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Comparison of Isokinetic Muscular Peak Torque And Power, Bone Speed of Sound and Body Composition Among Malaysian Adolescent Male Sepak Takraw Players, Volleyball Players and Sedentary Individuals

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ABSTRACT

This study investigated the differences of isokinetic muscular peak torque (PT) and average power (AVG.P), bone speed of sound and body composition among Malaysian adolescent male sepak takraw players, volleyball players and sedentary individuals. Thirty participants with mean age of 14.4 (1.4) years old participated in this study. The groups involved were sedentary control, sepak takraw and volleyball groups. Participant's fat free mass and percent body fat were measured by body composition analyzer. Bone speed of sound of arms and legs were measured by bone sonometer. Knee and shoulder muscular PT (indicator of muscular strength) and AVG.P were measured by isokinetic dynamometer. There were statistically significant higher values of body height and fat free mass in volleyball players compared to sedentary controls. However, there were no significant differences in bone speed of sound between sedentary control, sepak takraw and volleyball groups. In general, volleyball and sepak takraw groups showed significantly higher values in most of the muscular PT and AVG.P measurements compared to the sedentary control group. Volleyball group showed statistically significant higher values compared to sepak takraw group in knee extension PT at $300^{o}.s^{-1}$, shoulder extension PT at $180^{o}.s^{-1}$ and $300^{o}.s^{-1}$, and AVG.P at $300^{o}.s^{-1}$, as well as shoulder flexion PT at $60^{o}.s^{-1}$, $180^{o}.s^{-1}$ and $300^{o}.s^{-1}$, AVG.P at $180^{o}.s^{-1}$ and $300^{o}.s^{-1}$. In conclusion, isokinetic knee extension, shoulder extension and flexion muscular strength and power are essential muscular performance variables in volleyball. Meanwhile, engagement in volleyball and sepak takraw could enhance muscular strength and power compared to sedentary lifestyle.

Keywords: *isokinetic muscular peak torque, bone, body composition, sepak takraw, volleyball*

INTRODUCTION

Body composition refers to the proportion of fat and fat-free mass in the body. Body composition is one of the measurements that is used to evaluate athletes' health and fitness level. Fat-free mass includes bone, water, muscle, and tissues which are important for the body to function properly (Westerterp et al., 2021). Bone health status of an individual can be determined by measurement of bone speed of sound which reflects bone mineral density. In application of the technique, a focused sound wave is propagated through the bone, and ultrasound speed of sound of the bone is estimated from the received signal. The higher the density of the bone, the greater its modulus of elasticity and the more cohesive its microstructure, the faster the speed of propagation. Therefore, the faster or the higher bone speed of sound reflecting the stronger the bone. Bone speed of sound conveys relevant information regarding the density and structure of the bone that are not available from another method of measuring bone mineral density such as Dual-energy X-ray absorptiometry (DXA) (Gluer et al., 1992).

Muscular peak torque refers to muscular strength. Muscle strength is defined as the maximum force capacity of an individual which reaches its peak between the second and third decades, shows a slow or imperceptible decrease until about 50 years of age and then begins to decline thereafter at the rate of approximately 12% to 15% per decade, with more rapid losses above the age of 65 years (Wiegmann et al., 2021). Muscular power, defined as the product of force and velocity, declines more than muscle strength with aging (Wiegmann et al., 2021). Muscular power has been shown to be positively associated with the ability to perform activities of daily living, and may be a stronger predictor of functional dependency than muscular strength (Ramsey et al., 2021). Peak torque and average power for isokinetic concentric and eccentric contractions of the knee and shoulder flexor and extensor muscles of a person can be measured by using an isokinetic dynamometer (Ali et al., 2016).

Both sepak takraw and volleyball are known as court games, team sports and using a ball, while differences of sepak takraw and volleyball such as the amount of movement, muscle involved and types of training may resulting in differences in muscular peak torque and power, bone speed of sound and body composition among sepak takraw players, volleyball players and sedentary individuals. To the best of our understanding, studies to investigate the differences of isokinetic muscular peak torque and average power, bone speed of sound and body composition of Malaysian adolescent male volleyball players, sepak takraw players and sedentary individuals in Malaysia were not existent. Therefore, this present study was conducted.

