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Original Research Article

Gross Anatomical Anthropometry use in Fitness Assessment of Professional Academy Players in Bayelsa State, Nigeria

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Abstract

Anthropometric characteristics are critical determinants of football performance, yet their associations with fitness outcomes remain inconsistent, particularly in understudied regions like Sub-Saharan Africa. This study assessed anthropometric and physical fitness profiles of 20 male football academy players in Bayelsa State, Nigeria, and explored correlations between these variables. Using a correlational design, standardized protocols (International Society for the Advancement of Kinanthropometry guidelines) measured height, weight, limb lengths, circumferences, and waist-hip ratio. Fitness tests included the Illinois Agility Test, 40-m sprint, Yo-Yo Intermittent Recovery Test, sit-and-reach, standing long jump, and plank hold. Pearson correlations and regression analyses identified relationships between variables. Results revealed a mean thigh circumference of 52.77 ± 1.32 cm and Illinois Agility Test time of 17.87 ± 0.20 seconds. Thigh circumference significantly correlated with agility ($r = 0.543$, $p = 0.013$), with regression equation $Y = 0.08x + 13.50$ explaining 29.5% of variance ($R^2 = 0.295$). Conversely, limb length, weight, and calf circumference showed no significant associations with speed, endurance, or power. These findings align with studies highlighting thigh musculature's role in agility, though contrasts exist in contexts prioritizing vertical power. The study higlights thigh circumference as a key predictor of agility in Nigerian youth players, advocating targeted lower-body strength training for talent development. Future research should explore biomechanical mechanisms and socioeconomic barriers in Sub-Saharan Africa.

Keywords: Football Performance, Anthropometry, Agility, Youth Athletes, Talent Identification, Sub-Saharan Africa, Bayelsa State.

1. INTRODUCTION

Football, as a high-intensity intermittent sport, demands a complex interplay of anthropometric characteristics and physical fitness to achieve optimal performance (Williams *et al.*, 2023). Anthropometric measures such as height, limb length, body composition, and muscle mass are critical determinants of success, influencing speed, agility, power, and endurance (Stølen *et al.*, 2005). For instance, greater lower-body muscle mass, particularly in the thighs, has been associated with enhanced sprinting and jumping capabilities, which are pivotal for explosive movements during matches (Comfort *et al.*, 2012). Similarly, limb length and waist-hip ratio (WHR) are linked to biomechanical efficiency, affecting stride length, balance, and injury resilience (Kolodziej *et al.*, 2022). These relationships underscore the need for targeted anthropometric profiling in talent identification and training optimization, especially in competitive youth academies (Pion *et al.*, 2015).

Despite the recognized importance of anthropometry, existing studies report conflicting findings on its association with fitness outcomes. For example, while Ré *et al.*, positive correlation between thigh circumference and specific technical capacities, potentially including agility, in elite Spanish players. While not explicitly stated as agility, the study found that thigh circumference and other anthropometric factors, like body size, differentiated players by their level of play. However, Papadimitriou, *et al.*, (2009) found no significant relationship between limb length and sprint performance in Greek athletes. Such discrepancies may arise from population-specific variations in training regimens, genetic predispositions, or methodological differences in measurement protocols (Leko *et al.*, 2024; Kwon *et al.*, 2025). Furthermore, environmental factors, including access to advanced training facilities and nutritional resources, disproportionately affect athletes in low-resource settings, potentially altering anthropometric-fitness dynamics (Daniel Tang, 2021;

Yang *et al*., 2024). In Sub-Saharan Africa, where football academies often operate with limited infrastructure, these factors may uniquely shape player development trajectories, yet region-specific data remain scarce (Quansah, 2022).

The role of anthropometry in football performance is further complicated by the sport's evolving physical demands. Modern gameplay emphasizes rapid directional changes, high-speed sprints, and sustained aerobic capacity, necessitating a balance between muscle hypertrophy and functional mobility (Chetan, & Saxena, 2024; Radakovic *et al*., 2025). For instance, excessive thigh muscle mass may impair agility due to increased inertial resistance, whereas moderate hypertrophy enhances power generation (Van Hooren *et al*., 2024). Similarly, WHR, a marker of central adiposity, has been inversely correlated with endurance in adolescent players, likely due to its association with inefficient energy utilization (Chanda *et al*., 2021; Xu *et al*., 2024). These nuances highlight the context-dependent nature of anthropometric influences, warranting population-specific investigations to inform training strategies.

