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Bilateral Differences in Anthropometric Measurements and Isokinetic Strength Variables of Female University Netball Players

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Abstract

Background: The unilateral demands on the dominant (D) limbs in netball players, may lead to developments and changes that differs from that of the non-dominant (ND) limbs. An individual who is constantly exposed to unilateral movements or repeated use of the D limb, can also develop bilateral differences between the D and ND limbs. The purpose of the study was to determine if any significant bilateral differences in anthropometric and isokinetic strength measurements occurred between the D and ND limbs of the upper and lower parts of the body in female university netball players.

Methods: 44 female university-level netball players (age: 20.02±1.39 years) of the North-West University in South Africa, participated in this study. A total of 25 anthropometric measurements were taken and bilateral isokinetic muscle strength was also tested. Technical error of measurement (TEM) (only for the anthropometrical measurements) and Confidence Interval (CI) at 90% were calculated. Dependent t-tests were done to determine bilateral differences between the D and ND sides of the upper and lower limbs. Effect sizes (ES) were calculated with Cohen's effect size (d=0.8) to determine practical significance.

Results: To support the first objective of this study, results obtained from the biceps skinfold (-17.93±28.85%), showed the only significant level of asymmetry with statistical and practical significance differences of $p<0.00$ (d=0.34). To sustenance the second objective of this study, results obtained from the knee and shoulder isokinetic strength tests revealed no statistical nor practical significant differences between D and ND isokinetic knee strength ($p<0.48$; d=0.1). In contrast to the previous mentioned, the shoulder flexion/extension measurements showed statistical ($p<0.02$) and practical (d=0.28) significant differences between the D and ND side. The shoulder extensor revealed stronger statistical and practical significant differences ($p<0.00$; d=0.44) than the shoulder flexors ($p<0.01$; d=0.29).

Conclusion: The results of this study, revealed that netball players tend to develop marginal bilateral differences between D and ND limbs in response to the demands of the sport and the unilateral movements. Thus, the researcher concludes that university-level netball players showed more differences between the D and ND side in the upper body than the lower body.

Keywords: Anthropometry, bilateral differences, dominance, isokinetic strength, netball players.

Running title: Bilateral differences in Female Netball Players

Introduction

In many cases, when comparing unilateral tasks, some level of functional asymmetry will be present [1]. Functional asymmetry leads to bilateral differences. This is due to actions in which one side of the body is continuously used [2]. According to Pirnay et al. [3,4], the unilateral demands on the dominant (D) limbs leads to development and changes in body composition that differs from that of the non-dominant (ND) side. Unilateral movements such as running, changing direction, repetitive jumps, landing and passing are required of a netball player [5,6]. During these unilateral movements, power is generated by an individual limb, whereas both limbs are used during bilateral movements [7]. Elevation from, or landing on one leg during a rebound, or throwing an object with one arm is considered as a unilateral movement [8].

An individual who is constantly exposed to unilateral movements or repeated use of the D limb can develop bilateral differences between D and ND limbs [1,9,10]. It is therefore important to investigate the changes in bilateral differences between D and ND limbs [11]. Furthermore, what is known as anthropometric asymmetry (bilateral difference) is often found in participants in sport requiring unilateral movements, for example, tennis [3,12], javelin [13] and fast bowling in cricket [14,15]. The importance of studies on athletes with bilateral differences is emphasized by the negative consequences thereof, for example unilateral training and movements have a negative influence on range of motion and optimal performance [16]. Unilateral movements in netball may vary from player to player due to the demands of the position and the nature usually depends on their dominance [17].

Research in sporting codes that predominantly use movements from unilateral base support, noted that adaptation to certain anthropometrical measurements occurs. Upper limb dominance (stronger hand when performing certain tasks such as passing the ball) has a positive link to the hypertrophy of the distal humerus of inactive female subjects. The epicondyle breadth accurately reflects handiness (dominance) in 68% of cases, where the D epicondyle breadth is larger than that of the ND side [18]. The results showed statistically significant bilateral differences ($p<0.001$) between left- and right-handed test subjects, and therefore appeared to reflect a positive relationship regarding the direction of asymmetry and an individual's D limb [18]. In football players, the lower limbs showed a positive correlation ($r=0.31$-0.41) between kicking performance and lean mass values [19-21]. A positive correlation was found between the lean mass of the upper leg and kicking accuracy (Kicking limb: $r=-0.43$ to -0.59; Support limb: $r=-0.53$ to -0.59).

To measure the isokinetic strength of a contracting muscle, an isokinetic dynamometer can be used [22,23]. This is a reliable and objective method to measure muscle strength and bilateral strength differences in limbs [22,24,25]. It is recommended that bilateral strength differences should be less than 10-15% between the D and ND limb. A larger difference between D and ND limbs may influence performance negatively [10,26-28]. Regarding bilateral strength ratios between the agonist and antagonist muscle, several studies reported a ratio percentage of 50-80% to be an acceptable value [9,29,30]. Although no consensus could be found on the agonist and agonist ratio for the lower limbs, the general acceptance percentage for muscle ratio is 60%, dependent on the different testing velocities, but there seems to be no difference between gender or choice of sport [31,32].

Kong and Burns [30] concluded that the knee FLX:EXT differences, with a higher ratio on the D leg, can be attributed to the stronger knee flexor muscles in the D leg, while the knee extensor muscles was mostly similar for both legs, and explained that this difference is due to the different training background of the participants. Chan et al. [33] stated that the shoulder flexion/extension percentage ratios (FLX:EXT) measure between 75% and 85%, but it is noted in a study of Perrin [34] that overhead sport tends to achieve a percentage ratio of only 50%. Researchers stated that bilateral differences in the shoulder were due to the D shoulder developing a systematic superiority in overall muscle strength over years of training [35].