METHODOLOGY

Participants

Thirty Malaysian adolescent male participants age ranged between 13 to 17 years old were recruited in this study. The inclusion criteria for the participants in sepak takraw and volleyball groups were those who were involved in sepak takraw and volleyball sports for at least 3 years, and represented district or state levels in competitions. While inclusion criteria for sedentary control participants were those who were not involved in any competitive sports and exercised less than 2 times per week. This study was approved by the Human Research Ethic Committee of Universiti Sains Malaysia (JEPeM Code: USM/JEPeM/17020102). This research was carried out in the Sport Science Laboratory, Health Campus, Universiti Sains Malaysia.

Experimental Design

In this study, the participants were assigned into three groups with 10 participants per group, i.e. sedentary control group, sepak takraw group and volleyball group. All the participants were required to undergo anthropometric and body composition assessments, quantitative ultrasound measurement of bone speed of sound, and isokinetic muscular peak torque and power measurements.

Anthropometric and body composition measurements

The body weight and body height were measured by using a stadiometer (Seca 220, Hamburg, Germany). Participant's body composition i.e. percent body fat (% BF) and fat-free mass (FFM, kg) were measured by using a body composition analyzer (Tanita model TBF-140, Japan).

Figure 1: Body composition analyser (TANITA MODEL TBF-140, JAPAN)

Isokinetic muscular peak torque (strength) and power measurements

Isokinetic muscular performance measurements were carried out to determine the participants' isokinetic knee and shoulder extension and flexion peak torque (an indicator of muscular strength) and average power by using an isokinetic dynamometer (BIODEX Multi-Joint System 3 Pro, New York). Isokinetic knee and shoulder extension and flexion peak strength and power were assessed at 3 angular velocities of movement, i.e. $60^0.s^{-1}$, $180^0.s^{-1}$and $300^0.s^{-1}$.

Figure 2: Biodex Multi-Joint System 3 Pro, New York

Quantitative ultrasound measurements of bone speed of sound (SOS) by using bone sonometer

Quantitative ultrasound measurements of bone speed of sound (SOS, $m.s^{-1}$) which can reflect bone mineral density, were measured by using bone sonometer (Sunlight Mini Omni^{TM}, Petah Tikva, Israel). The participants' bone SOS were measured at participants' middle shaft tibia of dominant and non-dominant legs, and distal radius of dominant and non-dominant arms.

Figure 3: Bone sonometer (Sunlight Mini Omni™, Petah Tikva, Israel)

Statistical Analysis

All data were analysed using the Statistical Package for Social Science (SPSS) version 22.0. One-Way ANOVA followed by *Post hoc* Bonferroni test analysis were performed to determine differences of the measured parameters among groups. Data are presented as mean and standard deviation [mean(SD)]. Statistical significance was accepted at p value < 0.05.

RESULTS AND DISCUSSION

Physical characteristics and body composition of participants

A total of 30 participants with mean age 14.4 (1.4) years old completed this study. Table 1 shows the mean age, body height, body weight, body mass index (BMI), fat free mass (FFM) and percentage body fat (%BF) of the participants in sedentary control, sepak takraw and volleyball groups. Volleyball group showed significantly higher values in body height and fat free mass than sedentary control group.

Table 1: Physical characteristics and body composition of the participants

	Sedentary control group (n=10)	Sepak Takraw group (n=10)	Volleyball group (n=10)
Age (years)	14.1(1.4)	14.2(0.9)	14.9(1.7)
Body height (cm)	**154.8(11.7)**	156.0(8.0)	**165.0(6.7)***
Body weight (kg)	47.8(16.4)	44.7(9.1)	56.1(13.2)
BMI (kg/m^2)	19.4(3.8)	18.2(2.3)	20.7(5.4)
FFM (kg)	**36.4(9.2)**	37.6(7.3)	**45.3(7.7)***
% BF (%)	21.9(8.7)	15.6(2.2)	18.2(6.3)

Values are expressed as mean (SD). Bold numbers indicate statistically significant. p value correspond to comparison between groups.
*, $p<0.05$ significantly difference from sedentary control group.
Abbreviations: BMI= body mass index; FFM= fat free mass; %BF= percent body

Bone speed of sound (SOS)

Table 2 shows quantitative ultrasound measurement of bone speed of sound (SOS) of dominant and non-dominant arms and legs of the participants in sedentary control, sepak takraw and volleyball groups. There were no significant differences in all the bone SOS parameters among all the groups.

