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An Examination of the Arm, Shoulder, and Abdominal Muscle Endurance of Netball and Volleyball University Female Players in Relation to Specific Anthropometric Measurements

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Abstract This study intended to determine the association of arm, shoulder, and abdominal muscular endurance with specific anthropometric measurements among netball and volleyball university female players. An observational study design was used in assessment of the anthropometric indices and musculature endurance of twenty-eight female participants (14 Netball and 14 Volleyball players). The study found that the mean age of the participants was 19.54±0.69 years, with an average body weight of 52.99±10.51 kg, height of 156.71±5.34 cm, and body mass index (BMI) of 21.57±4.09 kg/m^2. Specific anthropometric measurements were determined using a bioelectric impedance analysis tool, push-ups determined arm and shoulder endurance, sit-ups and measured abdominal endurance. The number of sit-ups and push-ups in one minute was used as score. There was a negative association between upper body muscle endurance and Total Body Water (TWB) (r=-.058), Mass of Body Fat (MBF) (r=-.019), Visceral Fat Area (VFA) (r=-036), Abdominal Circumference (A.C.) (r=-.027), and Waist Hip Ratio (WHR) (r=-.069), whereas positive association exist for Body Mass Index (BMI) (r=.034), Percentage of Body Fat (PBF) (r=.066), and Lean Body Mass (LBM) (.065) for netball and volleyball players. Lower body muscle endurance showed positive association between different anthropometric indices BMI (r=.074), PBF (r=.203), TWB (r=.124), LBM (r=.203), MBF (r=.116), VFA (r=.001), AC (r=.112), and WHR (r=.113). These associations were not significant at the p=0.01 level. This study suggests that specific anthropometric measurements of netball and volleyball players have a positive association with abdominal muscle strength and a negative association with arm and shoulder muscle endurance.

Keywords Muscular Endurance, Total Body Water, Mass of Body Fat, Sit-Ups, Push-Ups

1. Introduction

Netball and volleyball are females' prominent games in Fiji. These non-contact games are high-intensity, intermittent team sports played on rectangular courts. Netball and volleyball are rapid advances in professionalism, and both require optimal performance as

they share some common abilities and capabilities. In essence, to achieve success, both sports require specifically similar body structural composition in terms of weight, height, and other body composition) with specific respiratory (heart rate) and cardiovascular performance [1,2]. The games need movements of explosive anaerobic nature through repetition of jumps, sprints, turning, cutting, accelerating, and decelerating) during a receive, throw, spike, or block of a ball [3]. Previous studies have identified several parameters that are associated with netball and volleyball performance, including but not limited to speed, strength, power, stability, agility, and flexibility [2–4]. The ability to maintain muscular endurance is a fundamental requirement for netball and volleyball players, as it enables them to consistently cover the entire court and execute a range of skills and techniques throughout the full duration of the game [4].

According to earlier studies, netball and volleyball games successful players display maximum tactical and technical skills and appropriate anthropometric characteristics and performance attributes. In games like netball and volleyball, players are tall in order to efficiently handle a ball above their heads [5,6]. Muscle mass is a good indicator of athletic performance since it helps athletes produce energy for exercises of high-intensity and provide ultimate strength [7]. On the contrary, higher fat mass adversely affects physical performance, and activities where the body must perform increases energy demands.

A study of national netball players' performance examined the data on various playing positions. Defensive players exhibit strength, higher leg power and the ability to sprint. International databases recommend that players perform repetitions of high-intensity movements such as jumps, shuffles, runs, and sprints. Therefore, the capacity to produce repeated high-intensity exercises and combat fatigue appears to be essential factors for netball and volleyball performance [8]. Furthermore, determining muscular endurance and anthropometric indices among netball and volleyball players is currently of great importance due to demanding competition requirements and evolving tactical play strategies, leading to even further game specialization [9].