Since no recent studies on netball players' shoulder flexion/extension isokinetic testing were available, a gap was found in the knowledge of bilateral differences in the upper limbs. The present study will provide a guideline for these professionals regarding scientifically formulated training programmed for preventing bilateral differences in netball players. The purposes of this article are therefore: 1.) to determine if university level netball players show significant presence of bilateral differences in the upper and lower body, and if so, 2.) which of the anthropometric measurements (skinfolds, girths, breadths and/or lengths) and isokinetic strength variables show the greatest degree of bilateral differences between the D and ND limbs.

Materials and methods

Experimental design and Participants

This study made use of an experimental test design with convenience sampling. Forty-four female netball players (N=44), from the North-West University in South Africa, with an average age of 20.2±1.4 years, were tested. The participants had an average stature of 175.7±7.2cm and an average body mass of 72.5±8.8kg. The players were tested during the in-season phase of their periodization cycle. Risks for these participants were minimal and all monitoring and safety measurements were in place.

Ethical Oversight

Before data collection, a project letter was sent to the university's department of sport, coaches, and managers, explaining the purpose of the study, and seeking permission. Approval was given by all relevant role players. Ethical approval for this study was obtained from the Human Research Ethics Committee of the Faculty of Health Science at North-West University in South Africa (NWU-00359-15-A1). Only players who provided voluntary consent, and complied with the inclusion and exclusion criteria, could participate in this study.

Procedures and Measurements

Anthropometric Measurements

Anthropometric measurements were taken early in the morning, before breakfast or training. Measurements were taken according to the protocol of the International Society for the Advancement of Kinanthropometry (ISAK) [36]. A total of 25 anthropometric measurements were taken. Stature, body mass, eight skinfolds, six girths, five segment lengths and four bone breadths were measured on both the dominant (D) and the non-dominant (ND) side. All measurements were taken twice, with a third measurement when any of the first 2 measurements were outside the allowed limits [36]. In case of 2 measurements, the

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mean value was used as the official reading whereas the median was used in the case of three measurements. Under ISAK protocol, the subjects were requested to present themselves in the appropriate clothing for measurements to be made as effective as possible [36].

Body mass was measured on a calibrated electronic scale (precision, A&D Company, Saitama, Japan) to the nearest 0.1 kg. Stretch stature was measured with a Seca213 stadiometer (Seca equipment, Hamburg, Germany) to the nearest 0.1 cm. Skinfolds (mm) were measured to the nearest 0.1 mm on eight different sites, namely the triceps, biceps, subscapular, iliac crest, supraspinale, abdominal, thigh and calf [36]. A Traditional Scientific Skinfold Caliper ($10g.mm^{-2}$) (Cescorf Equipment, Porto Alegre, Brazil) were used to measure skinfolds. Breadths (cm) were determined at four different sites, namely the femur, humerus, wrist and ankle breadths [36]. A bone caliper (Cescorf Equipment, Porto Alegre, Brazil) was used to measure the breadths to the nearest 0.1 cm. About the girths, five girths were measured. The relaxed upper arm, flexed upper arm, forearm-, mid-thigh- and calf. Girths were measured, using a flexible steel tape (Cescorf Equipment, Porto Alegre, Brazil) to the nearest 0.1cm [36].

A total of five lengths were measured. The upper arm, forearm, hand, upper leg, and lower leg. Lengths were measured using a segmometer (Cescorf Equipment, Porto Alegre, Brazil) to the nearest 0.1cm [36]. For the sum of the six skinfolds (Σ6 skinfolds) the triceps, subscapular, supraspinale, abdominal, thigh and calf skinfolds were used. Body fat percentages were obtained by means of the equation of Withers et al. [37]. The equations of Lee et al. [38] and Martin [39] were used respectively to calculate Muscle Mass and Skeleton Mass.

Technical error of measurement (TEM)

The technical error of measurement (TEM) was calculated [40,41]. An intra-tester TEM of 5-7.5% relative TEM values are considered as acceptable for skinfolds and 1-1.5% for the other anthropometrical measurements [41]. The relative TEM scores for this study showed less than 5.75%,1.14%, 0.89% and 1.69% for the skinfolds, girths, lengths as well as the breadths, respectively.

Limb Dominance Testing

Limb dominance was determined to compare the D side with the ND side to be able to investigate the bilateral differences. Limb dominance was determined by self-declaration for the upper and lower limb. Coren and Porac [42] reported that self-declaration was found to have a 97.7% agreement with task performance (kicking a ball) and a 96% test-retest agreement. Blackburn and Knüsel [18] stated that previous studies have linked self-professed (stronger hand when performing a certain task such as throwing a ball) for the upper limbs with the hypertrophy of the distal humerus.

Isokinetic Strength Tests

An isokinetic dynamometer (Cybex NormTM,) [43] was used for testing bilateral isokinetic muscle strength. Software used was the Humac 2014 and the Cybex was calibrated before each testing session. The calibration was done by the described protocol [43]. The testing consisted of knee flexion and extension [25,44,45] and a shoulder flexion and extension (supine) protocol. Both tests were done at a speed of 60°/sec for concentric movement [46]. Before the isokinetic strength tests, each player performed a warm-up session. All participants followed the same order of testing by starting with the lower limbs. The warm-up for the lower limbs consisted of five minutes cycling on a stationary ergometer on low intensity (75 Watts) [47], and specific dynamic stretches [48]. The upper body warm-up consisted of two minutes' sub-maximal intensity rowing on an upper-body ergometer [49], and specific dynamic stretches for the upper limbs [50].