Table 2: Means of bone speed of sound of dominant and non-dominant arms and legs

			Sedentary control group (n=10)	Sepak Takraw group (n=10)	Volleyball group (n=10)
D	Radius	Bone SOS ($m.s^{-1}$)	3632.0 (213.9)	3711.5 (92.4)	3621.4 (197.9)
	Tibia	Bone SOS ($m.s^{-1}$)	3585.5 (177.1)	3604.1 (215.6)	3680.4 (192.9)
ND	Radius	Bone SOS ($m.s^{-1}$)	3682.1 (156.2)	3728.3 (83.9)	3602.0 (164.5)
	Tibia	Bone SOS ($m.s^{-1}$)	3623.8 (138.4)	3560.1 (176.0)	3720.5 (243.9)

Values are expressed as mean (SD).
Abbreviations: D= Dominant limb; ND= Non- dominant limb; SOS= Speed of sound

Isokinetic muscular peak torque and average power

Isokinetic knee extension and flexion peak torque, peak torque per body weight and average power

Table 3 and Table 4 illustrate the mean values of isokinetic knee extension and flexion peak torque (PT), peak torque per body weight (PT/BW) and average power (AVG.P) at $60^{o}.s^{-1}$, $180^{o}.s^{-1}$ and $300^{o}.s^{-1}$ angular velocities in sedentary control, sepak takraw and volleyball groups respectively.
Regarding isokinetic knee extension, there were statistically significant higher mean values in most of the measured parameters in volleyball group compared to sedentary control group. Sepak takraw showed statistically significant higher mean values in dominant knee extension PT/BW at $60^{o}.s^{-1}$ and $180^{o}.s^{-1}$ compared to sedentary control group. Comparison between volleyball and sepak takraw groups showed that volleyball group exhibit statistically higher value than sepak takraw group in non-dominant knee extension PT at $300^{o}.s^{-1}$ (Table 3).
In terms of knee flexion, there were statistically significant higher mean values in most of the measured parameters in both sepak takraw and volleyball groups when compared to sedentary control group (Table 4).

Table 3: Isokinetic knee extension peak torque (PT), peak torque per body weight (PT/BW) and average power (AVG.P) of participants in sedentary control, sepak takraw and volleyball groups

			Sedentary control group (n=10)	Sepak takraw group (n=10)	Volleyball group (n=10)
$60^{o}.s^{-1}$	D	PT (Nm.)	**75.8(43.4)**	102.3(32.8)	**129.9(32.7)***
		PT/BW (%)	**151.0(39.9)**	**231.0(51.6)****	**232.6(37.9)****
		AVG.P (W)	**41.5(24.1)**	51.8(19.6)	**73.3(21.3)***
	ND	PT (Nm.)	**86.2(44.3)**	103.1(31.2)	**130.6(33.0)***
		PT/BW (%)	174.3(56.0)	233.5(54.2)	234.7(44.9)
		AVG.P (W)	**46.8(24.9)**	56.7(16.3)	**73.2(22.9)***
$180^{o}.s^{-1}$	D	PT (Nm.)	60.4(35.1)	72.5(22.2)	92.9(26.6)
		PT/BW (%)	**121.2(36.5)**	**163.5(29.4)***	**167.3(39.9)***
		AVG.P (W)	**75.6(49.4)**	95.6(26.2)	**129.0(39.3)***
	ND	PT (Nm.)	65.2(32.1)	71.5(18.4)	93.2(29.6)
		PT/BW (%)	132.6(35.4)	163.0(31.5)	165.0(36.9)
		AVG.P (W)	82.4(45.6)	97.4(24.0)	124.5(40.1)
$300^{o}.s^{-1}$	D	PT (Nm.)	49.2(26.6)	58.4(18.7)	76.8(27.2)
		PT/BW (%)	101.0(28.7)	132.5(26.7)	136.4(35.8)
		AVG.P (W)	**78.9(45.4)**	107.4(32.0)	**144.4(52.8)***
	ND	PT (Nm.)	57.1(29.8)	**51.7(11.3)**	**81.0(26.6)#**
		PT/BW (%)	116.7(32.3)	119.2(25.0)	146.3(41.1)
		AVG.P (W)	**90.0(47.8)**	101.8(25.5)	**142.3(55.7)***

Values are expressed as mean (SD). Bold numbers indicate statistically significant. *p* value correspond to comparison between groups.