Therefore, this research aimed to explore the association of arm, shoulder, and abdominal muscular endurance with specific anthropometric measurements among netball and volleyball university female players. The objective of this study is to establish a correlation between arm, shoulder, abdominal endurance and anthropometric measurements. The purpose of this correlation is to aid professionals, including coaches, therapists, sports medicine practitioners, and strength and conditioning professionals, in identifying potential impediments to athletic performance or injury risks during sports participation. This will be achieved by identifying physical and functional deficiencies in movement [10].

2. Materials and Methods

2.1. Study Design

An observational study design was used for this study to determine the association of arm, shoulder, and abdominal endurance and anthropometric measurements of netball and volleyball players at university level.

2.2. Sampling Technique

The non-parametric sampling technique was selected to carry out this study. The information pertaining to the study was disseminated to all players. Only those players who were willing to participated and had three years of playing experience at the university level were chosen.

2.3. Ethical Consideration

This study was approved by the FNU human research ethics committee of Fiji National University (FNU-HREC-22-25) FIJI. All willing participants signed a written consent form before participating in this study.

2.4. Participants

In this study, 28 female participants—14 netball players and 14 volleyball players—willingly participated in this study. It was decided that 14 players in one group would be enough with a power (80% at $p \leq 0.05$) that show a relationship between the two groups [6]. The mean age of the participants was 19.54 ± 0.69 years, with an average body weight of 52.99 ± 10.51 kg, height of 156.71 ± 5.34 cm, and body mass index (BMI) of 21.57 ± 4.09 kg/m^2. Players having lower body muscle or skeletal injuries or with record of injury three months prior were not allowed to participate in the study.

2.5. Measurements

2.5.1. Anthropometric Measurements

Height was recorded by using stadio-cum-weighing scale. BMI was measured as body weight (kg.) divided by squared height (m^2). Percentage of body fat (PBF), Total Body Water (TBW), Lean body mass (LBM), Mass of Body Fat (MBF), Basal Metabolic Rate (BMR), Visceral Fat Area (VFA), Abdominal Circumference (A.C.), and Waist Hip Ratio (WHR) were measured by using bioelectric impedance analysis tool (Tanita i010-BIA).

2.5.2. Muscular Endurance Test

The arm and shoulder endurance was measured by push-ups, and abdominal muscle endurance was measured by using sit-ups. The number of sit-ups and push-ups in one minute was used as score.

2.6. Procedure

Before the investigation, the purpose of the study and the risks of the experiment were explained to all the participants. Each participant gave verbal and written consent prior to the experiment. The investigation was done in the early morning session. At the same time, all the participants followed the six hours of fasting before the anthropometric indices' measurements were taken through the bioelectric impedance analysis tool. Participants were asked to stand barefoot on the electrodes of the bioelectric impedance device to measure specific anthropometric measurements. The gadget was programmed with the participant's age and height, and the participant was instructed to hold a hand-held electrode and press a button. While the measurement is being taken, participants must remain static. The device printed the result within 2-3 minutes.

After the anthropometric measurement, the participant moved to the next platform, where muscular endurance was measured. The muscular endurance of the arm and shoulder was tested using push-ups. In order to execute push-ups, the participants were directed to assume a prone position on the ground, with their hands placed at shoulder width and their knees resting on the surface. Lift the upper body off the ground with extended arms, then bring it down until the breasts are in contact with the ground. The push-ups were performed repeatedly without pause until the participant gave up. The score was determined by how many accurate pushups were done in a minute [11]. Knee-bent sit-ups were used to measure the strength of the abdominal muscles. Participants were instructed to start a sit-up by lying on their backs with their knees bent, placing their fingertips behind their ears, lifting their chests as close to their thighs as they could, and then lowering them to the floor. As often as possible, the sit-ups were performed without stopping within a minute. The score was determined by how many accurate sit-ups were done in a minute [11].

