs from Picanço et al. (2020), who reported a sprint-dominated sample drawn from a single club. The broader club coverage of the present study likely explains this divergence.

Sprint athletes presented higher mean values for body mass and height than endurance athletes, in agreement with international (O'Connor et al., 2007; Sedeaud et al., 2014) and national (Picanço et al., 2020) data. Height has been described as a relevant morphological parameter for sprint events, while endurance athletes typically display an ectomorphic profile with reduced body mass to optimise the power-to-weight ratio (Sedeaud et al., 2014; Stanula et al., 2013; Tjelta, 2016). However, the BMI difference between adult sprint and endurance athletes was very small in absolute terms (23.8 vs 23.6 kg/m²), reinforcing the limitation of BMI as a body-composition indicator (Etchison et al., 2011) and supporting the interpretation of BF% and LM% rather than BMI as the more informative variables in this sample.

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BMI differed markedly between adolescents and adults within both event categories (endurance: 19.8 vs 23.6 kg/m², p = 0.006; sprint: 20.1 vs 23.8 kg/m², p < 0.001), consistent with the transition from adolescence to adulthood and the accumulation of training-related lean mass (Hirsch et al., 2016; Roelofs et al., 2015). Adolescents showed higher BF% than adults among sprint athletes (16.9% vs 9.5%; p = 0.013), in agreement with the developmental pattern reported by Hirsch et al. (2016) and Aerenhouts et al. (2015) for young track-and-field athletes.

4.2 Android and gynoid fat distribution

Android and gynoid fat distribution differed between adult sprint and endurance athletes, with sprint athletes presenting lower values in both indices (android: 21.0% vs 27.2%, p = 0.031; gynoid: 22.5% vs 30.2%, p = 0.014). The mean differences (6.2 and 7.7 percentage points, respectively) are clinically relevant in the athletic context. Lower central adiposity has been linked to favourable cardiometabolic profiles in athletes (Bartkowiak et al., 2021; De Carvalho et al., 2019), but the cross-sectional design of the present study does not allow causal inference about the direction of this association, and the small sample size in each cell limits the precision of the estimates.

It is important to note that the unequal sex distribution within each event category — with more females in the endurance group and more males in the sprint group — may partially explain these differences in fat distribution, since gynoid deposition is typically greater in females. Accordingly, the observed differences between event categories should be interpreted with caution and cannot be attributed exclusively to event-specific training adaptations.

4.3 Phase angle as a biophysical marker

The phase angle findings are compatible with the body of evidence characterising PA as a biophysical parameter linked to the preservation of cellular integrity, lean mass quantity, and muscular function (Cirillo et al., 2023a; Hetherington-Rauth et al., 2021; Martins et al., 2022; Matias et al., 2021; Mattiello et al., 2022; Monteiro et al., 2018). The adult sprint subgroup presented higher total

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PA (7.3 ± 0.6°) than endurance athletes (6.5 ± 0.6°; p = 0.001). The mean difference of 0.8° is biologically substantial when contextualised against the Brazilian reference percentiles for healthy young adults reported by Mattiello et al. (2022), where adjacent percentiles typically differ by 0.2–0.3°. Comparable PA differences have been reported between strength/power and endurance athletes (Cirillo et al., 2023b), and adult sprint values in the present sample are within the upper range described in those reference percentiles.

Regional PA values (ULPA, LLPA) reinforce the same pattern: sprint athletes presented higher upper- and lower-limb PA than endurance athletes (ULPA: 6.7 vs 5.8°, p = 0.001; LLPA: 7.5 vs 6.7°, p = 0.003). Cirillo et al. (2023a) reported a robust positive association between PA and muscle strength in athletes from multiple sports, and the present data are compatible with that pattern. Nonetheless, because the present design is cross-sectional and does not include strength or performance measures, the relationship between higher PA and physical performance cannot be tested directly and is interpreted only as a contextual hypothesis.

4.4 Statistical significance and practical relevance

Beyond statistical significance, the present results are interpreted in light of the absolute magnitude of the observed differences in physiologically and clinically meaningful units. The most consistent and practically relevant differences were observed in phase-angle variables in the adult subgroup, where mean differences between sprint and endurance athletes (0.8° in total PA, 0.9° in ULPA and 0.8° in LLPA) are substantial when contextualised against the Brazilian reference percentiles for healthy adults (Mattiello et al., 2022), in which adjacent percentiles differ by approximately 0.2–0.3°. Differences in BMI between adolescents and adults (~3.7–3.8 kg/m² within both event categories) reflect the expected developmental and training-related accumulation of lean mass. By contrast, BF%/LM% differences between adult sprint and endurance athletes (~7 percentage points) — although statistically significant — should be interpreted as preliminary signals that require confirmation in larger samples, given the small subgroup sizes.

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For coaches and technical staff, the phase-angle differences therefore emerge as the most actionable findings of the present descriptive study.

4.5 Comparison with external references

The BF% values observed in adult sprint athletes (≈9.5%) are within the range reported for Division I sprint and power-event athletes (Hirsch et al., 2016) and below those reported for Brazilian female athletes from team sports (Alves Junior et al., 2021). LM% values for adult sprint athletes (≈90%) are comparable to those reported for elite power athletes (Kubo et al., 2011; Kumagai et al., 2000). Adult endurance athletes presented BF% (≈16%) and LM% (≈84%) within the range reported for Division I cross-country runners (Roelofs et al., 2015) and elite distance runners (Tjelta, 2016). Total PA values for adult endurance athletes (≈6.5°) fall close to the 50th percentile reported for Brazilian healthy young adults (Mattiello et al., 2022), while adult sprint values (≈7.3°) approach the upper percentiles in that reference. These comparisons situate the present sample as broadly consistent with published athletic populations, while reinforcing the descriptive — rather than normative — nature of the present data.

