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CHANGES IN SOMATOTYPE AND LOWER BACK STRENGTH IN UNIVERSITY-LEVEL FEMALE NETBALL PLAYERS DURING ONE SEASON

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ABSTRACT

Netball is a popular, high-intensity team sport played globally by more than 20 million players. Due to the high intensity and high participation levels, there is a high injury prevalence. The lower back region has been identified as the third most common site of injury within female team sports, with somatotype also influencing injury rates within netball. The objective of this research was to evaluate changes and explore relationships between somatotype and lower back strength (LBS) during a single netball season in university-level female netball players. A lack of evidence was found to support a relationship between changes in LBS and changes in a raw ectomorph (p=0.741), mesomorph (p=0.677) and endomorph (p=0.81) somatotype score during a single netball season in university-level female netball players. Statistically significant differences were noted for mesomorph somatotype score which increased LBS (12.35 kg) at the end of the season compared with the beginning of the season (p=0.004). A relationship between whole-body muscle strength and a dominant mesomorph somatotype score is important in netball because increased strength leads to adequate lumbo-pelvic hip-complex stability, thus reducing injuries and improving athletic performance.

Keywords: Back-leg-chest; Ectomorph; Endomorph; Lower back strength; Mesomorph; Netball; Somatotype

INTRODUCTION

Netball is a physically demanding, seven-a-side team sport played by more than 20 million players globally (Sinclair *et al*., 2020; Smyth *et al*., 2020; Whitehead *et al*., 2021). University-level of play in netball refers to the sub-elite standard of netball competition played by students representing their university or college. It typically involves organised teams competing in interuniversity leagues or tournaments, with a level of skill and intensity higher than recreational play but varying between social, competitive and elite divisions depending on the institution and competition. Sport in South Africa is a fundamental part of nation-building particularly since the end of apartheid in 1994 (Pillay & Frantz, 2012), with netball being one of the most governmentally supported sports in the country (Pillay & Frantz, 2012). More specifically, early research showed that netball is played by over half a million players in the 16- and 19-year age cohort and encompasses over 9700 adult players (Ferreira & Spamer, 2010. More recent literature showed that there are an astounding two and a half million netball players in the South African schooling system alone, affirming the popularity of netball in South Africa (Netball South Africa Annual Report, 2021/2022). Netball is played at a high intensity and entails bouts of short quick sprinting, jumping, landing, passing, and catching movements, which may account for the high injury prevalence in the sport (Bissel & Lorentzos, 2018; Smyth *et al*., 2020; Mullally *et al.,* 2023). Moreover, netball requires power outputs, flexibility, strength, endurance and speed (Pillay & Frantz, 2012; Ryan *et al.,* 2024), which further contributes to higher rates of injury (Bissel & Lorentzos, 2018).

The most common sites of injury are the ankle joint, followed by the knee joint (Langeveld *et al.,* 2012; Pillay & Frantz, 2012), with injuries to the lower back region identified as the third most common area of injury in female team sports (Gamble, 2011). Lower back strength (LBS) is related to core stability, therefore having a direct impact on physical performance thereby making it an essential component for general injury prevention, and it is especially important for averting incidences and perceptions of lower back pain (LBP) (Mortazavi *et al.,* 2015; Garcia-Vaquero *et al*., 2016; Zouita *et al*., 2018).

Incorrect landing kinematics, coupled with discrepancies in a player's somatotype and anthropometry, may also contribute to injury in netball (Ferreira & Spamer, 2010; Mothersole et al., 2013). Although these aspects are studied to a lesser extent and are therefore largely inconclusive, they may also contribute to injury in netball. Some research has suggested that higher body fat percentages, likely due to higher overall body mass, significantly increase the loading on the knee joint during landing, which in turn may perpetuate incidents of injury (Montgomery *et al*., 2017). Different positions in netball require different skills and conditioning for optimal performance (Hogarth *et al*., 2021) where previous literature documented that midcourt players could benefit from a higher mesomorphic component compared with defence and shooters, due to the greater proportion of defensive and attacking play that is linked with fast, explosive movements (Hogarth *et al.,* 2021). Defence players will benefit from being taller (Hogarth *et al*., 2021) and typically exhibit a higher ectomorphic component that likely favours continuous leaping associated with frequent passes and interceptions (Hopper, 1997). Additionally, defensive positions are also likely to experience LBP due to the constant blocking of passes and prolonged hyperextension postures (Gamble, 2011; Ball *et al*., 2019), thus stressing the importance of LBP and LBS in combination with somatotype in netball. Interestingly, Hopper (1997) also documented that 213 netball players with lower limb injuries and LBP had a lower endomorph component than uninjured players.