2.7. Statistical Analysis

The IBM SPSS (version 27) statistics program was utilized to conduct analysis. The Shapiro-Wilk test was used to determine the normality before analysis of data. The data for each parameter showed a normal distribution. In order to find significant differences in age, height, weight, BMI, PBF, LBM, MBF, TBW, BMR, VFA, A.C., and WHR for female netball and volleyball players in university, a student t-test was used. In order to identify significant differences between netball and volleyball players' muscle endurance (arm, shoulder, and abdominal), the student t-test was also used. The correlations between particular anthropometric parameters and muscle strength were examined using a Pearson correlation coefficient test. Statistical significance differences were determined using the p-level >0.05, and the correlation between particular anthropometric parameters and muscular strength was determined using the p-level >0.001.

3. Results

According to Table 1, there were no statistically significant differences observed in the anthropometric measurements of netball and volleyball players. Insignificant differences reflected that netball and volleyball players have similar anthropometrical characteristics, there was no difference between netball and volleyball players in terms of anthropometrical measurements.

Table 2 revealed a poor positive association between abdominal muscular endurance and any anthropometric measurements; this association is insignificant. Arm and shoulder muscular endurance was positively associated with anthropometric measurements except for the VFA. VFA negatively correlates with arm and shoulder muscular endurance; this association is not significant for netball players.

Table 3 revealed a poor negative association between the arm and shoulder muscular endurance with specific anthropometric measurements; this association is not significant. Whereas abdominal muscular endurance showed a poor positive association with specific anthropometric measurements, this association is not significant for volleyball players.

Table 4 revealed that there is a negative association between arm and shoulder muscular endurance and TWB (r=-.058), MBF (r=-.019), VFA (r=-036), A.C. (r=-.027), and WHR (r=-.069). In contrast, a positive association exists for BMI (r=.034), PBF (r=.066), and LBM (.065) for netball and volleyball players. Abdominal muscular endurance showed positive association between different anthropometric measurements BMI (r=.074), PBF (r=.203), TWB (r=.124), LBM (r=.203), MBF (r=.116), VFA (r=.001), AC (r=.112), and WHR (r=.113). These associations are not significant at the p=0.01 level.

Table 1. Descriptive statistics of netball and volleyball players for specific anthropometric measurements

Variables	Netball Players		Volleyball Players		Both Team Players		t
	Mean	SD	Mean	SD	Mean	SD	
BMI (kg/m)	21.24	3.50	21.90	4.71	21.57	4.09	0.42
PBF (%)	27.33	5.68	27.85	7.56	27.59	6.57	0.21
TBW (kg)	27.35	3.23	27.11	3.95	27.23	3.54	-0.18
LBM (kg)	37.98	4.49	37.66	5.46	37.82	4.91	-0.17
MBF (kg)	14.84	5.40	15.53	7.07	15.19	6.18	0.29
VFA (cm^2)	44.93	20.78	50.78	26.38	47.85	23.49	0.65
AC (cm)	73.31	6.27	74.16	8.33	73.73	7.25	0.31
WHR	.75	.04	.76	.06	.76	.053	0.52
Muscular Endurance (Arm and shoulder)	41.43	4.16	39.86	3.78	40.64	3.98	-1.05
Muscular Endurance (Abdominal)	27.57	2.74	25.07	4.81	26.32	4.05	-1.69

Table 2. Association between muscular endurance and specific anthropometric measurements for netball players

		BMI (kg/m)	PBF %	TBW (kg)	LBM (kg)	MBF (kg)	VFA (cm^2)	A.C. (cm)	WHR
Muscular Endurance (Arm and Shoulder)	Pearson Correlation	.338	.225	.079	.224	.169	.119	.156	.065
	Sig. (2-tailed)	.237	.440	.788	.441	.564	.684	.594	.824
Muscular Endurance (Abdominal)	Pearson Correlation	.211	.355	.064	.358	.163	-.028	.153	.055
	Sig. (2-tailed)	.470	.212	.829	.208	.579	.925	.603	.851

Table 3. Association between muscular endurance and specific anthropometric measurements for volleyball players