Each netball player was being positioned according to the directions of the specific protocol [43] for the different joints that were tested. A familiarization set was done before the formal test of the knee and shoulder. This familiarization consisted of two (2) submaximal concentric contractions, after which the player rested for 60 seconds [51]. This was followed by the maximal concentric contraction test, which consists of five repetitions for the knee flexion-extension [25,44,45] and shoulder flexion-extension [46] at the velocity of 60°/sec.

Statistical analysis

The Statistical Data Processing package (IBM SPSS Statistics Version 25) [52], was used to determine the descriptive statistics as well as the 90% confidance intervals (CI). Due to the small sample size, the statistically significant difference of all measurements between the D and ND sides were performed using a dependent t-test ($p \leq 0.05$). Effect size (ES) was also calculated for the total group (D and ND of the upper and lower limbs) and Cohen's effect size for practical significance was used, as reported by Ellis and Steyn [53]. Cohens's effect size (ES) was interpreted as follow: high practical significance, $d \geq 0.8$*; medium practical significance, $d \geq 0.5$; low practical significance, $d \geq 0.2$.

The 90% CI was qualitatively interpreted using the following thresholds: <0.19, trivial; 0.2-0.59, small; 0.6-1.19, medium; 1.2-1.99, large; 2.0-4.0, very large; >4, vast differences to determine the likelihood that the true value of the effect represents substantially beneficial or detrimental changes [54-60]. The smallest practically meaningful effect was considered 0.2 either positive or negative with values implicating either the D (positive) or the ND (negative) side. Effects where the CI overlapped, small positive or small negative effects were defined as unclear. Effect sizes could be beneficial/detrimental were either positive or negative medium to vast differences, with either the upper or lower limit of the 90% CI not exceeding a trivial ES (<0.19) on either side.

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Results

Anthropometric data

Descriptive statistics for the anthropometric variables are presented in Table 1. When comparing the mean scores from Table 1, the extent of bilateral differences between the dominant (D) and the non-dominant (ND) sides, are evenly distributed for all the skinfolds. It is important to note, that different fitness and competition levels of the players that trained and participated in different divisions at university level, may had an influence on the anthropometric measurements.

Table 1: Anthropometrical variables of university-level netball players (n = 44). Statistical and practical significant differences between dominant (D) and non-dominant (ND).

Variables	D	ND	Mean Diff between D and ND	90% Confidence Interval of the Diff between D and ND		Statistical significant diff (p)	Practical significant diff (d)
	Mean	Mean		Lower	Upper		
Skinfolds (mm):							
Biceps	8.78±4.11	10.66±5.58	-1.88	-2.71	-1.05	0.00#	0.34*
Triceps	17.83±5.52	16.82±4.71	1.01	0.31	1.7	0.02#	0.18*
Subscapular	11.56±4.39	12.21±5.57	-0.65	-1.29	-0.01	0.1	0.12*
Illiac crest	18.26±6.45	18.21±6.49	0.05	-0.51	0.61	0.88	0.01
Supraspinale	13.19±5.51	12.68±5.90	0.51	-0.04	1.06	0.13	0.09
Abdominal	18.37±5.15	17.12±4.6	1.25	0.82	1.67	0.00#	0.24*
Thigh	25.93±7.62	26.07±7.98	-0.14	-0.62	0.33	0.61	0.02
Calf	16.93±4.99	17.01±5.19	-0.08	-0.61	0.46	0.81	0.01
Girths (cm):							
Relaxed upper arm	28.31±2.56	28.12±2.54	0.19	0.04	0.34	0.04#	0.07
Flexed upper arm	29.46±2.18	29.13±2.29	0.34	0.17	0.51	0.00#	0.15*
Forearm	25.08±1.34	24.61±1.23	0.48	0.38	0.58	0.00#	0.36*
Thigh	56.26±3.51	55.88±3.69	0.38	0.11	0.66	0.02#	0.1
Calf	38.39±2.54	38.28±2.55	0.11	-0.02	0.24	0.18	0.04
Lengths (cm):							
Upper arm	34.05±1.62	34.07±2.25	-0.02	-0.46	0.41	0.93	0.01
Forearm	26.05±1.19	26.43±1.15	-0.38	-0.59	-0.18	0.00#	0.32*
Hand	20.13±0.78	20.20±0.72	-0.07	-0.21	0.07	0.39	0.09
Upper leg	44.42±2.92	44.44±2.78	-0.02	-0.48	0.43	0.93	0.01
Lower leg	47.29±3.05	47.50±3.30	-0.21	-0.46	0.03	0.15	0.06
Breadths (cm):							
Humerus	6.46±0.33	6.49±0.43	-0.02	-0.07	0.03	0.46	0.05
Wrist	5.36±0.39	5.32±0.36	0.04	0.01	0.07	0.05#	0.1
Femur	9.6±0.55	9.54±0.55	0.07	0.02	0.12	0.03#	0.12
Ankle	6.84±0.43	6.85±0.47	-0.01	-0.05	0.04	0.8	0.02
Body Composition:							

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Sum of 6 Skinfolds (mm)	104.3±29.68	101.9±28.56	2.4	1.18	3.63	0.00#	0.08
Body fat (%)	22.07±4.76	21.69±4.57	0.38	0.19	0.58	0.00#	0.08
Muscle mass (kg)	37.37±4.15	36.61±4.3	0.76	0.49	1.03	0.00#	0.18*
Skeletal mass (kg)	8.45±1.03	8.42±1.07	0.03	-0.02	0.08	0.31	0.03

#Statistical Significance level (p≤0.05); *Practical Significance (d≥0.8)
Abbreviation: D = Dominant; ND = Non-dominant; Diff = Difference

Table 1 represents statistical and practical significant anthropometrical differences between the D and ND sides. About the skinfolds, the biceps, triceps, and abdominal skinfolds showed both statistical as well as practical significant differences between the D and ND sides. The triceps and abdominal skinfolds had smaller measurements on the ND side, with the biceps showing a larger skinfold on the ND side. Although the subscapular skinfold showed no statistical significance, a practical significant difference between the D and ND side was found with the D skinfold the smaller value.

