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Relationship between anthropometric characteristics and basketball-specific skills among South African university players

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Abstract

Background and Study Aim Anthropometric characteristics are commonly considered important determinants of performance in basketball. Variations in body size and composition may influence the execution of fundamental technical skills such as passing, shooting, and dribbling. Despite their practical relevance, the extent to which these characteristics relate to specific skill performance remains of practical interest in university players. This study aimed to examine the relationship between anthropometric characteristics and sport-specific skills among university-level basketball players in South Africa.

Material and Methods The study included 32 players (18 males and 14 females; mean age 21.71 ± 2.34 years). Selected skills were assessed using the AAHPERD standardized test battery. Data were analyzed using the Statistical Package for the Social Sciences (SPSS). The analysis included descriptive statistics, independent t-tests to examine sex differences, Pearson correlation coefficients to assess relationships among variables, and multiple regression analyses to predict passing skill.

Results The results among female players showed that body mass and body fat percentage (BF%) were strongly and negatively correlated with passing ($p < 0.01$). Females' muscular mass showed a strong negative correlation with shooting ($p < 0.01$). It also showed moderate negative correlations with left-hand control dribbling and a positive correlation with right-hand control dribbling ($p < 0.05$). Among male players, body height ($p < 0.01$) and leg length ($p < 0.01$) were strongly and negatively associated with passing skill. Males' muscularity was positively correlated with left- and right-hand dribble control time ($p < 0.05$). Body fat percentage was positively correlated with shooting skill ($p < 0.05$). No significant correlations were found between somatotype scores and basketball-specific skills in either group. Multiple regression analysis revealed that, for female players, lower body fat percentage and greater height significantly predicted better passing skill ($R^2 = 0.71$, $p = 0.016$). For male players, muscular mass was the only significant predictor ($R^2 = 0.43$, $p = 0.097$).

Conclusions The findings indicate that certain anthropometric characteristics, such as lower body fat percentage and greater muscular mass, may support basketball skill performance. However, overall success depends largely on technical skill proficiency. Skill execution is driven more by correct technique than by body characteristics alone. This highlights the importance of skill-focused training programs designed to enhance neuromuscular development in South African university basketball players.

Keywords: passing skill, dribbling skill, shooting skill, body composition, university basketball

Introduction

Basketball performance is determined by the interaction of physical attributes and technical execution during game situations. Players are required to perform passing, shooting, and dribbling actions under varying movement speeds and defensive pressure, where body dimensions and composition may influence movement control and coordination. Differences in height, limb length, muscular mass, and fat percentage can affect balance and reach, as well as ball handling mechanics, thereby shaping the effectiveness of skill execution. These relationships have practical relevance for training organization and player development in university basketball.

In context, basketball is an intermittent, physically demanding sport that requires players to possess a range of skills to play strategically and effectively and to score more points [1]. Previous research has shown that successful teams are characterized by a higher frequency of performing sport-specific skills such as accurate passing, efficient dribbling, and greater shooting opportunities [2, 3]. It is also emphasized that teams executing more passes and shot attempts tend to have an increased probability of winning in professional basketball [4]. In support of this, a study highlighted that teams that prioritize frequent passes enhance game tempo, increase shooting frequency, disrupt defensive structures, and create offensive balance [3].

Anthropometric characteristics often vary among athletes and may result in differences in skill execution and overall sport performance [5]. It has been reported that basketball skills improve as anthropometric characteristics improve [6]. Previous research has explored the influence and predictive value of anthropometric characteristics on basketball-specific skills, consistently highlighting

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the importance of attributes such as body dimensions, body composition, and somatotype in predicting success in elite competition [3, 4, 7, 8, 9]. Greater arm length in Greek wheelchair basketball players is positively associated with accurate long-pass performance [7]. Similarly, stretched arm length, body height, and raised arm height of young basketball players were identified as significant predictors of dribbling speed and obstacle dribbling ability [8]. Leg length of male basketball players from universities in Northern India positively contributes to their passing, shooting, and dribbling abilities [10]. These findings highlight the impact of anthropometric characteristics on basketball performance and positional roles.