		BMI (kg/m)	PBF %	TBW (kg)	LBM (kg)	MBF (kg)	VFA (cm^2)	A.C. (cm)	WHR
Muscular Endurance (Arm and Shoulder)	Pearson Correlation	-.181	-.088	-.160	-.089	-.156	-.124	-.157	-.146
	Sig. (2-tailed)	.535	.766	.585	.762	.593	.673	.591	.619
Muscular Endurance (Abdominal)	Pearson Correlation	.062	.135	.180	.134	.135	.076	.134	.188
	Sig. (2-tailed)	.833	.645	.538	.648	.646	.795	.649	.520

Table 4. Association between muscular endurance and specific anthropometric measurements for netball and volleyball players

		BMI (kg/m)	PBF (%)	TBW (kg)	LBM (kg)	MBF (kg)	VFA (cm^2)	A.C. (cm)	WHR
Muscular Endurance (Arm and shoulder)	Pearson Correlation	.034	.066	-.058	.065	-.019	-.036	-.027	-.069
	Sig. (2-tailed)	.865	.740	.770	.743	.924	.857	.893	.728
Muscular Endurance (Abdominal)	Pearson Correlation	.074	.203	.124	.203	.116	.001	.112	.113
	Sig. (2-tailed)	.708	.301	.530	.300	.555	.995	.570	.568

4. Discussion

This research study aimed to explore the association between muscle endurance (arm, shoulder, and abdomen) and specific anthropometric measurements for the netball and volleyball participants at university. The arm and shoulder musculature endurance values were found to be 41.43±4.16 in netball players, 39.86±3.78 in volleyball players, and 40.64±3.98 in both players on average. The abdominal muscle endurance mean scores were estimated as 27.57±2.74 in netball players, 25.07±4.81 in volleyball players, and 26.32±4.05 in both players. As per the finding of the comparison analysis, netball players have greater arm, shoulder, and abdominal endurance than volleyball players. Insignificant differences were evident between specific anthropometric measurements and muscle strength for arm, shoulder, and abdominal in all participants regardless of their sport. These findings are in line with the finding of a previous study that revealed volleyball and netball players have such differences due to nature of the

games [12].

For both netball and volleyball players, arm and shoulder strength are much required for catching, throwing, scoring, lifting, setting, and smashing the ball. Whereas volleyball and netball players require abdominal strength for body control, running, jumping, and direction change. Sprinting, jumping, and throwing performance are all determined by upper and lower body muscular strength [13]. Players in this study perform at an intermediate level when compared to the elite players. The sit-up test can be utilized to measure musculature endurance, according to earlier research. Due to the greater gravitational force on the trunk during pull-ups, it can be difficult for small people to maintain appropriate postures [14]. Anthropometric indicators have been shown to affect actual game performance. Better ball control is made possible by muscular endurance, and a wider arm reach enables a player to cover more ground in both defensive and offensive circumstances [15]. According to Ahsan, volleyball players must engage in specific training for their lower limbs and upper body endurance. He emphasized that endurance is attained by the ankle, knee, and hip reacting simultaneously with the abdominal and lower back support [16]. Sit-ups as well as push-ups demand a large extent of torso muscle activity, according to Juker et al. [17]. People who had poor scores in one test are probably going to have poor performance in the other test. In this study, we found a positive insignificant relationship between volleyball and netball players in terms of anthropometric indices and musculature endurance.

The present study found positive associations between muscular endurance and BMI (r=.034, p=.865; r=.074, p=.708). The previous study revealed that size of body is the determinant that counts the most for muscular endurance. In contrast, poor muscular endurance is related to weight of lower body and vice versa [18]. Riddiford-Harland et al. [19] also revealed that upper limb push-up and pull-ups endurance suggested significantly greater result in the children with higher BMI than lower one, whereas Djokic and Medjedovic [20] contradicted his findings as participants with higher BMI was negatively associated with the arms and shoulder muscular strength. Mao et al. [21] also agrees that children with higher BMI had poorer abdominal muscular endurance.