4.6 The Amazonian context

The interpretation of these descriptive parameters should be contextualised within the specific Amazonian reality. The hot-humid equatorial climate of Amapá imposes thermal-stress and hydration demands distinct from those of athletes training in temperate regions, which may influence BIA measurements through alterations in body-water distribution (Barbosa-Silva & Barros, 2005). Access to specialised sports infrastructure, sports medicine and individualised nutritional support remains uneven across Amazonian states, with consequences for training quality, recovery and body-composition monitoring. The athletics modality is not extensively integrated into the school curriculum of the region, which limits the federated athlete pool and reduces opportunities for systematic talent identification.

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These contextual factors should not be used to draw causal inferences from cross-sectional data, but they justify the development of locally generated descriptive parameters as a first step toward future regional reference frameworks. The present sample therefore represents an under-investigated population whose anthropometric and bioelectrical profile may differ from that of athletes from major Brazilian centres, particularly in the southern and south-eastern regions.

4.7 Sex composition and confounding

A central concern in the interpretation of the present results is the unbalanced sex distribution within event categories: females predominate in the endurance group, while males predominate in the sprint group. Body composition, fat distribution and phase angle are strongly influenced by biological sex (Mattiello et al., 2022), so part of the differences observed between sprint and endurance athletes may reflect sex composition rather than event-specific training adaptations. Because the present sample size does not allow stable inferential analyses stratified by sex (which would create subgroups of n ≤ 5 in some cells), we did not perform sex-adjusted comparisons. This limitation implies that differences attributed here to event category should be interpreted as exploratory associations and not as direct effects of sprint versus endurance training. Future studies with balanced sex distributions are required to disentangle these effects.

5. Conclusions

The present cross-sectional study provides preliminary descriptive parameters of body composition and phase angle in track-and-field athletes from the Brazilian Amazon, stratified by event category and age group. The most consistent findings were higher phase-angle values in adult sprint athletes than in adult endurance athletes, with mean differences (0.8° in total PA, 0.9° in ULPA and 0.8° in LLPA) that are substantial against published reference percentiles, and higher BMI in adults than in adolescents within both event categories. Differences in BF% and LM% between adult sprint and endurance athletes were statistically

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significant but should be interpreted as preliminary signals to be confirmed in larger samples.

These parameters may support talent identification, individualised training prescription and longitudinal health monitoring of regional athletes, although they should not be interpreted as normative reference values, given the small sample size, the convenience sampling, the absence of sex stratification and the lack of biological-maturation control. The higher PA values observed in adult sprint athletes are consistent with this parameter being associated with cellular integrity, lean-mass status and neuromuscular readiness, but the cross-sectional design precludes any causal inference about training effects on phase angle. Future longitudinal studies with larger, sex-balanced samples, biological-maturation control and training-load monitoring are needed to consolidate these preliminary parameters into formal regional reference values.

6. Study Limitations

Several limitations should be considered when interpreting the present findings. (i) The cross-sectional design precludes causal or temporal inferences; observed differences may reflect training, biological selection into the modality, maturation, sex composition, dietary patterns, hydration status or competitive history. (ii) The total sample (n = 46) is small and was recruited by convenience from the federated population of a single Brazilian state; no a priori sample-size calculation or formal statistical power analysis was conducted. The geographic isolation of the Brazilian Amazon, the low penetration of athletics in regional school programmes and the small pool of federated athletes account for this restriction, but it limits the statistical power of subgroup analyses (n = 7–10 in some cells) and the generalisability of findings. (iii) Sex distribution within event categories is unequal, with females predominating in endurance and males in sprint groups, and the sample size did not allow stable sex-stratified inferential analyses; the resulting risk of confounding is therefore a central limitation rather than a secondary one, and differences attributed here to event category cannot be interpreted as independent of sex composition. (iv) Multiple comparisons were not adjusted, increasing the

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family-wise risk of type-I error; nominal p-values should therefore be interpreted with caution and alongside the absolute magnitude of the observed differences. Standardised effect-size estimators (e.g., Cohen's d) and non-parametric sensitivity analyses (e.g., Mann-Whitney U) were not reported because, given the small subgroup sizes (n = 7–10 in some cells), they would yield wide confidence intervals with limited additional inferential value, and the present study is therefore positioned as descriptive-exploratory; these analyses should be incorporated in future studies with larger and adequately powered samples. (v) Biological-maturation indicators (Tanner staging or peak height velocity per Mirwald et al., 2002) were not collected in adolescent participants, despite the substantial maturational heterogeneity expected in the 14–18 year range; adolescent-versus-adult comparisons should therefore be interpreted cautiously. (vi) Although inclusion criteria required at least 12 months of systematic training with a minimum of two weekly sessions and participation in at least two state-level competitions in the previous year, detailed information on weekly training volume (hours), intensity, current periodisation phase and competitive level was not systematically collected and could not be controlled for. (vii) Jump and throw events were excluded owing to insufficient subgroup numbers, restricting comparison across the full range of track-and-field disciplines. (viii) BF% and LM% derive exclusively from octapolar BIA using age-specific predictive equations validated for the Brazilian population (Gonzalez et al., 2019, for adults; Costa et al., 2022, for adolescents); although both equations were cross-validated against reference methods in their original samples, their applicability to athletic populations specifically has not been formally tested and may introduce systematic bias. (ix) Skinfold measurements are reported as descriptive measures and were not used to derive the BF%/LM% values, to avoid mixing methods. These limitations support the framing of the present results as preliminary descriptive parameters rather than as formal reference values.

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