In Nigeria, football academies serve as critical hubs for nurturing elite talent, yet empirical data on the anthropometric and fitness profiles of players are limited. Existing studies in West Africa have primarily focused on senior athletes, neglecting the youth developmental phase where targeted interventions could yield long-term benefits (Mustafovic *et al*., 2020; Thompson *et al*., 2022). Moreover, cultural and socioeconomic factors, such as varying dietary practices and early specialization in sport, may uniquely influence the growth and performance metrics of Nigerian academy players compared to global cohorts (Seriki, 2024). Without localized evidence, coaches rely on generalized international guidelines, which may misalign with the biological and environmental realities of Nigerian athletes (Johan Cruyff Institute, 2024).

This study addresses these gaps by examining the relationships between anthropometric measures (height, weight, limb length, thigh and calf circumference, WHR) and fitness performance (speed, agility, endurance, strength, flexibility) among male football academy players in Bayelsa State, Nigeria. By focusing on a homogeneous cohort within a defined geographic and developmental context, the study aims to elucidate how localized anthropometric traits interact with functional capacities, providing actionable insights for talent development. The objectives of the study were:

1. To assess the anthropometric and physical fitness characteristics of football academy players in Bayelsa State.
2. To determine the correlations between specific anthropometric measures (e.g., thigh circumference, limb length) and fitness performance metrics (e.g., agility, sprint speed).
3. To identify the strongest anthropometric predictors of key fitness outcomes, such as endurance and power.

By achieving these objectives, this study will provide evidence-based recommendations for tailoring training programs to optimize player performance, enhance talent identification processes, and contribute to the growing body of sport science research in Sub-Saharan Africa.

2. METHOD

2.1 Study Design

In this study, we employed a correlational research design to examine the relationships between selected anthropometric measures (height, weight, limb length, thigh and calf circumference, waist-hip ratio) and fitness performance (speed, agility, endurance, strength, flexibility) among football academy players in Bayelsa State, Nigeria.

Study Population and Sampling Technique

The study involved a sample size of 20 male football players from a football academy in Bayelsa State, representing the entire population of active players at the time of data collection. A total population (census) sampling technique was employed, allowing the inclusion of all eligible participants to ensure complete representation and minimize sampling bias. This method was appropriate given the small, well-defined population and ensured that variations in anthropometric and fitness characteristics across the entire squad were captured. The approach enhanced the reliability, validity, and generalizability of the findings within the context of the academy.

2.2 Method of Data Collection

The data collection process for this study was designed to capture accurate and reliable measurements of anthropometric characteristics and physical fitness parameters among the 20 football players. All data were collected at Fezi Resorts in Elebele town, Ogbia Local Government Area, Bayelsa State, a well-equipped training environment. Data collection was overseen by trained professionals including fitness coaches and sports scientists to ensure procedural integrity. To minimize environmental variability, measurements were conducted in a controlled setting that limited distractions and maintained stable conditions, such as temperature and surface consistency.

Figure 1: Picture showing the setup process

2.2.1 Anthropometric Measurements

Anthropometric data were collected following the guidelines of the International Society for the Advancement of Kinanthropometry (ISAK) to ensure cross-subject consistency and comparability (Petri *et al.*, 2024). Each measurement was taken twice, using calibrated instruments, and either the average or higher of the two readings was recorded to reduce intra-observer variability and improve precision.

Players' height (cm) was measured using a calibrated stadiometer while standing barefoot with their back straight and head positioned in the Frankfurt plane to standardize posture and minimize measurement error. Each participant was measured twice, with the higher value recorded.

Weight (kg) was recorded using an electronic weighing scale with players dressed in minimal clothing and barefoot to ensure uniformity across participants. The scale was calibrated prior to each session to maintain measurement integrity.

Upper limb length was measured from the acromion to the tip of the middle finger with the player's arm fully extended, while lower limb length was recorded from the anterior superior iliac spine to the floor. All participants stood upright, barefoot, and relaxed to avoid tension-related discrepancies, and each measurement was taken twice to confirm consistency.

The waist-to-hip ratio (WHR) was calculated using waist circumference (WC) and hip circumference (HC), which were measured using a non-stretchable tape. WC was measured midway between the lowest rib and the iliac crest, while HC was measured at the widest portion of the buttocks. Measurements were repeated and the ratio was derived using the formula:

$$WHR = \frac{Waist\ Circumference\ (WC)}{Hip\ Circumference\ (HC)}$$

Thigh circumference (cm) was measured at the midpoint between the hip and knee joints using a flexible measuring tape, while calf circumference (cm) was taken at the widest part of the calf. Both were conducted while the participant stood with relaxed posture and feet apart, with two readings taken to ensure repeatability.