*, $p<0.05$, **, and $p<0.01$, significantly different from sedentary control group

#, $p<0.05$, significantly different from sepak takraw group

Abbreviations: D = Dominant limb; ND = Non- dominant limb;T = Peak torque; PT/BW = Peak torque/body weight; AVG.P = Average power

Table 4: Isokinetic knee flexion peak torque (PT), peak torque per body weight (PT/BW) and average power (AVG.P) of participants in sedentary control, sepak takraw and volleyball groups

			Sedentary control group (n=10)	Sepak takraw group (n=10)	Volleyball group (n=10)
$60^{o}.s^{-1}$	D	PT (Nm.)	**36.3(24.9)**	51.0(13.6)	**67.0(23.8)***
		PT/BW (%)	**70.7(26.2)**	**115.3(17.8)*****	**117.5(22.5)*****
		AVG.P (W)	19.8(17.6)	29.7(15.4)	39.7(18.7)
	ND	PT (Nm.)	39.3(23.5)	54.6(17.1)	**64.1(22.0)***
		PT/BW (%)	**77.9(26.1)**	**122.3(19.1)*****	**112.6(20.4)****
		AVG.P (W)	22.7(18.0)	34.1(9.7)	38.5(17.4)
$180^{o}.s^{-1}$	D	PT (Nm.)	**34.5(22.2)**	45.8(12.2)	**57.9(19.9)***
		PT/BW (%)	**68.2(26.9)**	**103.8(22.3)***	**104.3(30.8)***
		AVG.P (W)	37.9(38.2)	63.1(23.5)	75.8(37.8)
	ND	PT (Nm.)	**37.7(23.2)**	47.0(8.3)	**60.4(17.4)***
		PT/BW (%)	**75.5(26.3)**	**108.3(16.5)***	**109.0(25.7)***
		AVG.P (W)	38.2(39.8)	59.1(16.6)	74.6(33.7)
$300^{o}.s^{-1}$	D	PT (Nm.)	**48.7(24.8)**	56.4(11.4)	**78.8(20.7)****
		PT/BW (%)	**100.1(33.0)**	131.6(32.9)	**141.7(29.0)***
		AVG.P (W)	43.6(48.0)	61.7(18.7)	84.1(43.0)
	ND	PT (Nm.)	**51.2(21.2)**	54.0(13.2)	**77.0(26.6)***
		PT/BW (%)	107.9(28.0)	125.3(33.4)	137.9(40.9)
		AVG.P (W)	40.7(49.2)	49.0(17.5)	79.3(41.3)

Values are expressed as mean (SD). Bold numbers indicate statistically significant. *p* value correspond to comparison between groups.

*, $p<0.05$, **, $p<0.01$ and ***, $p<0.001$, significantly different from sedentary control group

Abbreviations: D = Dominant limb; ND = Non- dominant limb; PT = Peak torque; PT/BW = Peak torque/body weight; AVG.P = Average power

Isokinetic knee extension and flexion peak torque, peak torque per body weight and average power

Table 5 and Table 6 illustrate the mean values of isokinetic shoulder extension and flexion peak torque (PT), peak torque per body weight (PT/BW) and average power (AVG.P) at $60^{o}.s^{-1}$, $180^{o}.s^{-1}$ and $300^{o}.s^{-1}$ in sedentary control, sepak takraw and volleyball groups respectively.

Regarding isokinetic shoulder extension, there were statistically significant greater values in volleyball compared to sedentary control group in non-dominant shoulder extension PT and AVG.P at $300^{o}.s^{-1}$. Furthermore, volleyball group showed statistically significant higher isokinetic dominant shoulder extension PT at $180^{o}.s^{-1}$ and $300^{o}.s^{-1}$, and non-dominant shoulder extension AVG.P at $300^{o}.s^{-1}$ than sepak takraw group (Table 5).

In terms of isokinetic shoulder flexion, there were statistically significant higher mean values in most of the measured parameters in volleyball group when compared to sedentary control group. In addition, volleyball group showed significantly higher values in dominant shoulder flexion PT at $60^{o}.s^{-1}$, $180^{o}.s^{-1}$ and $300^{o}.s^{-1}$, dominant shoulder flexion AVG.P at $180^{o}.s^{-1}$ and $300^{o}.s^{-1}$ when compared to sepak takraw group (Table 6).