Percentage body fat furthermore influences athletic performance in elite netball (Soh *et al*., 2006). For optimal performance, fitness levels and effective movement in netball, the percentage body fat should range from 10% to 16%, and not exceed 25% as it may limit movement patterns, as well as being 'inert' tissue that proportionately increases the inertia associated with high-speed movements (e.g., acceleration, deceleration) (Soh *et al*., 2006). However, no previous research has investigated whether whole-body strength (i.e., LBS) is linked to somatotype, nor the extent to which these qualities are amenable to change within a given netball season.

Due to the increasing popularity of netball (Bissel & Lorentzos, 2018; Ferreira & Spamer, 2010), and injury rates in netball that have escalated through recent years (Langeveld *et al*., 2012; Pillay & Frantz, 2012; Bissel & Lorentzos, 2018), it is essential to evaluate LBS and somatotype, which are fundamental in optimal physical performance and injury prevention (Zouita *et al*., 2018).

Purpose of research

The primary objectives of this study were to evaluate: (1) changes in somatotype, limb girths, and LBS within a given netball season, and (2) explore the associations between somatotype, limb girths and LBS in a given netball season in university-level female netball players.

METHODS

Study design

A cross-sectional, repeated measures design was implemented for this study.

Participants

The minimum sample size of 15 participants required for the present study was calculated a priori using the following inputs: (1) expected effect size (f) = 0.25, (2) alpha error probability = 0.05, (3) beta error probability = 0.20, and (4) number of measurements = 2, (v) expected correlation among repeated measures = 0.80 (G Power, 3.1.9.7). Due to the high demands of training and competition, the final sample was 11 university-level female netball players.

Procedure

A week prior to testing, the North-West University (NWU) netball squad was called in for a meeting during which the benefits and potential risks and the functional procedure of the study were explained to them. Demographic information of the participants was collected using an electronic demographic and injury questionnaire at the beginning of the netball season. The participants furthermore reported injury occurrences during the season bimonthly. This was also done electronically and although not documented as one of the objectives of the study, the information was additionally collected for possible participant fall out information.

Data collection instruments

Lower back strength

The back-leg-chest (BLC) dynamometer (Omron, Kyoto, Japan) has a high test–retest reproducibility of r=0.92 in females. The testing procedures recommended by Ten Hoor *et al*., (2016) were implemented for the BLC test. Briefly, familiarisation with the procedure was ensured by giving each participant one trial repetition. For the test trials, the participants stood with both feet on the base of the BLC dynamometer, with their knees and hips slightly flexed while maintaining a normal lordotic curve. To achieve this position, the chain length was adjusted for each participant to make it more suitable according to the participants' height. More specifically, participants were asked to stand upright on the base of the BLC dynamometer with their knees fully extended, with the handle then being positioned at the height of the intra-articular surface of the knee joint. Participants were then asked to perform a torso lift in a gradual vertical motion by providing isometric contractions of the back, knees and hips. Maximal isometric squeezing force was applied and sustained for 3–5 s for each trial. A 60 s rest period was allowed between trials, with a total of three successful trials being recorded for each participant. The highest value was recorded in kg and retained for analysis.

Anthropometric measurements

Anthropometric measurements were taken to calculate the percentage body fat of the participants and to determine their somatotype. Two female field workers that were qualified according to the International Society for the Advancement of Kinanthropometry (ISAK: level two) performed the measurements, ensuring the reliability and validity of the measurements. The participants had to wear as little clothing as possible; shorts and a training top was ideal (Carter, 2003). Measurements were taken in the early morning, approximately 12 h after the previous meal (Carter, 2003). Skinfold measurements were not taken after training, saunas, swimming or showering because heat produces increased blood flow and therefore the skinfold thickness would have increased (Carter, 2003). Measurements were taken in millimetres to the nearest 0.2 mm (Carter, 2003). Two measurements were taken at each skinfold site, a possible third measurement was taken when the first and second measurements were not within 5% of each other (Carter, 2003). The mean value was used if two measurements were taken and the median value if three measurements were taken (Carter, 2003).