Positive associations were found between total muscular endurance and body fat percentage (r=.066, p=.740; r=.203, p=.301). Previous studies showed no significant difference in the correlation between body fat percentage and muscular strength in overweight and normal participants [21]. This might be because muscular endurance may correlate more with muscle mass than the percentage of body fat [22]. Our study also revealed no significant difference in terms of the percentage of body fat between netball and volleyball players. However, both types of sports players were similar in this regard.

According to previous research, increases in body mass are associated with up to a 44 per cent rise in lean mass [23]. Increases in strength are also associated with increased lean mass. As a result, improved whole-body muscular endurance should be expected due to increased lean mass alone. The volleyball players demonstrated that they had a larger body and lean mass than the basketball players. Granados et al. [24] found that having more fat-free mass was associated with improved performance due to increased muscular strength. However, it is interesting to note that there were no significant differences between players' lean mass and body mass irrespective of sports they play. Recent studies indicate that muscle mass loss is responsible for less than 10% of muscular strength loss [25]. Despite having a larger body mass and fat mass, netball players demonstrated higher arm, shoulder and abdominal muscular endurance. It is crucial to remember that lean mass does not always correlate to upper-body muscular endurance, as measured by sit-ups and push-ups, because lean mass can be found in parts of the body that have little influence on muscular endurance.

Total body water is the main component of an individual body. Water content in fat tissue is about 10% and about 70 to 75% in lean mass [26]. In the present study, the average total body water of a player was 27.23±3.54 of average body mass 37.82 kg. in both team players. Our result might be lower due to our participants were females. This is consistent with results by Malavolti et al. [27], who also reported that lower total body water in females corresponds with a higher body fat percentage. We observed that muscle mass is strongly related to total body water; as the muscle mass increases, strength also increases. From the research finding, it is evident that total body water is also positively associated with muscular endurance. Another crucial finding of this research was that muscular endurance decreased with VFA and A.C. A study conducted in the U.S. revealed that muscular endurance reduced with increasing excessive abdominal fat and body fat. This study demonstrated that increased visceral fat is positively associated with increased metabolic risk, such as metabolic syndrome and its components [28]. Therefore, the subject can improve physical strength while lowering metabolic risks by using proper techniques to decrease visceral fat and body fat mass. Surprisingly, according to a German study, women's muscular endurance in the upper and lower limbs is influenced by visceral fat distribution. Increasing fat mass had a detrimental impact on muscular endurance in both males and females. In contrast, increased WHR favored knee extension strength in women but had no effect on muscular endurance [29]. Therefore, understanding the variables that affect muscular endurance is critical for determining the mechanisms that lead to poor performance in female netball and volleyball players and establishing strategies and interventions to help them perform better.

These findings should be strongly considered within the context of study. First, the cross-sectional study design puts limitation on our ability to do more of the described association. Future cohort studies are needed better to understand the different parameters' cause and effect.

Second, the anthropometric data were determined by the bioelectrical impedance device rather than from dual-energy X-ray absorptiometry (DEXA) or Air Displacement Plethysmography (ADP) devices, which raises concerns about valid measurement. Thirdly, the functional tests measured only muscular endurance, rather than the dynamometers tests, which may be affected by a specific training program. Finally, anthropometric measurements were examined in the early morning period with an empty stomach, whereas, in different periods, these may have different outcomes. Misfortunately, incorporating additional two or three approach effects would have significantly impacted the power available to draw a purposeful conclusion.

5. Conclusions

In conclusion, this study suggests that specific anthropometric measurements of netball and volleyball players have a positive association with muscular endurance for abdominal and a negative association with arm and shoulder muscular endurance. It implies that as the BMI, PBF, and LBM increase, the musculature endurance of the upper part of the body increases, while the TBW, MBF, VFA, A.C., and WHR decrease, and the upper body muscular endurance increases. There is no significant association between anthropometric measurements and lower-body muscular endurance.

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