Despite extensive global research examining the relationship between anthropometric profiles and basketball performance, there is limited evidence within the South African context. Existing studies in South Africa have primarily focused on describing the anthropometric and physical fitness profiles of female basketball players at the national, provincial, and university levels [11]. In South Africa, university basketball players often train in resource-constrained environments characterized by a lack of infrastructure and facilities dedicated to basketball. This results in limited opportunities for training and competition at both grassroots and elite levels [12], limited sport science support, and the absence of long-term athlete development systems [13, 14] compared with athletes in professional or well-resourced university leagues internationally. In addition, basketball is not a compulsory school sport in many public schools, and organized community or club-based development structures remain limited [14].

Analysis of research findings has shown that anthropometric characteristics are closely associated with the execution of basketball-specific skills and may influence performance outcomes and positional roles. Researchers emphasize that body dimensions and composition interact with technical actions such as passing, dribbling, and shooting under game conditions. At the same time, the expression of these relationships depends on training conditions, competitive structure, and athlete development pathways, which may modify how physical attributes translate into effective skill performance. In many cases, players are exposed to formal basketball training for the first time at the university level and may have had little or no structured technical development during adolescence. Such contextual factors can influence both anthropometric development and the acquisition of sport-specific skills, potentially altering the relationships observed between body composition and performance. Consequently, findings derived from elite or well-resourced populations may not be directly transferable to South African university athletes, indicating the relevance of examining these relationships within a specific competitive and developmental environment.

Investigating these relationships within this context is therefore important for developing locally appropriate training strategies, talent identification practices, and player development models. Therefore, the purpose of this study was to examine the relationship between anthropometric characteristics and basketball-specific skills among university-level basketball players in South Africa.

Materials and Methods

Participants

Thirty-two university-level basketball players (18 males and 14 females) with a mean age of 21.71 ± 2.34 years, who participated in University Sport South Africa (Males Division C and Females Division B), were recruited from one university for the study. The study included full-time and part-time registered South African and international students who played basketball for the selected university. Athletes with an injury lasting over 3 weeks, those who had previous surgery within the last 3 months, or those who were pregnant were excluded.

The researchers first obtained permission from the Health Research Ethics Committee at the University of Fort Hare (Certificate Reference Number: Ref #2024-04-04 HRECLVN05). The data collection process adhered to ethical principles.

Participants' confidentiality was ensured through anonymous identification codes, and all data were securely stored on OneDrive and accessible only to authorized users. Data were collected only from those who voluntarily participated in the study and provided consent. Participants were also informed that they had the right to withdraw from the study without consequences.

Study Design

The study followed a cross-sectional quantitative research design. Participants were recruited using a purposive sampling method, and all were assessed individually during data collection. The assessment of anthropometric characteristics lasted 1 week and was conducted at the gym facility laboratory. The assessment of sport-specific skills also lasted 1 week and was conducted at the university indoor basketball court. All anthropometric assessments were conducted by qualified ISAK Level 1 and Level 2 anthropometrists. Sport-specific skills were assessed by qualified Human Movement Science practitioners with prior experience to maintain reliability and validity. Standardized procedures were strictly followed for each participant.

Procedures

Anthropometric assessments

Standard procedures from the International Standards for Anthropometric Assessment (ISAK) were used for the assessments [15], using calibrated equipment and trained assessors. To minimize technical error of measurement (TEM), each variable was measured twice. If the two measurements differed by more than the acceptable ISAK tolerance (5% for skinfolds and 1% for girths, breadths, and lengths), a third measurement was taken, and the median value was recorded. This procedure is consistent with ISAK recommendations for reducing intra-observer variability and improving data reliability [15]. After all participants provided informed consent, each session began with a 10-minute briefing to explain the purpose of the assessments.

Body weight was measured using a weighing scale to the nearest 0.1 kg. Measurements were obtained in the morning, at least twelve hours after food intake and after voiding. The scale was set to zero before each measurement. Participants stood in the center of the scale without support and with weight evenly distributed on both feet.

Height was measured using a stadiometer to the nearest 0.1 cm. The participant stood with heels together, buttocks together, and the upper back touching the scale. Orbitale and tragion were aligned in the same horizontal plane to achieve the Frankfort plane. The participant was asked to take and hold a deep breath while keeping the head in the Frankfort plane. The headboard was firmly placed on the vertex, compressing the hair as much as possible. The measurement was taken before the participant exhaled.