The humerus and femur breadths needed to obtain somatotype were taken in mm to the nearest 0.5 mm using a Cescorf bone calliper (NutriActiva, Minnesota, USA) (Carter, 2003), and the girth measurements of the humerus and calf using a Cescorf anthropometric measuring tape (NutriActiva, Minnesota, USA) to the nearest 0.1 mm (Carter, 2003). These anthropometric measurements are important for obtaining the participants' percentage body fat and their somatotype category. A Seca stadiometer (Medical Scales and Measuring System, Birmingham, UK) was used to measure stature to the nearest 0.1 cm. Participants were asked to remove their shoes and socks, the participant's head was placed in the Frankford plane, and participants were asked to inhale while the measurement was taken (Carter, 2003).

Body mass was measured on a Soehnle (Leifheit AG, Nassau, Germany) electronic scale to the nearest 0.1 kg. The participants were wearing as little clothing as possible (shorts and a training). Best results were obtained in the early morning hours, approximately 12 h after the previous meal (Carter, 2003).

Body mass index (BMI) was calculated by dividing the body mass in kg by height in metres squared.

The following skinfold measurements were taken using a Harpenden skinfold calliper (Baty International, UK): triceps, subscapular, biceps, iliac crest, supraspinale, abdominal, front thigh and the medial calf. The following formula was used to determine percentage body fat: Body Fat Percentage = (C1 * (sum of skinfolds)) + (C2 * age) + (C3 * gender) + C4 (George & Wallace, 2009).

The following 10 measurements were used to calculate somatotype: stature and body mass; skinfold measurements of the triceps, subscapular, supraspinale and medial calf; the humerus and femur breadths; and the tensed and flexed upper arm girth and calf girth (Carter, 2003).

Data analyses

All statistical analyses were completed using JASP (JASP Team, version 0.18.1, Netherlands) and the R programming language (R Core Team, version 2022.04.01, RStudio, Posit Software PBC, URL: https://posit.co/download/rstudio-desktop/). Data were evaluated for normality using the Shapiro–Wilk test and accepted as being normally distributed when the p-value exceeded the alpha threshold of 0.05. All data are presented as mean ± one standard deviation (SD) unless otherwise stated. To evaluate temporal changes in the mean differences (Mdiff) across key metrics within the season, paired t-tests were used (Patil, 2021). The standardised effect size was computed as Hedge's g (ESg) and interpreted as follows: trivial: <0.2; small: 0.2–0.59; moderate: 0.6–1.2; and large: >1.2 (Hopkins et al., 2008). To evaluate the relationships between somatotype, girth metrics and LBS strength at different stages of the season, a correlation analysis was completed using the Spearman rank correlation where the magnitude of the coefficient was qualitatively interpreted as follows: negligible: 0.00–0.10; weak: 0.10–0.39; moderate: 0.40–0.69; strong: 0.70–0.89; very strong: 0.90–1.00.

Ethical considerations

Ethics approval for the research study was obtained from the NWU Health Research Ethics Committee (NWU-00195-21-A1). Moreover, the approval was also obtained from the NWU Research Data Gatekeeper Committee(NWU-GK-21-070) as the participants were students at the NWU.

RESULTS

The descriptive statistics for the anthropometric parameters are provided in Table 1.

Almost all the metrics of interest were normally distributed ($p > 0.05$), with the exception of some metrics that did not meet the normality threshold, such as BMI, subscapular skinfold, supraspinale skinfold, and femur breadth, which appeared to be relatively consistent in the sample of athletes.