In relation to the girth measurements, only two of these measurements, flexed upper arm and forearm, showed statistical as well as practical significant differences. The relaxed upper arm and mid-thigh showed only statistically significant differences between the two sides. All the girths, the girths on the D side were larger than those on the ND side. Although all the length measurements on the ND side surpass those on the D side, the radial-stylion (forearm) length was the only measurement with a statistically significant difference as well as a practical significant difference between D and ND. For the breadths, the wrist and femur breadths had statistically significant differences between the D and ND, with both these measurements having larger values on the D side.

Regarding the differences in body composition, the sum of six skinfolds (mm), body fat percentage (%) and muscle mass (kg) showed statistically significant differences between D and ND. Muscle mass also showed a practical significant difference between the D and ND sides. About all four the body composition measurements, the D sides showed larger values than that of the ND side. In Table 1, the results depict the mean differences (MD) between the D and ND sides and the 90% CI for the effect size (ES) of the upper and lower limits of each of the variables that did not indicate trivial to unclear ES in the measurements. From the obtained results of all measured variables: biceps skinfold (MD -1.88: -2.71 and -1.05), subscapular skinfold (MD -0.65; -1.29 and -0.01), forearm length (MD -0.38; -0.59 and -0.18), and lower leg length (MD -0.21; -0.46 and 0.03), attained small to very large worthwhile effect in favour of the ND side. In this regard, the ND side measurements exceeded that of the D side. Furthermore, triceps skinfold (MD 1.01; 0.31 and 1.70), supraspinale skinfold (MD 0.51; -0.04 and 1.06), abdominal skinfold (MD 1.25; 0.82 and 1.67), body fat percentage (MD 0.38; 0.19 and 0.58), and muscle mass (MD 0.76; 0.49 and 1.03) attained small to medium worthwhile effect in favour of the D side.

The calf girth (MD 0.11; -0.02 and 0.24), relaxed upper arm girth (MD 0.19; 0.04 and 0.34), flexed upper arm girth (MD 0.34; 0.17 and 0.51), forearm girth (MD 0.48; 0.38 and 0.58) and thigh girth (MD 0.38; 0.11 and 0.66)] resulted in a small to medium worthwhile effect in favour of the D side. Only sum of 6 skinfolds (MD 2.40; 1.18 and 3.63) showed medium to very large worthwhile effect in favour of the D side. All other results obtained are considered unclear due to CI upper and lower limit exceeding the smallest positive and smallest negative effect of 0.2.

Isokinetic measurements

Descriptive statistics for the isokinetic measurements used in this study are presented in Table 2.

Table 2: Isokinetic variables of university-level netball players (n = 44). Statistical and practical significant differences between dominant (D) and non-dominant (ND).

Variable	D	ND	Mean Difference between D and ND	90% Confidence Interval		Statistical significant difference (p)	Practical
Knee Ext/Flex	Mean	Mean		Lower	Upper		
Extensor PT Value (Nm)	164.95±28.36	163.91±26.74	1.05	-4.37	6.46	0.75	0.04
Extensor (TBW) (Nm/kg)	2.28±0.38	2.27±0.39	0.61	-7.08	8.3	0.89	0.02
Flexors PT Value (Nm)	106.93±23.9	109.32±18.05	-2.39	-8	3.23	0.48	0.1
Flexors TBW (Nm/kg)	1.52±0.27	1.51±0.24	0.16	-4.7	5.02	0.96	0.01
H:Q ratio (%)	66.75±8.36	67.68±12.68	-0.93	-3.93	2.06	0.6	0.07

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Extensors deficit (%)	9.39±7.63						
Flexors deficit (%)	9.73±6.24						
Shoulder Ext/Flex							
Extensor PT Value (Nm)	63.00±8.38	59.27±7.67	3.73	2.07	5.38	0.00#	0.44*
Extensor TBW (Nm/kg)	0.87±0.11	0.82±0.11	4.91	2.71	7.1	0.00#	0.45*
Flexors PT Value (Nm)	44.45±7.35	42.32±6.12	2.14	0.86	3.41	0.01#	0.29**
Flexors TBW (Nm/kg)	0.62±0.1	0.59±0.09	2.75	0.91	4.59	0.02#	0.28**
Shoulder FLX:EXT ratio(%)	71.23±11.1	72.32±11.21	-1.09	-4.12	1.93	0.55	0.1
Extensors deficit(%)	8.68±6.55						
Flexors deficit(%)	9.18±7.04						

#Statistical Significance level (p≤0.05); *Medium Practical Significance (d≥0.5); **High Practical Significance (d≥0.8);
Abbreviation: D = Dominant; ND = Non-dominant; PT = Peak torque; TBW = Torque to body weight

The entire group of university-level netball players showed a mean peak torque (PT) of 164.95±28.36Nm and 106.93±23.9Nm for knee extensor and flexor strength respectively with regards to the D limb. Values of 163.91±26.74Nm and 109.32±18.05Nm were recorded respectively for the ND limb. Where results were normalised for total body weight (TBW), the group had a mean TBW of 2.28±0.38Nm/kg for knee extensor strength and 1.52±0.27Nm/kg for knee flexor strength of the D limb. The ND limb revealed a mean TBW in knee extensor strength of 2.27±0.39Nm/kg and 1.51±0.24Nm/kg for knee flexor strength.