Skinfold thickness was measured using a skinfold caliper at seven sites (biceps, triceps, subscapular, suprailiac, thigh, calf, abdomen) to the nearest 0.5 mm. All skinfold landmarks for the participant were marked with a demographic pen to minimize location errors across repeated measures. The skinfold was grasped at the marked site with the thumb and finger, perpendicular to the skinfold orientation, with the back of the hand facing the measurer. The contact face of the caliper was placed at 90 degrees, 1 cm away from the edge of the thumb and finger. The measurement was recorded 2 seconds after full caliper pressure was applied.

Girth measurements (arm relaxed, arm flexed and tensed, waist, gluteal, thigh, and calf) were conducted using an anthropometric tape. Each site was measured twice, and the average was recorded.

Arm length (acromiale–radiale, radiale–stylion, midstylion–dactylion) was measured using a segmometer. Participants stood in a relaxed position with their arms hanging by their sides. Measurements were taken twice, and the average values were recorded.

Leg length (trochanterion–tibiale laterale and tibiale laterale height) was measured using a segmometer and box. Participants stood with feet together. Measurements were taken twice, and the average values were recorded.

Breadths (humerus, bi-stylion, and femur) were measured using large and small sliding calipers. Participants were measured in a relaxed seated position. The caliper was held at right angles to the body segments being measured. Reliability was ensured by maintaining constant caliper pressure and correct placement on the designated landmarks.

Body fat percentage was estimated using the equations proposed by Withers et al. [16].

Equation 1

Male players

$$BD = 1.10326 - 0.00031\,(Age) - 0.0036\,(\Sigma 6SF)$$
$$\%Fat = (495 / BD) - 450$$

Female players

$$BD = 1.07878 - 0.00035\,(\Sigma 6SF) + 0.00032\,(Age)$$
$$\%Fat = (495 / BD) - 450$$

Where: BD — body density ($g \cdot cm^{-3}$); %Fat — body fat percentage (%); Age — age (years); Σ6SF — sum of six skinfold thicknesses (mm): biceps, triceps, subscapular, suprailiac, thigh, and calf.

Muscle mass was estimated using the anthropometric equation proposed by Lee et al. [17].

Equation 2

$$SMM = Ht\,(0.00744\,CAG^2 + 0.00088\,CTG^2 + 0.00441\,CCG^2) + 2.4\,(Sex) - 0.048\,(Age) + Race + 7.8$$

Where: SMM — skeletal muscle mass (kg); Ht — height (m); CAG — corrected arm girth (cm); CTG — corrected thigh girth (cm); CCG — corrected calf girth (cm); Age — age (years); Sex — sex (male = 1, female = 0); Race — ethnic coefficient (White/Hispanic = 0, Black = 1.4, Asian = −1.2).

Lean body mass was estimated from height and body mass using the equations proposed by Boer [18].

Equation 3

Men

$$eLBM = 0.407W + 0.267H - 19.2$$

Women

$$eLBM = 0.252W + 0.473H - 48.3$$

Where: eLBM — estimated lean body mass (kg); — body mass (kg); H — height (cm).

Basketball-specific skills assessments

All participants wore comfortable sportswear and basketball shoes. Each assessment began with a 10-minute standard warm-up. Adequate rest intervals of 3 minutes were provided between every sport-specific skill test to ensure that each evaluation reflected maximal effort. Two Human Movement Science practitioners with prior training carried out the assessments. All tests were administered in a standardized manner to ensure comparability with existing literature, and the same stopwatch and testers were used for all participants to ensure consistency.

The speed spot shooting test [19] was used to assess the speed and accuracy of shooting performance under time restrictions, including agility and ball handling. Five shooting spots were marked at 3.66 m from the basket. On the signal, the participant began behind a designated place, attempted a shot, retrieved the rebound, and moved to the next spot, repeating the sequence continuously for 60 seconds. Each successful shot was scored as 2 points, while 1 point was awarded after an unsuccessful shot. If a lay-up was successful with the ball returning from the hoop, it was scored as 2 points. If two successful lay-ups were made in a row, the second was not scored. No points were awarded for shots made with violations in dribbling, ball handling, or the shooting line [Hopkins et al., 1984]. The stopwatch was calibrated before each session. All scores were recorded on a data sheet.

The obstacle dribble test [19] was performed on an indoor basketball court. An obstacle course (3.6 m × 5.8 m) was marked by six cones placed in the free-throw lane. The participant started dribbling on the signal while passing the cones and changing hands. Participants were instructed to cover a distance of 17.9 m as fast as possible while maintaining control of the basketball. Each participant performed two trials per hand, and the time was recorded. The shortest time was used for analysis. The stopwatch was calibrated before each session. All scores were recorded on a data sheet.