Table 1. **DESCRIPTIVE STATISTICS OF THE PARTICIPANT ANTHROPOMETRY**

Variable	Baseline M±SD	Post-season M±SD	Normality baseline (SW p-value)	Interpretation baseline	Normality post-season (SW p-value)	Interpretation post-season
Stature (m)	1.77±0.074	1.77±0.073	0.657	Normal	0.761	Normal
Body mass (kg)	80.28±12.32	79.98±13.88	0.150	Normal	0.033*	Not normal
BMI (kg/m2)	25.46±3.16	25.38±3.62	0.009**	Not Normal	0.020*	Not normal
Percentage body fat	18.85±4.93	18.92±5.55	0.219	Normal	0.152	Normal
Triceps skinfold (mm)	16.52±4.59	17.13±5.38	0.450	Normal	0.390	Normal
Subscapular skinfold (mm)	13.88±6.50	13.31±6.62	0.035*	Not normal	0.006**	Not normal
Supraspinale skinfold (mm)	10.67±4.46	10.50±5.74	0.086	Normal	0.005**	Not normal
Abdominal skinfold (mm)	14.61±4.59	14.17±5.35	0.511	Normal	0.313	Normal
Iliac crest skinfold (mm)	15.38±3.41	15.27±4.47	0.236	Normal	0.669	Normal
Front thigh skinfold (mm)	23.26±4.80	21.51±4.14	0.080	Normal	0.224	Normal
Calf skinfold (mm)	12.98±3.30	13.69±3.84	0.173	Normal	0.273	Normal
Humerus breadth (cm)	6.46±0.31	6.70±0.50	0.278	Normal	0.948	Normal
Femur breadth (cm)	8.68±0.44	9.76±0.701	0.753	Normal	0.019*	Not normal
Tensed and flexed upper arm girth (cm)	30.69±1.82	31.16±2.0	0.221	Normal	0.856	Normal
Calf girth (cm)	38.93±1.82	39.55±1.93	0.577	Normal	0.933	Normal

SW = Shapiro–Wilk BMI = body mass index. *$p<0.05$; **$p<0.01$.

From Figure 1, it is evident that considerable variability was present in the data as indicated by the lack of statistically significant differences in ectomorphy ($p=0.458$), endomorphy ($p=0.882$), arm circumference ($p=0.095$) and calf circumference ($p=0.067$) scores. However, considerable changes were evident for mesomorphy ($p=0.004$) and LBS ($p=0.030$) scores in the transition from baseline to post-season.