2.2.2 Fitness Performance Tests

A series of performance-based fitness tests were conducted to assess agility, speed, endurance, flexibility, muscle strength, and muscular endurance. All tests were performed on natural grass in a consistent, distraction-free training environment, with clear marking and preparation according to standard testing procedures. Each test was performed twice (unless otherwise stated), with the best result recorded to ensure fair comparison and minimize performance anomalies.

Agility was assessed using the Illinois Agility Test, in which players navigated a 10-meter by 5-meter zigzag course, with four cones placed 3.3 meters apart along the central axis, as described by Goral (2015) and Eraslan *et al*., (2025). To ensure test reliability, trials were conducted on a flat, non-slippery surface, and players completed two timed runs with adequate rest intervals. The best time, recorded using a stopwatch, was used for analysis.

Figure 2: The setup of the Illinois Agility Test

The 40-meter sprint test was used to evaluate maximal speed. Players sprinted from a standing start, and timing was recorded with a stopwatch. To ensure standardization, the test was conducted on a flat, grassy surface following a warm-up, and two trials were completed with rest intervals; the fastest time was selected.

To assess aerobic capacity, players completed the Yo-Yo Intermittent Recovery Test (Level 1), running back and forth between two 20-meter markers in time with progressive beep signals. The test continued until the player could no longer keep pace. The level and number of completed shuttles were recorded and used to estimate VO_{2max} using the formula:

$$VO_{2max} = 3.46\ x\ \left(\frac{L + S}{L\ x\ 0.4325 + 7.0048}\right) + 12.2$$

where L represents the final level reached and S the number of shuttles completed at that level. The test was conducted once per player, with strict adherence to protocol to ensure internal validity.

Figure 3: Players during the Yo-Yo Intermittent Recovery Test

Flexibility was assessed through both the traditional sit-and-reach test and the single-leg sit-and-reach test, which targets each leg individually. Participants sat with one leg extended and the other bent, reaching forward along a measurement box while avoiding knee flexion. Both legs were tested twice, and the maximum distance reached (in cm) for each leg was recorded to detect flexibility imbalances. This dual-approach was chosen based on findings by Mayorga-Vega *et al*., (2014), which highlighted the complementary validity of both methods.

Lower-body muscle strength was measured using the standing long jump test, where players jumped from a stationary position with both feet. The distance jumped was measured from the starting line to the point of heel contact upon landing. Two trials were performed, and the longer distance was recorded to standardize performance outcomes.

Lastly, core muscle endurance was assessed using the plank hold test, where players maintained a forearm plank position with elbows aligned beneath shoulders and a neutral spine. The position was monitored to avoid sagging or arching, and the maximum duration held was recorded. This setup ensured uniform technique and allowed for consistent measurement of core endurance across participants.

2.3 Data Recording and Quality Control

To enhance data accuracy and reliability, all measurements were recorded twice. In instances where the two values differed beyond an acceptable range, a third measurement was taken, and the average of the two closest values was used for analysis. All measuring instruments were calibrated prior to each session to maintain precision and reduce systematic error.

Data were collected and recorded on structured paper-based sheets by trained personnel familiar with the standardized protocols for each test, thereby ensuring inter-rater and intra-rater reliability. The collection sheets were independently cross-verified by members of the research team immediately following each session to detect and correct any inconsistencies or missing values. Subsequently, data were digitized and entered into a secured database for statistical processing. Double-entry verification was used to minimize transcription errors during digital input. The use of structured data formats facilitated organized and efficient analysis while reducing the likelihood of missing or miscoded data points.

2.4 Data Analysis

All data were initially entered into Microsoft Excel 2013 and subsequently analyzed using IBM SPSS Statistics version 25.0. Descriptive statistics were calculated, and results were expressed as mean ± standard deviation. A one-way analysis of variance (ANOVA) was performed to determine significant differences in mean anthropometric and fitness parameters among players. Pearson correlation analysis was used to assess the strength and direction of relationships between anthropometric measurements and fitness performance indicators. Additionally, multiple regression analysis using the stepwise method was employed to identify the strongest predictors of fitness outcomes. Statistical significance was set at $p < 0.05$.