The AAHPERD Basketball Passing Test [19] was conducted on a smooth wall surface 9 m in length. Each passing test station was set up according to the AAHPERD protocol. A restraining line, 8 m long, was marked 2 m from and parallel to the testing wall. Participants were instructed to execute only chest passes, emphasizing speed and accuracy, two fundamental components of basketball passing. Scoring was as follows: two points for each pass hitting the target or its boundary lines, one point for passes landing between targets, and zero points if the participant stepped on or over the restraining line or used a pass other than a chest pass

Statistical Analysis

All data were analyzed using the Statistical Package for the Social Sciences (IBM SPSS) version 28. Descriptive statistics (mean values, standard deviation, and minimum and maximum values) were reported for all variables. Independent t-tests were used to determine differences between male and female basketball players. The Kolmogorov-Smirnov and Shapiro-Wilk tests were used to assess normality. The Pearson correlation coefficient (r) was used to determine relationships between anthropometric characteristics and sport-specific skills when normal distribution was assumed. The strength of the Pearson coefficient was interpreted as follows: 0.00–0.199 very weak, 0.20–0.399 weak, 0.40–0.599 moderate, 0.60–0.799 strong, and 0.80–1.000 very strong. Assumptions were evaluated before conducting parametric tests. Multiple regression analyses were conducted separately for males and females to predict passing skill. Residual plots and variance inflation factors (VIF) were used to assess regression assumptions (multicollinearity). No severe multicollinearity was detected (all VIF < 10). Statistical significance was set at $p = 0.05$.

Results

Table 1 presents the comparison between male and female basketball players in terms of anthropometric characteristics and basketball-specific skills.

The mean and standard deviations for anthropometric characteristics and sport-specific skills are presented for males and females in Table 1. Analysis showed significant differences between males and females across all measures ($p < 0.05$) except for body mass and mesomorph scores. Males showed higher values across most anthropometric measures, except for body fat percentage (16.60 ± 5.77). In terms of somatotype, females were more endomorphic (4.55 ± 1.33), whereas males displayed greater ectomorphic characteristics (2.59 ± 1.46).

Table 2 presents Pearson correlations between anthropometric characteristics and basketball-specific skills in female players.

As shown in Table 2, muscular mass was strongly negatively correlated with shooting ($r = -0.680$) and with right-hand control dribble ($r = -0.635$), and moderately positively correlated with left-hand control dribble ($r = 0.587$). Body mass ($r = -0.682$) and body fat percentage ($r = -0.683$) showed strong negative correlations with passing skill. Body height ($r = -0.502$) and lean body mass ($r = -0.590$) showed moderate negative correlations with passing skill.

Table 3 presents Pearson correlations between anthropometric characteristics and basketball-specific skills in male players.

As shown in Table 3, body height ($r = -0.672$) and leg length ($r = -0.624$) demonstrated strong negative correlations with passing skill, while lean body mass ($r = -0.561$) and arm length ($r = -0.525$) showed moderate negative correlations with passing skill. A strong positive correlation was observed between muscular mass and left-hand control dribble ($r = 0.617$). Moderate positive correlations were observed between body mass and left-hand control dribble ($r = 0.523$), leg length and right-hand control dribble ($r = 0.529$), and lean body mass with left-hand ($r = 0.558$) and right-hand ($r = 0.459$) control dribble. Body fat percentage showed a moderate positive correlation with shooting skill ($r = 0.497$).

Table 4 presents the multiple regression analysis predicting the passing skill of university female basketball players.

Table 1. Comparison between male and female basketball players in anthropometric characteristics and basketball-specific skills