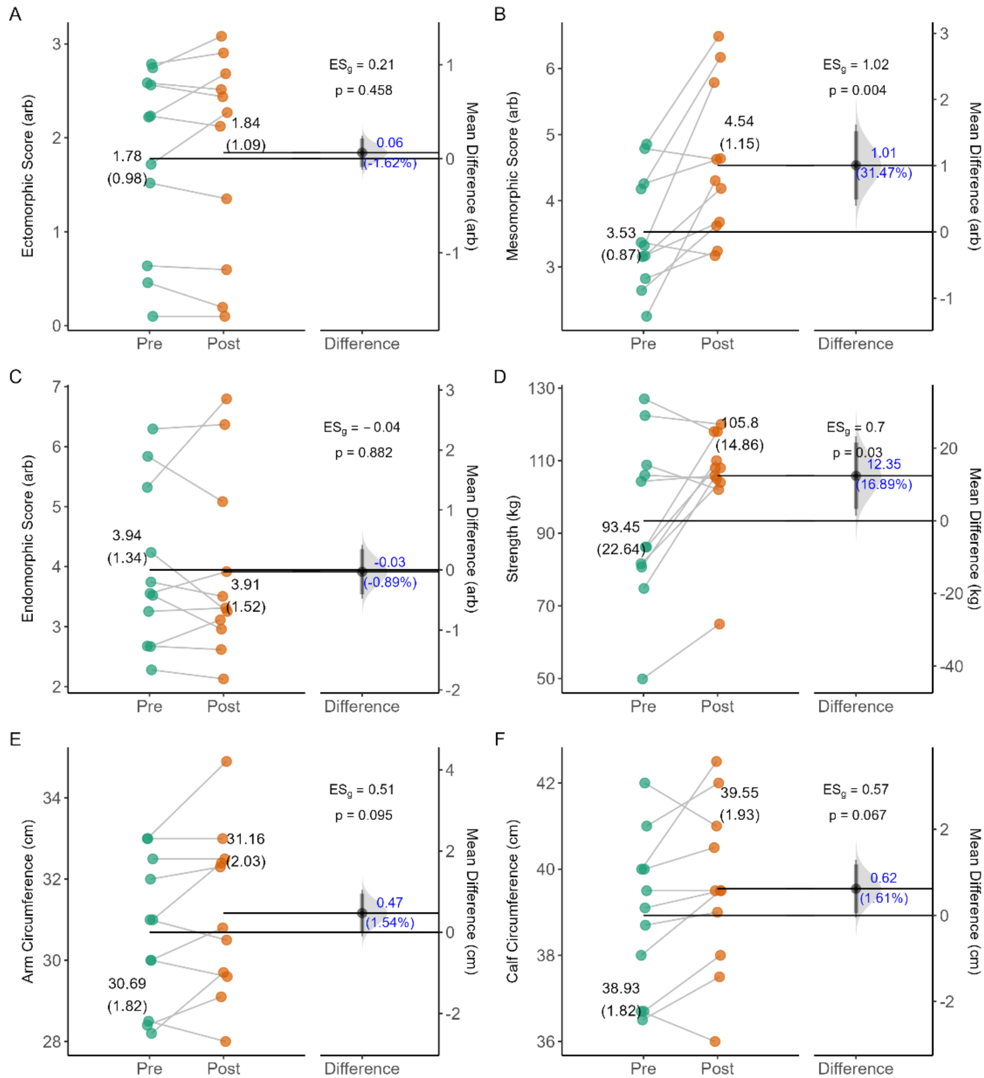

Figure 1. **CHANGES IN SOMATOTYPE, GIRTHS AND LOWER BACK STRENGTH**

Individual data points are shown for each athlete at baseline (i.e., pre-) and at the end of the season (i.e., post-). The mean ± standard deviation are shown in black text, whereas the post–pre differences are shown in blue text. The mean difference is shown, along with its corresponding 95% confidence interval, the standardised effect size, and the corresponding p-value, all in black text, above the distribution. (A) indicates the pre–post ectomorph scores; (B) indicates the pre–post mesomorph scores; (C) indicates the pre–post endomorph scores; (D) indicates the pre–post strength scores obtained from the back-leg-chest dynamometer; (E) indicates the pre–post arm circumference measures; (F) indicates the pre–post calf circumference measures. From Figure 2 it is apparent that there is a lack of evidence to support a relationship between the change in LBS and raw and ectomorph (p=0.868), mesomorph (p=0.244), and endomorph (p=0.974) somatotype score during baseline testing. Such a result suggests independence between strength and somatotype, as no clear favourable body type was evident in the sample of athletes regarding whole-body strength.