Table 5: Isokinetic shoulder extension peak torque (PT), peak torque per body weight (PT/BW) and average power (AVG.P) of participants in sedentary control, sepak takraw and volleyball groups

			Sedentary control group (n=10)	Sepak takraw group (n=10)	Volleyball group (n=10)
$60^{o}.s^{-1}$	D	PT (Nm.)	15.5(10.0)	16.5(8.5)	22.3(7.4)
		PT/BW (%)	33.0(17.5)	36.9(15.2)	40.8(12.6)
		AVG.P (W)	1.2(2.5)	2.3(4.1)	5.7(7.3)
	ND	PT (Nm.)	23.1(9.7)	18.6(5.8)	26.7(5.2)
		PT/BW (%)	52.1(18.6)	42.8(11.9)	49.2(11.2)
		AVG.P (W)	1.5(2.9)	1.5(3.3)	3.7(3.7)
$180^{o}.s^{-1}$	D	PT (Nm.)	28.2(9.6)	**25.5(10.6)**	**37.4(7.5)#**
		PT/BW (%)	63.3(20.9)	59.2(27.3)	69.9(20.7)
		AVG.P (W)	1.4(3.3)	0.9(0.6)	5.1(9.0)
	ND	PT (Nm.)	39.6(16.9)	36.5(13.7)	44.5(13.7)
		PT/BW (%)	88.6(39.4)	88.8(46.1)	79.6(20.2)
		AVG.P (W)	1.1(2.7)	0.8(0.8)	4.6(5.1)
$300^{o}.s^{-1}$	D	PT (Nm.)	61.5(29.1)	**51.6(15.2)**	**84.0(19.6)#**
		PT/BW (%)	140.1(74.7)	126.4(56.1)	158.0(55.4)
		AVG.P (W)	1.6(2.8)	1.7(1.0)	10.3(14.6)
	ND	PT (Nm.)	**56.7(21.1)**	63.1(16.4)	**82.4(17.5)***
		PT/BW (%)	131.2(63.1)	151.3(56.0)	151.6(38.0)
		AVG.P (W)	**1.4(3.0)**	1.5(1.3)	**5.8(4.8)*#**

Values are expressed as mean (SD). Bold numbers indicate statistically significant. *p* value correspond to comparison between groups.

*, $p<0.05$, significantly different from sedentary control group, #, $p<0.05$, significantly different from sepak takraw group

Abbreviations: D = Dominant limb; ND = non-dominant limb; PT = Peak torque; PT/BW = Peak torque/body weight; AVG.P = Average power

Table 6: Isokinetic shoulder flexion peak torque (PT), peak torque per body weight (PT/BW) and average power (AVG.P) of participants in sedentary control, sepak takraw and volleyball groups

			Sedentary control group (n=10)	Sepak takraw group (n=10)	Volleyball group (n=10)
60°.s^{-1}	D	PT (Nm.)	**57.0(20.7)**	**57.8(22.1)**	**84.5(14.4)*#**
		PT/BW (%)	**120.5(18.1)**	**147.9(20.8)***	**153.3(21.6)***
		AVG.P (W)	37.3(16.8)	45.9(11.0)	61.6(12.0)
	ND	PT (Nm.)	56.9(23.6)	65.2(16.9)	78.2(11.4)
		PT/BW (%)	122.7(32.8)	147.2(19.0)	142.2(18.4)
		AVG.P (W)	37.5(21.4)	46.7(14.4)	55.9(11.1)
180°.s^{-1}	D	PT (Nm.)	**74.8(28.5)**	**81.7(14.4)**	**110.7(8.8)**#**
		PT/BW (%)	166.0(59.9)	191.7(48.7)	196.0(44.4)
		AVG.P (W)	**72.5(44.2)**	**78.2(26.3)**	**123.8(34.8)*#**
	ND	PT (Nm.)	**74.2(24.0)**	86.6(17.7)	**101.1(25.0)***
		PT/BW (%)	161.3(43.3)	201.8(47.8)	183.1(44.8)
		AVG.P (W)	**69.7(38.0)**	77.6(21.2)	**111.8(34.6)***
300°.s^{-1}	D	PT (Nm.)	**94.4(36.9)**	**88.4(17.9)**	**134.8(36.0)*#**
		PT/BW (%)	215.7(92.4)	206.9(49.5)	246.9(66.6)
		AVG.P (W)	**83.3(46.7)**	**82.1(21.4)**	**130.5(42.8)*#**
	ND	PT (Nm.)	**89.4(31.0)**	**88.5(27.1)**	**129.1(28.4)*#**
		PT/BW (%)	197.2(62.6)	205.8(60.5)	245.2(60.7)
		AVG.P (W)	**74.7(43.4)**	88.1(24.2)	**130.1(48.4)***

Values are expressed as mean (SD). Bold numbers indicate statistically significant. *p* value correspond to comparison between groups.