Variables	All players (N = 32) M ± SD	Range (Min–Max)	Female (N = 14) M ± SD	Male (N = 18) M ± SD	p-value
Basic body metrics					
Body mass (kg)	69.33 ± 10.26	52.70–101.50	68.81 ± 9.09	69.69 ± 11.23	0.08
Height (cm)	170.02 ± 8.48	154.80–188.50	164.54 ± 6.92	173.86 ± 7.40	<0.001**
Body composition					
BF%	19.36 ± 6.35	10.92–32.29	23.31 ± 5.03	16.60 ± 5.77	<0.001**
Muscular mass (kg)	29.20 ± 4.30	19.90–38.80	25.33 ± 2.51	31.91 ± 3.01	<0.001**
LBM (kg)	51.97 ± 6.92	38.80–72.40	46.86 ± 5.41	55.57 ± 5.50	<0.001**
Somatotype profile					
Endomorph score	3.19 ± 1.80	1–7	4.55 ± 1.33	2.25 ± 1.46	<0.001**
Mesomorph score	5.08 ± 1.28	2–8	5.29 ± 1.04	4.94 ± 1.45	0.452
Ectomorph score	1.98 ± 1.36	0–5	1.11 ± 0.47	2.59 ± 1.46	<0.001**
Limb dimensions					
Total arm length	75.10 ± 6.34	63.70–89.90	70.06 ± 4.40	78.63 ± 4.97	<0.001**
Total leg length	88.73 ± 6.75	71.20–102.80	85.11 ± 6.68	91.26 ± 5.70	<0.001**
Skills					
Passing skill	1.18 ± 0.30	5–19	8.00 ± 1.96	13.33 ± 3.46	<0.001**
Left-hand control dribble	11.00 ± 3.93	9.99–14.75	13.45 ± 0.85	11.57 ± 1.02	<0.001**
Right-hand control dribble	12.39 ± 1.33	9.76–14.75	13.03 ± 1.00	10.99 ± 0.77	<0.001**
Shooting skill	11.88 ± 1.34	14–29	19.29 ± 3.10	25.11 ± 2.61	<0.001**

Note. *p < 0.05, **p < 0.01. BF% — body fat percentage; LBM — lean body mass.

Table 2. Pearson correlation (r) between anthropometric characteristics and sport-specific skills in female players

Variables	Body mass	Body height	BF%	Muscular mass	LBM	Arm length	Leg length	Endo	Meso	Ecto
Passing skill (points)	-0.682**	-0.502*	-0.683**	-0.008	-0.590*	-0.473	-0.701	-0.420	-0.098	0.437
Left-hand control dribble (s)	0.334	0.456	-0.366	0.587*	0.414	0.216	0.207	-0.485	-0.121	0.153
Right-hand control dribble (s)	-0.121	-0.232	0.203	-0.635**	-0.190	0.009	0.260	0.116	-0.409	-0.208
Shooting skill (points)	-0.067	-0.202	0.417	-0.680**	-0.149	0.073	0.274	0.368	-0.242	-0.262

Note. *p < 0.05, **p < 0.01. BF% — body fat percentage; LBM — lean body mass.

Table 3. Pearson correlation (r) between anthropometric characteristics and sport-specific skills in male players

Variables	Body mass	Body height	BF%	Muscular mass	LBM	Arm length	Leg length	Endo	Meso	Ecto
Passing skill (points)	-0.282	-0.672**	-0.435	-0.236	-0.561*	-0.525*	-0.624**	-0.045	0.206	-0.375
Left-hand control dribble (s)	0.523*	0.193	0.329	0.617**	0.558*	0.196	0.405	0.225	0.260	-0.225
Right-hand control dribble (s)	0.321	0.372	0.331	0.374	0.459*	0.282	0.529*	0.105	0.023	0.105
Shooting skill (points)	0.333	0.264	0.497*	0.150	0.423	0.235	0.430	0.281	0.073	0.054

Note. *p < 0.05, **p < 0.01. BF% — body fat percentage; LBM — lean body mass.

Table 4. Multiple regression analysis predicting passing skill in university female basketball players

Predictor variables	B	SE B	β	t	p-value	Tolerance	VIF
Constant	-22.335	8.748	–	-2.553	0.031	–	–
Body fat percentage	-0.243	0.084	-0.622	-2.877	0.018	0.691	1.448
Muscular mass	0.130	0.195	0.166	0.666	0.522	0.518	1.929
Body height	0.174	0.066	0.614	2.654	0.026	0.602	1.660

Note. $R^2 = 0.71$, Adjusted $R^2 = 0.58$, $F(4, 9) = 5.502$, $p = 0.016$

Table 5. Multiple regression analysis predicting passing skill in university male basketball players

Predictor variables	B	SE B	β	t	p-value	Tolerance	VIF
Constant	-18.425	20.845	–	-0.884	0.393	–	–
Body fat percentage	0.157	0.169	0.207	0.929	0.370	0.885	1.130
Muscular mass	0.720	0.299	0.539	2.407	0.032	0.873	1.145
Body height	0.052	0.106	0.104	0.493	0.630	0.980	1.021

Note. $R^2 = 0.42$, adjusted $R^2 = 0.26$, $F(4, 13) = 2.465$, $p = 0.097$.