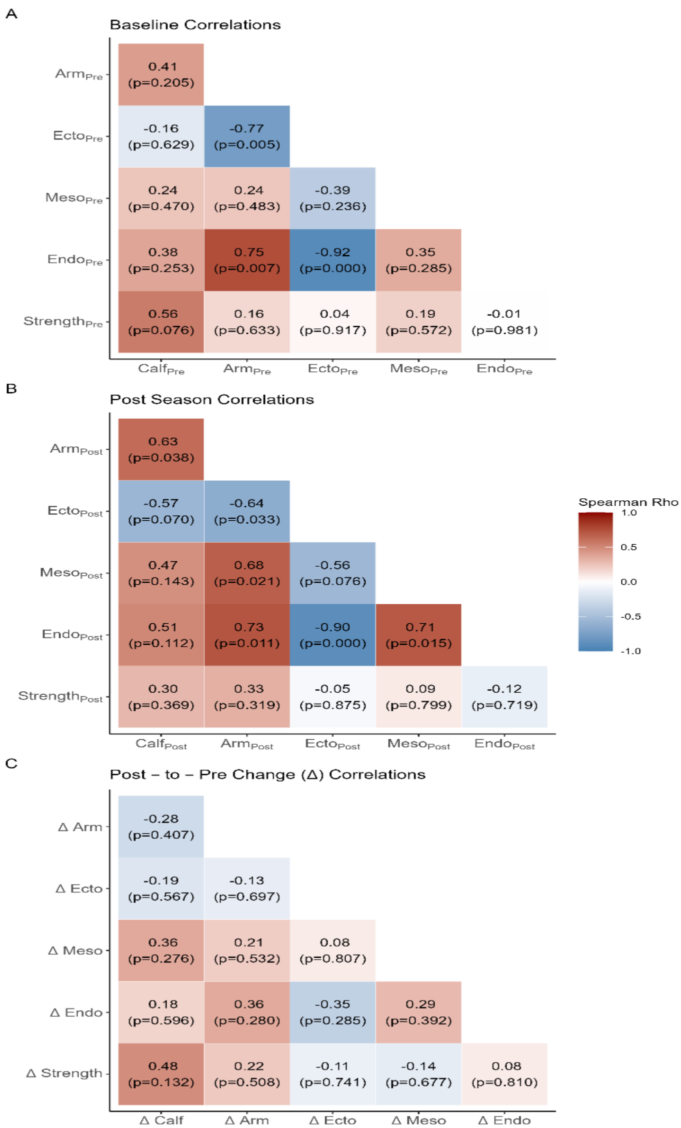

Figure 2. **RELATIONSHIPS BETWEEN SOMATOTYPE, GIRTHS, AND LBS AT THE BEGINNING OF THE SEASON (A), END OF THE SEASON (B) AND THE CHANGE THROUGHOUT THE SEASON (C)**

DISCUSSION

The primary objectives of this study were firstly to evaluate changes in somatotype and LBS and secondly to evaluate the relationships between somatotype, girth and LBS in university-level netball players. For the first objective, our results showed that statistically significant improvements in LBS [Mdiff=12.35 kg (16.89%), *p*=0.030] and mesomorphy [Mdiff=1.01 arb (31.47%), *p*=0.004] were evident during a single netball season. These improvements represent moderate and potentially meaningful changes that appear to be driven by small adjustments in limb circumference (arm=0.47 cm; calf=0.62 cm) rather than changes in body mass or body fat, although a direct causal inference is not possible. Both ectomorphy [Mdiff=0.06 arb (1.62%), *p*=0.458] and endomorphy [Mdiff=-0.03 arb (-0.89%), *p*=0.882] scores remained fairly consistent throughout the netball season as indicated by the trivial to small standardised effect sizes. Such a finding is aligned with previous research showcasing that high-level netball players were able to maintain their physique (e.g., lean mass and fat mass) over a competitive season despite changes in physical performance (Hogarth *et al*., 2021). The transition to a greater mesomorphic score may be advantageous on the basis that some evidence shows those with a higher mesomorphic component tend to perform better in sprinting and vertical jumping (Hogarth *et al*., 2021) although evidence for this within netball is lacking. Knowledge of somatotype and its informed advantages in performance would be of interest to conditioning coaches and sports scientists, based on the fact that netball is a physically demanding sport that requires high-intensity movements, including quick, short sprinting, rapid changes in direction, jumping, landing, passing, and catching (Ryan-Steward *et al.,* 2017). In our study, athletes were largely mesomorphic endomorphs at the start of the season which reversed towards the end when mesomorphy became the dominant component (see Figure 1). Although the somatotype scores obtained in the present study were from high-level university netball players, they were comparable to those expected of senior elite netball players.

For the second objective, an exploration of the relationships between changes in LBS and calf circumference, although not statistically significant, revealed moderately strong associations (r = 0.48, p = 0.132). Such a finding likely implies that changes in lower extremity strength and hypertrophy may have transferred favourably to LBS whereas the same was not true for arm circumference (r=0.22, p=508). Moreover, the change in strength was only negligibly to weakly associated with changes in somatotype scores, thereby indicating that strength performances were largely independent of body type. Research by Terzi and Kalkavan (2024) on handball and volleyball players provided some evidence for a link between somatotype and strength where they showed that mesomorphy positively predicted grip strength (r^2=0.23) and back strength (r^2=0.11), but negatively predicted flexibility (r^2=0.25), long jump (r^2=0.31), sprinting (r^2=0.26) and reaction time (r^2=0.13). Further research states that players with a higher mesomorph somatotype score are more likely to excel in elite sport due to increased whole-body muscle strength (Busko *et al*., 2017; Ryan-Steward *et al.,* 2017; Rakovic *et al*., 2019). This latter finding was not corroborated by our study as there was no preferential link between whole-body strength, as evaluated by the BLC dynamometer, and somatotype (all r<0.20, all *p*>0.05). Stated differently, changes in strength appear to be independent of somatotype, thereby indicating a lack of a preferential body type for changes in strength in high level netball players. To the knowledge of the authors at the time of the study, there was no literature specifically on changes in LBS and somatotype in elite female netball players to support our findings, which highlights the importance for more research on the possible relationship between changes in LBS and somatotype.