The knee FLX:EXT revealed an average percentage ratio of 66.75±8.36% for the D limb and 67.68±12.68% for the ND limb. The knee flexor PT and the knee FLX:EXT ratio showed higher values for the ND side, whereas the knee extensor PT, normalised for body weight extensor PT and normalised for body weight flexor PT values, presented higher values for the D side. Knee extensors showed an average of 9.39±7.63% deficit, where the D knee had higher mean PT values. The knee flexors resulted in 9.73±6.24% deficit, with the ND knee having higher mean PT values.

Regarding the upper limbs, the shoulder extension/flexion isokinetic test results revealed that the shoulder extensor and flexor mean PT were 63.0±8.38Nm and 44.45±7.35Nm respectively for the D limb and 59.27±7.67Nm and 42.32±6.12Nm for the ND limb. Normalized for total body weight, the group showed a mean PT for the extensors and flexors of 0.87±0.11Nm/kg and 0.62±0.10Nm/kg for the D limb respectively. The ND limb showed a mean PT value of 0.82±0.11Nm/kg for the extensors and 0.59±0.09Nm/kg for the flexors, respectively.

Regarding the shoulder FLX:EXT, an average of 71.23±11.10% for the D limb and 72.32±11.21% for the ND limb were recorded. The shoulder extension means PT, normalized for body weight extension PT, shoulder flexion mean PT and normalized for body weight flexion PT values, resulted in higher values for the D side. The shoulder FLX:EXT percentage ratio had higher values for the ND side. For the shoulder extension/flexion test, the bilateral differences for the extensor and flexors showed an average percentage of 8.68±6.55% deficit and 9.18±7.04% deficit respectively where the D shoulder had the greater mean PT values on both sides.

Table 2 represents the statistical and practical significant bilateral differences for the knee and shoulder extension/flexion tests at a testing velocity of 60°/sec. In Table 2, none of the isokinetic knee extension/flexion measurements showed statistical or practical significant differences between the D and ND sides (p<0.48). In contrast to this, the shoulder flexion/extension measurements showed a statistical (p<0.02) and practical (d=0.28) significant difference between the D and ND sides; the shoulder extensor variable showed a stronger statistical and practical significant difference (p<0.00; d=0.44) than the shoulder flexors (p<0.01; d=0.29). The shoulder FLX:EXT percentage ratio showed no statistical or practical significant difference between the D and ND side (p<0.55; d=0.10).

The 90% CI of the difference, depict the mean differences between the D and ND sides size and the 90% CI for effect size (ES) upper and lower limits of each of the variables that did not indicate trivial to an unclear ES of measurements. From the results obtained, the shoulder extensor PT (MD 3.73; 2.07 and 5.38), shoulder extensor TBW (MD 4.91; 2.71 and 7.10), shoulder flexor PT (MD 2.14; 0.86 and 3.41) and shoulder flexor TBW (MD 2.75; 0.91 and 4.59), presented medium to vast difference with a worthwhile effect size in favour of the D side. All other obtained results were considered unclear due to CI upper and lower limit exceeding the smallest positive and smallest negative effect of 0.2.

No statistical and practical significant differences were found in the knee extension/flexion isokinetic strength test, which is in correspondence with Kobayashi et al. [60], who tested healthy male subjects. In the last-mentioned study, the researchers found

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no statistical differences between the D and ND lower limbs regarding the knee extensors and flexors ($p<0.25$ and $p<0.39$ respectively), with only a small practical significant difference ($d=0.22$ and $d=0.26$ respectively) at a testing velocity 60°/sec. In this study the bilateral differences were less than 10% between the D and ND lower body, indicating that the netball players in this study had muscle balance that was in line with the recommendations given in the literature [10,26-28].

Discussions

About the anthropometric data, it is evident that the biceps skinfolds had the highest extent of bilateral differences and showed statistical and practical significant differences between the D and ND sides of the upper limbs. A smaller biceps skinfold on the D side may have a positive effect on performance [55] since players with a higher muscle mass and lower body fat mass perform better than players with a lower muscle mass and a higher body fat mass [53]. The biceps skinfold bilateral differences may be present due to the use of the D arm during the one-handed overhead and shoulder pass which is frequently used [57,58]. This study showed statistically significant differences between the D and ND side for the sum of six skinfolds, bone density, body fat percentage, and muscle mass. The sum of six skinfolds and body fat percentage was in favour of the ND side; the measurements were smaller on the ND side than the D side which has a better outcome in performance [56]. Only muscle mass showed a small practical significant difference between the D and ND sides. Muscle mass was in favour of the D side, where the muscle mass results were larger than on the ND side. These findings correspond to those of the study of Krzykała and Leszczyński [59], which found statistically significant differences between the left and right side of the body for muscle mass and fat mass of female hockey players where the left side had the larger measurements. The bilateral differences in muscle mass can be caused by the side preferences in unilateral movement and the demands of a netball match. A better understanding of the mechanism of the bilateral difference and the effect on performance will enable a more targeted approach to specific training [20,21].