To determine whether anthropometric characteristics significantly related to passing skill could predict performance, multiple regression analysis was applied. As shown in Table 4, the regression model including body fat percentage, muscular mass, and body height was statistically significant ($R^2 = 0.71$, adjusted $R^2 = 0.58$, $F(4, 9) = 5.50$, $p = 0.016$), explaining 58% of the variance in passing performance. Body fat percentage emerged as a significant negative predictor of passing skill ($\beta = -0.62$, $p < 0.05$). Body height was a significant positive predictor ($\beta = 0.61$, $p < 0.05$). Muscular mass did not independently predict passing skill ($\beta = 0.166$, $p > 0.05$). No multicollinearity was observed among the predictors, as tolerance and variance inflation factor values were within acceptable ranges.

Table 5 presents the multiple regression analysis predicting passing skill in university male basketball players.

As shown in Table 5, the regression model was not statistically significant ($R^2 = 0.42$, adjusted $R^2 = 0.26$, $F(4, 13) = 2.47$, $p = 0.097$). Muscular mass was identified as a significant positive individual predictor of passing skill ($\beta = 0.54$, $p < 0.05$). Body fat percentage and body height were not significant predictors ($p > 0.05$). No evidence of multicollinearity was detected.

Discussion

The study aimed to determine correlations between anthropometric characteristics and basketball-specific skills in South African university basketball players. The sex differences observed in the current study show that males have more favorable anthropometric characteristics. These differences are consistent with previous findings. Fields et al. [20] reported similar differences among collegiate basketball players, Hernandez-Martinez et al. [21] among professional players, and Sansone et al. [22] across male and female basketball players competing at international, national, and regional levels. From the sport-specific skills perspective, males significantly outperformed females across all measures. The results align with the study by Argiriou [23] among top-ranking men's and women's teams in the Greek National Basketball Championship and with a study by Theoharopoulos et al. [24] among male and female basketball teams in Thessaloniki, Greece, in different group divisions. These differences are likely attributed to biological and hormonal distinctions between sexes, particularly post-puberty [21, 25].

The present study revealed that body mass and body fat percentage in female basketball players were strongly and negatively correlated with passing skill, whereas lean body mass and height were moderately negatively correlated with passing skill. This suggests that passing accuracy may be negatively affected by excessive body size, whether fat or lean mass. The results are consistent with the study by Eroğlu et al. [6], who reported that basketball players with greater body size demonstrated poorer passing skills, with a significant negative correlation ($r = -0.021$, $p = 0.000$). Passing skill is associated with agility and quick positioning, and heavier or taller players may struggle with agility, quick repositioning, and fine motor control, all of which are critical for producing accurate and timely passes [26]. Passing performance depends more on neurological abilities such as coordination and motor control, which are not determined by anthropometric characteristics across different competitive levels [27]. Although lean mass is typically associated with strength production, it does not appear to directly enhance technical skills.

Muscular mass showed a strong negative correlation with right-hand control dribble time and a moderate positive correlation with left-hand control dribble. This suggests that greater muscular mass was associated with faster right-hand dribbling but slower left-hand dribbling, likely because most players were right-handed and had reduced coordination on the non-dominant side. This aligns with the study by Franciosi et al. [28], who observed that explosive leg power and upper-body endurance positively contributed to ball-handling performance among youth basketball players, suggesting that it is not merely muscle mass alone but rather explosive and functionally applied strength that supports skill development.

Higher muscular mass was also associated with poorer shooting skill. No specific study was found examining the correlation between muscle mass and shooting skill; however, some studies reported a relationship between muscle mass and strength. Čabarkapa et al. [29] examined male and female collegiate basketball players with prior competitive and resistance training experience and found no significant relationship between maximal upper- or lower-body strength and shooting accuracy, emphasizing that raw strength alone may not directly enhance shooting performance. In contrast, Franciosi et al. [28] reported that explosive leg power and upper-body endurance positively influenced shooting performance, suggesting that it is not sheer muscle strength but rather explosive and functionally applied strength that supports skill development. Similarly, Ahmed [30] demonstrated that neuromuscular training improved shooting, dribbling, and passing, reinforcing the idea that training that enhances skill-specific motor control and stability, rather than muscular bulk, is more effective in developing basketball proficiency.