Regarding the anthropometric measurements in the present study, it is evident that the mean body mass of the participants at baseline (80.28±12.32 kg) and post-season (79.98±13.88 kg) testing could be considered normal and comparable to that of elite Australian netball players (77.30±9.7 kg) (Hogarth *et al.,* 2021). Similar interpretations can be made regarding the mean stature at both baseline and post-season testing (1.77±0.07 m) which was also aligned with values from Australian elite netball players (1.82±0.10 m), but higher when compared with elite Malaysian female netball (1.68±0.67 m) and basketball (1.71±0.55 m) players (Soh *et al.,* 2006; Hogarth et al., 2016;). A previous study by Venter *et al.* (2005) that reported on stature of elite female netball players in South Africa (1.72±0.08 m) and Australia (1.77±0.04 m) shows that statures have changed substantially over the past 20 years for South African players (i.e., ~5 cm) to be more comparable with international cohorts. Such changes can have meaningful implications, given that the literature has highlighted the importance of stature in netball, as defensive players benefit more from being taller than their shorter peers due to interceptions and contesting for rebounds (Hopper, 1997; Hogarth *et al.,* 2021).

The BMI recorded in the current study at baseline testing (25.46±3.16 kg/m^2) and at testing at the end of the season (25.38±3.62 kg/m^2) are considered higher than that typically expected for netball players at this level. Although the BMI values are marginally higher than normal in the current study, research has shown that BMI is not a good indicator of fat mass and unlikely to be related to performance or injury risk (Flegal, 2023). Somatotype in high performance female netball players may influence player position and the incidence of lower limb and back injuries (Flegal, 2023).

The percentage body fat during baseline (18.85%±4.93%) and post-season (18.92%±5.55%) testing was comparable to those of elite Malaysian netball players (18.93%±4.41%) and substantially lower than those at similar national levels (27.1%–32.9%). These data indicate that the netball players in the present study tend to exhibit muscular, yet higher body fat levels, than the typically recommended body fat percentages of 10%–16% typically shown at elite netball levels for optimal performance (Soh *et al.,* 2006). The substantial variability of body fat percentages across different levels of play highlights that it is unlikely to be a key performance indicator when considered in isolation with the caveat that it should fall within the expected bounds already mentioned. It is more likely that combinations of body proportions, leanness and muscularity work in agreement to produce favourable performance outcomes and minimise the potential risk of injury. The extent to which this holds within female netball players, however, remains underinvestigated and would therefore likely prove a valuable avenue for research.

Several limitations must be acknowledged, the primary of which rests on the small sample size. Although care was taken to evaluate the normality of the data and incorporate appropriate statistical techniques to minimise the type 1 error rates, the same study should be replicated with a larger sample size across different playing positions and provinces for better generalisability. Further studies should also investigate whether a possible relationship exists between LBS and LBP and other performance variables. Due to the smaller sample size, it was not possible to investigate differences across playing positions, which would provide an avenue for future research. Our study focused on university-level athletes; therefore, it is not clear whether differences would be expected across different levels of play (e.g., school, national, international). Finally, our study focused on much needed research regarding female athletes; however, it must be acknowledged that these results likely cannot be generalised to male netball players.

Recommendations

Further research is required across different playing positions and levels of play. It would also be beneficial to conduct the same study on male netball players as netball participation within the male community continues to increase globally. Limited research exists on injury in netball; therefore, research is required on the relationship between LBS, lower back pain and whether these factors may be mediated by somatotype in netball players.

CONCLUSIONS

Based on the results attained in the study, the following conclusions appear warranted: (1) mesomorph scores and strength can exhibit moderate to large improvements in a netball season, (2) other anthropometric qualities appear to remain largely consistent, (3) small to moderate associations are evident between changes in strength and calf circumference, indicating that whole-body strength seems to be driven predominantly by changes in lower-body strength/hypertrophy, and (4) changes in strength appear to be independent of somatotype, thereby indicating a lack of a preferential body type for improvements in strength.

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Conflict of interest

The authors declare no conflict of interest.

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