About the isokinetic measurements, the study of Kobayashi et al. [60] contradicts other studies [30,61-63] with regards to the knee extension/flexion isokinetic strength test. Statistically significant differences ($p<0.001$) were found between the D and ND lower limbs in the knee extension/flexion isokinetic test of female Swedish test subjects [62], male and female recreationally active athletes [30], random selected test subjects of different age groups and gender [61], as well as in cadet basketball players [63]. The knee FLX: EXT percentage ratio of the netball players was 66.75±8.36% for the D knee and 67.68±12.68% for the ND knee, which falls within the acceptable range between 50-80% at a testing velocity of 60°/sec [9,29,30]. We attribute these findings to the specific strength training programmed and court training of these netball players partaking in which involved unilateral as well as bilateral movements, or to the various passing and landing movements throughout netball training or a match. This further showed that the netball players from our study were in a well-balanced condition concerning their lower limb bilateral differences and FLX:EXT muscular balance.

Even though the netball players showed statistical and practical significance about isokinetic strength, bilateral differences between the D and ND sides for the shoulder flexion/extension test, the D shoulder had greater values than the ND shoulder. The reason for this could be due to the asymmetric nature of shoulder movements in overhead throwing sport codes [64], where this relates to studies done on the isokinetic shoulder internal/external rotation test. Although limited studies were found on isokinetic strength for the shoulder flexion/extension movement, studies were included in the literature review that investigated isokinetic strength for the shoulder internal/external rotation movement.

In a study done on elite female handball players, researchers found that the players showed statistically significant differences between the D and ND shoulder for internal/external rotation ($p<0.05$) [65]. These findings correspond with the results of Markou and Vagenas [35], who found statistically significant differences ($p<0.001$) between the D and ND sides for the shoulder internal-external rotation strength test in elite male volleyball players. Both above-mentioned studies showed that the D shoulder achieved higher values than the ND shoulder [35,65]. Regarding shoulder FLX:EXT ratio, these netball players had a ratio of 71.23±11.10% for the D shoulder and 72.32±11.21% for the ND shoulder. These finding are like the shoulder FLX:EXT ratio of Berg et al. [46], who indicated that 81% and 77% for the left and right shoulders respectively (dominance was not recorded) at a testing velocity of 60°/sec.

Bilateral differences observed for both the upper and lower body, were less than the 10-15% of that recommended by various researchers [10,26,28]. This may be due to the unilateral movements in various sporting codes [9,11]. The reason for the bilateral differences being larger in the upper body than in the lower body, may be since the upper body is more exposed to unilateral movement in netball as well as upper body dominance and daily activity demands [9,11].

Conclusion

In conclusion, these findings support the hypothesis, that netball players tend to develop bilateral differences between D and ND limbs. Sporting codes other than netball, that predominantly use unilateral movements, differ significantly between the D and ND limbs concerning different anthropometrical measurements. Research has found statistically significant bilateral differences for some anthropometrical variables of various sporting codes predominantly using unilateral movements. Regarding the anthropometric measurements, it might have been predicted from

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previous research that a unilateral sport code, such as netball, would have greater differences in bilateral measurements. The results of this study partially confirm this. The Biceps skinfold and muscle mass, showed statistical and practical significance were as the sum of skinfolds, bone density and body fat percentage showed statistically significant difference but not practical.

For the isokinetic strength, only the upper body showed statistical and practical significant difference, where the D surpassed the ND upper limb's variables. These findings are due to the demands of the netball and its unilateral movements such as repeated passing action on the D side during netball games. Thus, we conclude that university-level netball players showed significant differences between the D and ND side in the upper body. Training programs could be developed specifically for the needs of these netball players and implemented appropriately, firstly to prevent, and secondly to remedy the occurrence of such bilateral differences. In the end, this will improve their performance and help with the conditioning of these players. A better understanding of the mechanism of the bilateral difference will enable a more targeted approach to training.

Limitations & Recommendations

The study provides significant insight into the field of study for university-level netball players concerning bilateral differences. However, it has certain shortcomings that need to be addressed and taken into consideration when interpreting the results:

i. Firstly, the sample size could also have been larger for more validity in the study, which can therefore not be generalized to the whole of the country or the world. It is recommended that different university sites be included in future studies for the better demographic representation of South Africa.

ii. Secondly, only two joints were tested for isokinetic strength to determine bilateral differences. It is recommended that more isokinetic strength tests over different joints, such as the wrist, ankle, and hip, could be included in the research design so that more information can be obtained about the bilateral difference development in netball players.

iii. Thirdly, different playing levels and positions have different training programmes and schedules. Investigating the effect of different playing levels and/or positions may give a good indication of bilateral development of the D versus the ND limbs.

Lastly, the rotator cuff muscle, which is primarily involved in the passing mechanism (although the netball passing mechanism differs from other passing) may also give a good indication of bilateral development of the D versus the ND shoulder. Future studies can take these recommendations into account.