Ethical Considerations

This study adhered strictly to ethical standards to protect the rights, welfare, and privacy of participants. Informed consent was obtained from all football players after clearly explaining the study's objectives, procedures, and potential risks and benefits. Participation was entirely voluntary, with players free to withdraw at any time without consequence, despite the use of total population sampling. To maintain confidentiality and anonymity, each participant was assigned a unique identification number, and all data were securely stored in encrypted formats accessible only to authorized personnel. All fitness assessments were conducted under professional supervision to ensure safety, with appropriate medical support and rest provided throughout. The research team upheld data integrity by transparently reporting all findings and deviations, and ensured fairness by treating all participants equally. Ethical approval was obtained from the Bayelsa Medical University Research Ethics Committee prior to the commencement of the study.

3. RESULTS

Anthropometric and Fitness Characteristics of Players

The anthropometric and fitness characteristics of the players are presented in Tables 1 and 2, respectively. As shown in Table 1, the mean age of the participants was 18.25 ± 0.49 years, with an average body weight of 62.95 ± 1.92 kg and height of 173.62 ± 3.16 cm. Limb measurements revealed a mean upper limb length of 62.88 ± 0.96 cm and a lower limb length of 94.90 ± 4.58 cm. The average hip-waist ratio was 0.83 ± 0.01, while thigh and calf circumferences were 52.77 ± 1.32 cm and 34.64 ± 0.52 cm, respectively.

In terms of physical fitness characteristics (Table 2), the players recorded a mean Illinois Agility Run time of 17.87 ± 0.20 seconds and a 40-meter sprint time of 5.71 ± 0.06 seconds. Flexibility measures showed average reach values of 24.60 ± 1.36 cm for the left leg, 25.70 ± 1.38 cm for the right leg, and 26.45 ± 1.61 cm for trunk flexibility. The mean performance in the standing long jump was 247.98 ± 3.93 cm, while core endurance, assessed via the plank test, averaged 111.80 ± 15.14 seconds.

Table 1: Anthropometric characteristics of players (n=20)

Anthropometric parameters	Mean	Standard error of mean (SEM)	Standard Deviation of Mean
Age (years)	18.25	0.49	2.17
Weight (kg)	62.95	1.92	8.60
Height (cm)	173.62	3.16	14.15
Upper limb length (cm)	62.88	0.96	4.27
Lower limb length (cm)	94.90	4.58	20.49
Hip-waist ratio (cm)	0.83	0.01	0.03
Thigh circumference (cm)	52.77	1.32	5.89
Calf (cm)	34.64	0.52	2.31

n = sample size

Table 2: Fitness characteristics of players (n=20)

Fitness parameter	Mean	Standard Error of Mean (SEM)	Standard Deviation
Illinois Agility Run (sec)	17.87	0.20	0.90
40 Meters Run (sec)	5.71	0.06	0.29
Left leg(cm)	24.60	1.36	6.07
Right leg(cm)	25.70	1.38	6.16
Trunk (cm)	26.45	1.61	7.18
Standing long jump (cm)	247.98	3.93	17.55
Plank test (sec)	111.80	15.14	67.71

n = sample size

Correlation between Anthropometric Parameters and Fitness Performance among Players

As shown in Table 3, Pearson correlation analysis revealed that most anthropometric parameters were not significantly associated with fitness performance measures among the players ($p > 0.05$). However, thigh circumference showed a statistically significant positive correlation with agility as measured by the Illinois agility test ($r = 0.543$, $p = 0.013$), indicating that players with greater thigh circumference tended to perform better in agility tasks. While upper limb length demonstrated a moderately positive, though non-significant, correlation with VO_2 max ($r = 0.404$, $p = 0.078$) and standing long jump ($r = 0.376$, $p = 0.102$), these relationships did not reach statistical significance. Similarly, lower limb length showed a negative trend with standing long jump ($r = -0.438$, $p = 0.053$), suggesting a potential inverse relationship between leg length and explosive leg power, though again not statistically significant. Other anthropometric variables, including weight, height, hip-waist ratio, and calf circumference, exhibited weak and non-significant correlations across fitness domains such as speed, flexibility, and endurance.