Among males, body height, arm length, leg length, and lean body mass were negatively and moderately correlated with passing skill. The results contrast with the study by Singh and Singh [10], who reported that leg length and arm length had a positive and significant correlation with passing skill ($r = 0.59$ and $r = 0.51$, $p < 0.001$, respectively) among male basketball players from the University of Northern India, suggesting that greater height or limb length may provide mechanical advantages in passing performance. Furthermore, Apostolidis et al. [8] reported that longer arms facilitated better passing, indicating that the advantages might be skill-specific or modulated by positional role. Lean body mass showed a moderate negative correlation with passing skill. This indirectly supports the notion that passing skill is associated with agility and quick positioning, and heavier or taller players may struggle with agility, quick repositioning, and fine motor control, all of which are critical for producing accurate and timely passes [26].

The current study showed a strong positive correlation between muscular mass and left-hand control dribble, likely because most players were right-handed and had reduced coordination on the non-dominant side. Moderate positive correlations were observed between body mass and left-hand control dribble, leg length and right-hand control dribble, and lean body mass and both left-hand and right-hand control dribbling skills. These results suggest that greater muscular mass may be associated with poorer execution of left-hand dribbling, which requires efficient coordination because it is performed with the non-dominant hand. A study by Zarić et al. [31] supports this by stating that basketball players who perform well in dribbling are usually point guards, who are typically smaller, suited for quick acceleration and deceleration, and possess good agility.

Body fat percentage was positively and moderately correlated with shooting skill. This contrasts with a study involving Ethiopian university players that found a significant negative correlation between body fat percentage and basketball skill performance, indicating that increased body fat adversely affects shooting accuracy [32]. A study by Ramos et al. [33] also reported weak negative correlations between body fat percentage and points scored per basketball game ($r = -0.200$, $p < 0.005$) among elite regional basketball players.

The study showed that in both sexes, higher body mass and lean mass were linked to poorer passing performance. Muscular mass influenced dribbling differently: in females, it improved dominant-hand speed but hindered non-dominant-hand control, whereas in males, greater body and lean mass, along with leg length, reduced right-hand dribbling ability. Overall, females with less muscular mass performed better in passing, while males with higher body fat achieved better shooting results. These differences between sexes suggest that the relationships between anthropometric characteristics and skill performance differ for males and females, similar to findings by Haïdara et al. [34] among male and female students, Sánchez-Díaz et al. [35] among elite male and female youth basketball players, Theoharopoulos et al. [24] among male and female basketball players in the Greek championships, and Gómez et al. [4] among elite male and female basketball players from Spanish professional leagues.

The current results indicate that excessive body fat is detrimental to performance, whereas lean or muscular mass contributes positively in specific contexts. However, contradictions arise concerning body size, as the Ethiopian study reported body mass, height, and limb lengths positively associated with skill performance [32]. In contrast, the present findings suggest that these traits can hinder technical precision, particularly in passing and shooting, with females disadvantaged by overall mass and fat, and males by height and limb length.

The quality of training, availability of facilities, and competitive levels across different countries could contribute to these contrasting outcomes, as many studies have involved elite or highly competitive basketball players, such as the study by Conte et al. [36] conducted among Italian elite women basketball players and the study by Zarić et al. [31] among elite basketball players in the FIBA World Cup. Compared with international studies, South African basketball players show higher body mass and lower muscular mass relative to international basketball fitness standards [11, 12], suggesting that South African players may not have developed the same basketball skills and anthropometric profiles that allow larger players at higher competitive levels to maintain technical proficiency despite greater body mass.

The stratified regression analyses revealed a noticeable difference in how the selected anthropometric characteristics explained passing skill variance between female and male basketball players. The results confirm gender-specific determinants of anthropometric characteristics and quantify the models' descriptive power and statistical robustness within each group. Previous studies have analyzed performance prediction using game statistics to predict overall basketball performance [37] or focused on shooting and dribbling performance [8, 38]. Garcia-Gil et al. [37] designed a model to predict basketball performance in terms of PIR per minute, whereas Apostolidis et al. [8] established a prediction model of dribbling and shooting technical skills based on significant anthropometric variables. To the best of our knowledge, the current study is the first to develop a prediction model for a specific basketball skill, namely passing skill.