References

1. Maulder PS (2013) Dominant limb asymmetry associated with prospective injury occurrence. South African Journal for Research in Sport, Physical Education & Recreation 35(1): 121-131.
2. Strydom G (2000) Biokinetika Handleiding MBW323. North West University. Potchefstroom, South Africa
3. Pirnay F, Bodeux M, Crielaard JM, Franchimont P (1987) Bone mineral content and physical activity. International Journal of Sports Medicine 8(5): 331-335.
4. Merletti R, Knaflitz M, DeLuca CJ (1992) Electrically evoked myoelectric signals of back muscles: Effect of side dominance. 1324-1325.
5. Chang RY, Briffa K, Edmondston S (2013) Bone mineral density and body composition in elite female golf and netball players. European Journal of Sport Science 13(2): 183-190.
6. Terblanche E, Venter RE (2009) The effect of backwards training on the speed, agility, and power of netball players. South African Journal for Research in Sport, Physical Education & Recreation 31(2): 135-145.
7. Jakobi JM, Chilibeck PD (2001) Bilateral and Unilateral Contractions: Possible Differences in Maximal Voluntary Force. Canadian Journal of Applied Physiology 26(1): 12-33.
8. McCurdy K, C Conner (2003) Unilateral support resistance training incorporating the hip and knee. Strength and Conditioning Journal 25(2): 45-51.
9. Cheung RTH, Smith AW, Wong DP (2012) H: Q Ratios and Bilateral Leg Strength in College Field and Court Sports Players. Journal of Human Kinetics 33: 63-71.
10. Hewit JK, Cronin JB, Hume PA (2012) Asymmetry in multi-directional jumping tasks. Physical Therapy in Sport 13(4): 238-242.
11. Botton CE (2013) Bilateral deficit between concentric and isometric muscle actions. Isokinetics & Exercise Science 21(2): 161-165.
12. Green DJ (1996) Endothelium-derived nitric oxide activity in forearm vessels of tennis players. Journal of applied physiology (Bethesda, Md.: 1985) 81(2): 943-948.
13. Kruger A (2005) Die voorkoms van morfologiese asimmetrie by elite-internasionale manlike spiesgooiers. South African Journal for Research in Sport, Physical Education and Recreation 27(2): 47-55.
14. Engstrom CM, Walker D, Kippers V, Hunter J, Hanna AJ, et al. (1999) A prospective study on back injury and muscle morphometry in junior cricket fast bowlers. Journal of Science and Medicine in Sport 2(4): 411.
15. Grobbelaar H, De Ridder JH (2001) Asymmetry in the upper body of high school fast bowlers in cricket in South Africa. African Journal for Physical Health Education, Recreation and Dance 7: 61-76.
16. Starosta W (1989) Symetria czy asymetria w doskonaleniu techniki sportowej. Symmetry or asymmetry in the improvement of sports technique. Kultura Fizyczna 43(5-6): 14-16;13.
17. Hopper D, Lo SK, Kirkham C, Elliott B (1992) Landing patterns in netball: analysis of an international game. British Journal of Sports Medicine 26(2): 101-106.
18. Blackburn A, Knsel C (2006) Hand Dominance and Bilateral Asymmetry of the Epicondylar Breadth of the Humerus : A Test in a Living Sample. Current Anthropology 47(2): 377.
19. Hart NH (2014) Leg Strength and Lean Mass Symmetry Influences Kicking Performance in Australian Football. Journal of Sports Science & Medicine 13(1): 157-165.
20. Carpes FP, Mota CB, Faria IE (2010) On the bilateral asymmetry during running and cycling - a review considering leg preference. Phys Ther Sport 11(4): 136-142.
21. Sale DG (1988) Neural adaptation to resistance training. Med Sci Sports Exerc 20(5 Suppl): S135-45.

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22. Land H, Gordon S (2011) What is normal isokinetic shoulder strength or strength ratios? A systematic review. Isokinetics & Exercise Science 19(4): 231-241.

23. Erol Kovacevic, Ensar Abazovic, Josipa Bradic, Mensur Vrcic (2012) The predictive value of isokinetic assessment on the explosive strength of the lower extremities. Homo Sporticus 14(1): 49-55.

24. Bandy WD, McLaughlin S (1993) Intramachine and intermachine reliability for selected dynamic muscle performance tests. J Orthop Sports Phys Ther 18(5): 609-613.

25. Dervišević E, Hadžić V (2012) Quadriceps and hamstrings strength in team sports: Basketball, football, and volleyball. Isokinetics & Exercise Science 20(4): 293-300.

26. Knapik JJ, Bauman CL, Jones BH, Harris JM, Vaughan L (1991) Preseason strength and flexibility imbalances associated with athletic injuries in female collegiate athletes. / Les desequilibres entre la force et la souplesse associees aux blessures dues a la pratique du sport chez des femmes' athletes universitaires, avant la saison. American Journal of Sports Medicine 19(1): 76-81.

27. Zuzana Xaverova, Johannes Dirnberger, Michal Lehnert, Jan Belka, Herbert Wagner (2015) Isokinetic Strength Profile of Elite Female Handball Players. Journal of Human Kinetics 49(1): 257-266.

28. Fort-Vanmeerhaeghe A, Gabriel Gual, Daniel Romero-Rodriguez, Viswanath Unnitha, et al. (2016) Lower Limb Neuromuscular Asymmetry in Volleyball and Basketball Players. Journal of Human Kinetics 50(1): 135-143.

29. Hewett TE, Myer GD, Zazulak BT (2008) Hamstrings to quadriceps peak torque ratios diverge between sexes with increasing isokinetic angular velocity. Journal of Science and Medicine in Sport 11(5): 452-459.

30. Kong PW, SF Burns (2010) Bilateral difference in hamstrings to quadriceps ratio in healthy males and females. Physical Therapy in Sport 11(1): 12-17.

31. Rosene JM, TD Fogarty, BL Mahaffey (2001) Isokinetic Hamstrings: Quadriceps Ratios in Intercollegiate Athletes. Journal of Athletic Training 36(4): 378-383.

32. Coombs R, Garbutt G (2002) Developments in the use of the hamstring/ quadriceps ratio for the assessment of muscle balance. Journal of Sports Science & Medicine 1(3): 56-62.

33. Chan KM (1996) Principles and practice of isokinetics in sports medicine and rehabilitation. New Territories, Hong Kong; Williams & Wilkins Asia-Pacific Ltd.

34. Perrin DH (1993) Isokinetic exercise and assessment. (2nd edn.), Champaign, IL: Human Kinetics Publishers.

35. Markou S, Vagenas G (2006) Multivariate isokinetic asymmetry of the knee and shoulder in elite volleyball players. European Journal of Sport Science 6(1): 71-80.