Table 3: Relationship between anthropometric parameters and fitness performance among individual players (n = 20)

	Pearson Correlation	Agility: Illinois agility test	Speed: 40 metres sprint test	Beep Test: VO2 Max (mL/kg/min)	Flexibility: left leg (cm)	Flexibility: Right (cm)	Flexibility: Trunk (cm)	Power: standing long jump (cm)	Endurance: Plank Test (seconds)
Weight (Kg)	r	-0.259	0.272	-0.254	-0.326	-0.317	-0.211	0.076	-0.160
	P	0.270	0.247	0.280	0.160	0.174	0.372	0.750	0.499
Height (cm)	r	-0.182	0.181	0.232	0.219	0.191	0.048	0.228	0.124
	p	0.442	0.445	0.324	0.354	0.420	0.842	0.334	0.601
Upper Limb length (cm)	r	-0.346	0.210	0.404	0.111	0.067	0.147	0.376	0.050
	p	0.135	0.373	0.078	0.642	0.777	0.535	0.102	0.834
Lower limb length (cm)	r	0.017	0.039	0.059	-0.070	-0.135	-0.138	-0.438	-0.087
	p	0.945	0.869	0.804	0.768	0.569	0.561	0.053	0.715
Hip-waist-ratio	r	-0.008	-0.128	0.250	-0.134	0.007	-0.043	0.053	-0.211
	p	0.973	0.590	0.288	0.574	0.977	0.857	0.825	0.371
Thigh circumference	r	0.543	0.263	-0.272	-0.249	-0.411	-0.342	-0.308	-0.243
	p	0.013	0.263	0.246	0.290	0.072	0.139	0.187	0.302
Calf (cm)	r	-0.385	-0.052	-0.325	-0.217	-0.183	-0.126	0.226	-0.287
	p	0.094	0.826	0.161	0.357	0.441	0.597	0.339	0.221

Values are presented as Mean ± SEM. r: Pearson's correlation, P: statistical level of significance was determined using Pearson's correlation. p<0.05 means there is significant association between mean values. n = sample size or number of subjects

Predictive Association between Thigh Circumference and Illinois Agility Test Performance

Table 4 and Figure 4 show a statistically significant moderate positive correlation between thigh circumference and Illinois agility test performance among professional football players in Bayelsa State ($r = 0.543$, $p = 0.013$), indicating that larger thigh circumference is associated with slower agility times, as represented by the regression equation $Y=0.08x+13.50$ and coefficient of determination $R^2=0.295$, which suggests that approximately 29.5% of the variance in agility performance can be explained by thigh circumference.

Table 4: Predictors of fitness performance among professional football players in Bayelsa State

Football Players	Parameter	r	r^2	p-value	Prediction Equation
Total (n = 20)	Thigh circumference - Illinois agility test	0.543	0.295	0.013	Y = 0.08x + 13.50

r: Pearson's correlation, P: statistical level of significance was determined using Pearson's correlation. p<0.05 means there is significant association between mean values, n: sample size. y: dependent variable, x: Independent variable.

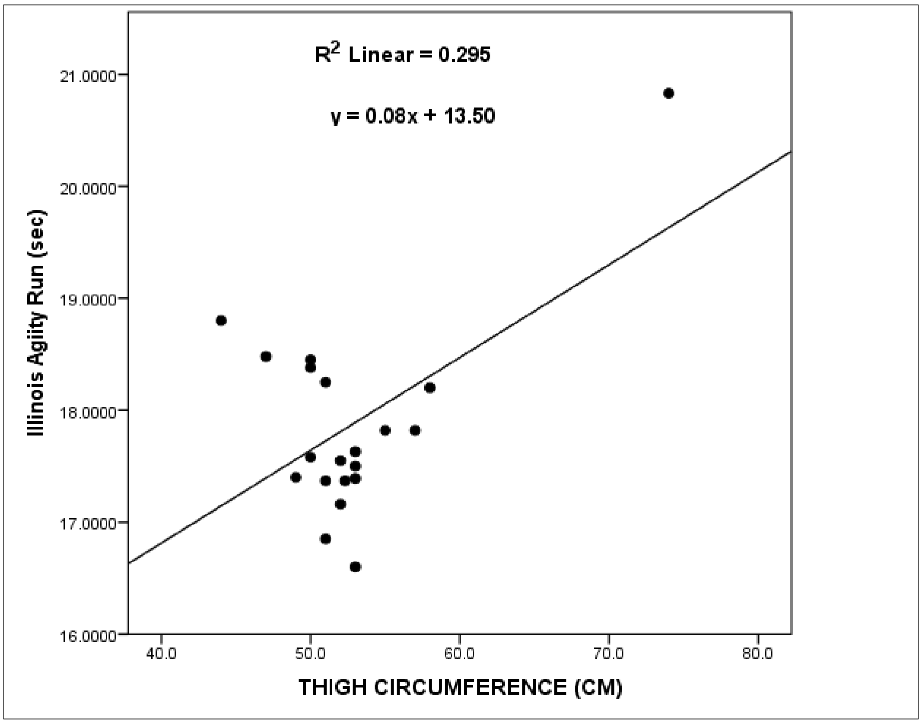

Figure 4: Scatterplot showing the linear regression between thigh circumference (cm) and Illinois agility run (sec) in the total players