*, $p<0.05$, **, and $p<0.01$, significantly different from sedentary control group, #, $p<0.05$, significantly different from sepak takraw group

Abbreviations: D = Dominant limb; ND = non-dominant limb; PT = Peak torque; PT/BW = Peak torque/body weight; AVG.P = Average power

It was evidenced in the present study that volleyball players showed significant higher values in body height and fat free mass compared to sedentary controls. Cherouveim *et al*. (2020) mentioned that body height of volleyball players is an important anthropometric characteristic, in which volleyball players are involved in frequent attack and blocking actions. Besides, Schons *et al*. (2023) reported that volleyball requires handling of the ball above the head, thus having a greater height is an advantage and could be considered the most important physical attribute in volleyball games. The above phenomenon is supported by the present study finding that volleyball players showed higher value in body height than sedentary controls.

The present study also found that there was significant higher value of fat free mass in volleyball players than sepak takraw players and sedentary controls. This finding was in agreement with the previous studies by Lukaski & Raymond-Pope (2021), where the authors reported that regular physical activity positively influences the quality of body composition. The authors also found that elite volleyball players showed significantly higher values on chosen parameters in body composition, i.e. lean body mass and fat free mass compared to non-athletes. In addition, the present study finding was consistent with the report by Matłosz *et al.* (2023), which mentioned that there was significantly higher fat free mass in volleyball players compared to controls.

Isokinetic muscular strength measurement has been reported in previous studies involving various sports. It was reported to be a reliable tool to assess specific muscle functions such as rotation and elevation of the shoulder that may mimic performance patterns in volleyball (Baltaci & Tunay, 2005). Specifically, the supraspinatus muscle, which is activated during shoulder elevation, plays an important role in dynamic stabilization of the glenohumeral joint as a part of rotator-cuff muscles, which are very important for the functions of the shoulder during rope jumping and in elite overhead athletes (Baltaci & Tunay, 2005).

The notable finding of the present study was that volleyball and sepak takraw groups showed statistically significant higher values in most of the knee extension and flexion peak torque (PT) and average power (AVG.P) compared to sedentary control group. Volleyball group showed significant greater values in more isokinetic knee extension PT and AVG power measured parameters than sedentary control group, when compared to sepak takraw group. In addition, volleyball group showed statistically significant higher knee extension PT at 300 $^{0}.s^{-1}$ than sepak takraw group. Furthermore, volleyball group also showed significant greater values in more isokinetic knee flexion PT/BW measured parameters than sedentary control when compared to sepak takraw group. These results imply that volleyball players have significantly stronger knee extensor muscle of the leg than sepak takraw players. Meanwhile, volleyball players may also have more powerful knee extensor muscle and stronger knee flexor muscle of the leg than sepak takraw and sedentary individuals.

Volleyball players showed significant greater shoulder extension PT and AVG.P than sedentary individuals. In addition, volleyball players also showed significant greater values of shoulder extension PT and AVG.P than sepak takraw players. Besides, volleyball players showed significantly higher PT and AVG.P shoulder flexion than sepak takraw and sedentary controls. These results imply that volleyball players have stronger and more powerful shoulder extensor and flexor muscles of the arm than sepak takraw players and sedentary individuals.

The isokinetic strength parameters of knee extension and flexion peak torque and average power of the legs in volleyball players and sepak takraw players were significantly higher than sedentary control group. According to Sgrò *et al.* (2024), muscular strength in the lower limbs is crucial in volleyball because vertical jump is directly related to the performance of the players, since jumping is one of the components of service and defence movement of volleyball. Moreover, volleyball training is generally complemented with weight training to increase smash and jumping power. Kluka & Hendricks (2020) also mentioned that volleyball is characterised by a great amount of jumps, skips, hops and other kinds of take-off .Take offs can be divided into two basic skills, the spike jump (from one leg and both legs) and block jump (from standing, after movement) (Kluka & Hendricks, 2020). Volleyball requires the athletes to jump as high as possible while attacking the ball with upper body movements. Meanwhile, Pechlivanidou et al. (2024) mentioned that leg muscle power is considered a critical element for successful athletic performance, and particularly relevant in volleyball.