36. Stewart A, Marfell-Jones M, Olds T, De Ridder JH (2011) International standards for anthropometric assessment. New Zealand: ISAK.

37. Whithers RT, Craig NP, Bourdon PC, Norton KI (1987) Relative body fat and anthropometric prediction of body density of male athletes. European Journal of Applied Physiology 56(2): 191-200.

38. Lee RC, Wang Z, Heo M, Ross R, Janssen I, Heymsfield SB (2000) Total body skeletal muscle mass: development and cross-validation of anthropometric prediction models. American Journal of Clinical Nutrition 72(3): 796-803.

39. Martin AD (1991) Anthropometric assessment of bone mineral. In L. Himes (Ed.), Anthropometric assessment of nutritional status (185-196). New York: Wiley-Liss.

40. Pederson D, Gore C (1996) Anthropometry Measurement Error, in Anthropometrica: A Textbook of Body Measurement For Sports And Health Courses, K. Norton & Tim Olds. Editors. UNSW Press: Sydney, Australia. 413.

41. Perini Oliveira T (2005) Technical error of measurement in anthropometry (English version). Revista Brasileira de Medicina do Esporte 11: 81-85.

42. Coren S, Porac C (1978) The validity and reliability of self-report items for the measurement of lateral preference. British Journal of Psychology 69(2): 207.

43. Norm C (1996) Testing and rehabilitation system user's guide, I. Cybex International, Editor. Cybex International, INC: Ronkonkoma, New York.

44. Boone J, Bourgois J (2013) Morphological and physiological profile of elite basketball players in Belgium. International Journal of Sports Physiology and Performance 8(6): 630-638.

45. Miller LE, Nickols-Richardson SM, Wootten DF, Ramp WK, Herbert WG (2004) Relationships among Bone Mineral Density, Body Composition, and Isokinetic Strength in Young Women. Calcified Tissue International 74(3): 229-235.

46. Berg K, Blanke D, Miller M (1985) Muscular fitness profile of female college basketball players. J Orthop Sports Phys Ther 7(2): 59-64.

47. Lategan L (2012) Differences in knee flexion and extension angles of peak torque between men and women. Isokinetics & Exercise Science 20(2): 71-76.

48. Papadopoulos G, Siatras T, Kellis S (2005) The effect of static and dynamic stretching exercises on the maximal isokinetic strength of the knee extensors and flexors. Isokinetics and Exercise Science 13: 285-291.

49. Malerba JL (1993) Reliability of dynamic and isometric testing of shoulder external and internal rotators. Journal of Orthopaedic & Sports Physical Therapy 18(4): 543-552.

50. Cools AM (2004) Evaluation of isokinetic force production and associated muscle activity in the scapular rotators during a protraction-retraction movement in overhead athletes with impingement symptoms. British Journal of Sports Medicine 38(1): 64.

51. Parcell AC, Robert D Sawyer, Valmor A Tricoli, Troy D Chinevere (2002) Minimum rest period for strength recovery during a common isokinetic testing protocol. Medicine and Science in Sports and Exercise 34(6): 1018-1022.

52. IBM, Ibm Spss Statistics for Windows. (2015) IBM: Armonk, New York: IBM Corp.

53. Ellis SM, Steyn HS (2003) Practical significance (effect sizes) versus or in combination with statistical significance (p-values): research note. Management Dynamics: Journal of the Southern African Institute for Management Scientists 12(4): 51-53.

54. Hopkins WG, Stephen W Marshall, Alan M Batterham, Juri Hanin (2009) Progressive Statistics. Sportscience13: 1-20.

55. Legaz A, Eston R (2005) Changes in performance, skinfold thicknesses, and fat patterning after three years of intense athletic conditioning in high level runners. British Journal of Sports Medicine 39(11): 851-856.

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56. Ryan-Stewart H, Faulkner J, Jobson S (2018) The influence of somatotype on anaerobic performance. PLoS One 13(5): e0197761.

57. Gamble P (2011) Physical Preparation for Netball -Part 1: Needs Analysis and Injury Epidemiology. Professional Strength and Conditioning 10-15.

58. Woodlands J (2006) The netball handbook. Champaign, IL: Human Kinetics.

59. Krzykała M, Leszczyński P (2015) Asymmetry in body composition in female hockey players. HOMO - Journal of Comparative Human Biology 66(4): 379-386.

60. Kobayashi Y (2013) Relationship Between Bilateral Differences in Single-Leg Jumps and Asymmetry in Isokinetic Knee Strength. Journal of Applied Biomechanics 29(1): 61-67.

61. Phillips BA, Lo SK, Mastaglia FL (2000) Isokinetic and isometric torque values using a Kin-Com dynamometer in normal subjects aged 20 to 69 years. Isokinetics and Exercise Science 8(3): 147-159.

62. Lanshammar K, Ribom EL (2011) Differences in muscle strength in dominant and non-dominant leg in females aged 20–39 years – A population-based study. Physical Therapy in Sport 2011 12(2): 76-79.

63. Radjo I (2013) Asymmetry in strength of thigh muscles in basketball players. Technics Technologies Education Management Volume 8: 723-729.

64. Vedran Hadzic, Tine Sattler, Matjaž Veselko, Goran Markovic, Edvin Dervisevic (2014) Strength asymmetry of the shoulders in elite volleyball players. J Athl Train 49(3): 338-344.

65. Marilia Dos Santos Andrade, Anna Maria Fleury, Claudio Andre Barbosia de Lira, Joao Paulo Dubas, Antonio Carlos da Silva. (2010) Profile of isokinetic eccentric-to-concentric strength ratios of shoulder rotator muscles in elite female team handball players. J Sports Sci 28(7): 743-749.

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