4. DISCUSSION

This study examined the anthropometric and physical fitness profiles of male football academy players in Bayelsa State, Nigeria, and explored relationships between these variables. The findings revealed that participants exhibited anthropometric characteristics (e.g., mean height: 173.62 cm, thigh circumference: 52.77 cm) and fitness performance metrics (e.g., 40-m sprint: 5.71 s, standing long jump: 247.98 cm) consistent with regional norms for adolescent footballers. Notably, thigh circumference demonstrated a significant positive correlation with agility performance ($r = 0.543$, $p = 0.013$), whereas limb length, weight, and other anthropometric measures showed no robust associations with fitness outcomes. These results align with the study's objectives, providing insights into region-specific predictors of athletic performance and highlighting the potential role of lower-body musculature in agility.

The significant correlation between thigh circumference and agility performance (Illinois Agility Test) suggests that greater muscle mass in the thigh region may enhance rapid directional changes, a critical skill in football. This finding aligns with studies on European youth players, where thigh muscle hypertrophy was linked to improved acceleration and deceleration during agility tasks (le Gall *et al.*, 2010; Till *et al.*, 2015). However, the regression equation ($Y = 0.08x + 13.50$) indicates that larger thigh circumference may also marginally slow agility times. This paradoxical relationship could reflect a balance between muscle power and inertial resistance, as excessive muscle mass may hinder quick limb repositioning (Till *et al.*, 2015). This paradox mirrors findings in basketball, where players with greater muscle mass exhibited trade-offs between power and agility (Köklü *et al.*, 2011). The coefficient of determination ($R^2 = 0.295$) further implies that nearly 30% of agility variance is attributable to thigh size, highlighting its importance while suggesting additional factors such as neuromuscular coordination, technique) dominate performance.

Upper limb length showed a non-significant positive trend with VO_{2max} ($r = 0.404$, $p = 0.078$) and standing long jump ($r = 0.376$, $p = 0.102$), contrasting with basketball studies where longer limbs enhanced vertical jump efficiency (Nikolaidis, 2017; Zhou *et al.*, 2024). Similarly, the inverse trend between lower limb length and standing long jump ($r = -0.438$, $p = 0.053$) suggests shorter limbs may favour explosive power generation, as seen in rugby players with compact physiques (Bchini *et al.*, 2025). These discrepancies may arise from sport-specific demands: football prioritizes agility and repeated sprints over vertical leap capacity, potentially diminishing the influence of limb length.

Weight, height, and calf circumference exhibited weak correlations with speed and endurance, diverging from studies linking lean mass to sprint performance in elite academies (Abe *et al.*, 2020). This inconsistency may reflect the homogeneity of the sample, where all players underwent similar training regimens, minimizing anthropometric variability.

Environmental factors, such as limited access to advanced conditioning resources in Bayelsa State, may also attenuate the impact of body composition on fitness outcomes (Oyeyemi *et al*., 2012). For instance, socioeconomic constraints could restrict nutritional quality, indirectly affecting muscle development and recovery.

Strengths and Limitations

The study's strengths include the use of standardized ISAK protocols for anthropometry, ensuring measurement reliability, and the inclusion of all eligible academy players, which reduced selection bias. However, the small sample size (n = 20) limited statistical power, potentially obscuring subtle relationships, such as the near-significant association between lower limb length and explosive power. The cross-sectional design precludes causal inferences, and unmeasured confounders, such as maturation status and dietary intake, may have influenced results. Future longitudinal studies with larger cohorts are needed to track how anthropometric changes during adolescence interact with fitness development.

5. CONCLUSIONS

This study underscores thigh circumference as a critical predictor of agility in Bayelsa State footballers, offering actionable insights for coaches and academies. Prioritizing lower-body strength training (e.g., plyometrics, resisted sprints) could enhance agility, aligning with global best practices (Bradley *et al*., 2023). Additionally, integrating thigh circumference into talent identification frameworks may improve scouting accuracy in resource-limited settings. However, addressing systemic barriers, such as nutritional deficits and inadequate training infrastructure, is essential to fully realize the anthropometric potential of regional athletes. Future research should explore biomechanical mechanisms linking thigh musculature to agility and investigate how socioeconomic factors modulate these relationships in Sub-Saharan Africa.

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