Sepak takraw is also known as kick volleyball, it resembles volleyball except that it uses a rattan ball and only allow players to use their feet and head to touch the ball. Sepak takraw players are required to jump as much as his height in the height stage, and a ball is struck by the spike like acrobatics and hatched. The

present study findings of greater values in knee extension and flexion muscles of the legs of both volleyball and sepak takraw players compared to sedentary controls have confirmed the importance of strong leg muscle elicited by jumping movement in both the games. The present study also found that volleyball players have significantly stronger and more powerful knee extension compared to sepak takraw players, implying that differences in the types of training, size of the courts covered, duration of the games may have caused the discrepancies of the results on leg muscles between volleyball and sepak takraw players.

Another main finding of the present study was that volleyball players have significantly stronger and more powerful shoulder extensor and flexor muscle of the arms than sepak takraw players and sedentary controls. This could be explained by the reasons that sepak takraw players do not use their hand to pass the ball. Sepak takraw players are allowed to use their legs, head and torso to contact the ball, with no contact of the ball with their arms or hands. This could be the reason why the sepak takraw players showed lower value in shoulder extension and flexion peak torque and power measurements than volleyball players.

In volleyball players, the basic volleyball skills are passing, setting, spiking, blocking, digging, and serving which involve the use of shoulders and arms. Volleyball is a sport that requires strength in upper and lower limbs. Both ball throwing and jumping performance are important factors for successful volleyball performance (Pawlik *et al*., 2022). It is believed that the strength training as well as other physical training carried out by the volleyball players have contributed to the strong muscles of the arm in volleyball players. The present finding on stronger and more powerful muscles in the arms and shoulders of volleyball players compared to sepak takraw and sedentary controls implies that involvement in volleyball are more beneficial in enhancing muscles of the arms compared to sepak takraw and sedentary lifestyle.

The present study observed that there were no significant differences in qualitative ultrasound measurement of bone speed of sound (SOS) of dominant and non-dominant arm and legs of adolescent males among sedentary control, sepak takraw and volleyball players. It was hypothesised that athletes participating in volleyball may have strong bone and high bone density due to high impact forces are imposed on the tibia bone during jumping and spiking. Previous study by Andreoli *et al.* (2001) reported higher anterior bone mineral density (BMD) at different locations throughout the lower extremity in soccer and volleyball groups than control group. While in the previous study conducted by Nikander *et al*. (2008), in which pQCT was used to determine cortical volumetric BMD differences in the tibia of national level volleyball players, hurdlers, racket game players, soccer players and swimmers, it was found that there were no significant differences among the groups. Comparison between the aforementioned previous studies and the present study on bone health status cannot be made due to the differences in the bone measuring devices used. Bone sonometer but not pQCT was used to measure bone speed of sound instead of bone mineral density in the present study. In addition, Kopiczko *et al*. (2020) mentioned that the years of involvement in sports, age of the participants, genetic, hormone, and nutritional factors may have caused differences in the bone health status results of the present study compared to previous studies. The average years of involvement in sepak takraw and volleyball players was 4 years in the present study. It is speculated that the present study finding of absence of significant differences in bone speed of sound among sedentary individuals, sepak takraw and volleyball players could be due to the players' years of engagement in sepak takraw and volleyball were not long enough for eliciting discernible differences in bone health status. Through the personal conversation, some of the players mentioned that they did not consume green leafy vegetables, milk, soy etc. which contain bone-building nutrients such as calcium, phosphorus, magnesium, and iron in their daily diet. It is believed that if the athletes consume more nutritious food containing nutrients vital for enhancing bone health to compensate the nutrients used during training, better bone health status may can be observed in the sepak takraw and volleyball players.

CONCLUSION

Findings of the present study implying that isokinetic knee extension, shoulder extension and flexion strength and power are essential muscular performance variables in volleyball. Meanwhile engagement in volleyball and sepak takraw could enhance muscular strength and power than sedentary lifestyle. The present findings obtained from this study can be used as guidelines for planning training program for volleyball and sepak takraw athletes, as well as promoting active lifestyle by engaging in court team sports such as volleyball and sepak takraw.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR'S CONTRIBUTIONS

SNFA conducted the study and wrote the manuscript, FKO and CKC designed, conducted the study and edited the manuscript, MNMJ designed and conducted the study, HMJ conducted the study, NS conducted the study and edited the manuscript, and MAHA conducted the study. All authors participated in the final approval of the manuscript.

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