The regression model among female basketball players was significant, and the predictors collectively accounted for a large proportion of variance in passing skill scores. The adjusted R^2 value indicated that over 58% of the variance in passing skill among females was explained by the model, suggesting a meaningful and well-specified model. This was further supported by the relatively low standard error of the estimate (1.27). In contrast, the regression analysis for male basketball players was not statistically significant, with the predictors accounting for only 43.1% of the variance, which, after adjustment, dropped to 25.6%. The high standard error of the estimate (2.99) for males also suggested greater prediction error and more unexplained variability in skill scores. This disparity in model efficacy indicates that the selected anthropometric variables were more strongly and linearly related to passing skill in females than in males within this cohort.

For females, the significant negative relationship between body fat percentage and skill performance is consistent with principles of dynamic efficiency, where excess adiposity may impede rotational agility, movement speed, and the fluid transmission of force required for skilled passing [39, 40]. Concurrently, the positive association with body height likely confers biomechanical advantages such as an elevated release point, extended reach, and improved visual perspective, which are critical in interceptive and projectile sports [41]. The non-significance of muscular mass suggests that, in this context, body composition and lever mechanics are more critical for skill expression than absolute muscularity.

For males, only muscular mass emerged as a significant unique predictor within a model of limited overall utility. Greater muscle mass may enhance the capacity to generate passing force, leading to improved passing effectiveness [3]. The lack of significance for body fat and height suggests a more homogeneous anthropometric range among skilled male athletes.

Summary of the main findings and their practical implications

The study revealed that anthropometric characteristics were associated with skill performance in both male and female players. Higher muscularity and lean body mass were associated with improved dribbling control but were negatively linked to passing and shooting, suggesting that non-functional or excessive muscle mass may hinder skills requiring precision and coordination. These findings support the theory of differentiated talent models across sexes in sport [21, 23]. The strong and significant female model indicated that skill was closely tied to optimal body composition for movement and structural advantages. The weaker significance among males suggested that skill execution was more dependent on the capacity to apply force but was also influenced by unmeasured factors such as neuromuscular control, technical proficiency, and decision-making.

From an applied perspective, this evidence supports sex-specific conditioning and talent identification frameworks:

- Female athlete development should prioritize achieving lean body composition and refining technique that maximizes height-based leverage.
- Male athlete development, while benefiting from strength training, should extend beyond the anthropometric variables measured here. Coaches and scientists should integrate technical-tactical assessments and, where appropriate, specific power diagnostics to better explain and enhance skill performance.

Limitations and Future Research

This study has several limitations that should be considered when interpreting the findings. The cross-sectional design does not allow causal conclusions. The difference in model fit may also have been influenced by the smaller female sample size (n = 14) compared with males (n = 18), which can affect stability; however, the significant results in the female group, despite the smaller n, underscore the strength of the relationships observed. The primary limitation is the omission of key variables, particularly technical proficiency metrics, training history, and sport-specific power tests, which likely account for the substantial unexplained variance, especially in the male model.

Future research should employ longitudinal designs to track how changes in these physical traits co-evolve with skill acquisition. Furthermore, studies should incorporate kinematic and kinetic analyses to explain why body fat was detrimental to female skill but not male skill, and why muscular mass was critical for males but not females in this specific task. Given the limitations of sample size and institutional scope, future research should investigate larger, sex-stratified samples across multiple universities and competitive levels.

Conclusions

The relationship between anthropometric characteristics and sport-specific skill performance appears to be mediated by technical proficiency and neuromuscular control. The lack of significant associations between somatotype and skill outcomes indicates that body type alone does not determine basketball proficiency. In a South African university basketball team, the passing skill of female basketball players was strongly predicted by lower body fat and greater height, whereas male skill depended more on muscular mass development, although to a lesser degree and with lower significance. These findings indicate that physical standards should not be applied uniformly across sexes and that, while physical attributes may support performance, skill shaped by neuromuscular control, technical training, and contextual adaptation ultimately determines success. Because prior studies assessed passing indirectly through assists or composite performance indices, the present study provides direct examination of passing performance and its anthropometric predictors. For coaches and talent developers working in resource-constrained environments, the results support skill-focused, sex-informed training strategies that prioritize technical mastery alongside monitored strength and conditioning when improving skill performance.

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Data availability statement

The data underlying the study are not publicly available but may be available upon reasonable request from the corresponding authors.

Conflict of Interest

There was no potential conflict of interest.

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