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Speed of Sound, Isokinetic Muscular Peak Torque and Power, and Body Composition of Malaysian Young Male Taekwondo and Wushu Practitioners

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Abstract

The aim of this study was to determine the differences of bone health status, isokinetic muscular strength and power, and body composition among Malaysian young male taekwondo and wushu practitioners in Malaysia. Thirty Malaysian participants with mean age 15.6 ± 1.5 years old were recruited. The participants were divided into three groups, i.e. sedentary control, wushu and taekwondo groups. Participant's percent body fat (%BF), fat-free mass, quantitative ultrasound measurement of bone speed of sound (SOS), and isokinetic muscular absolute peak torque (an indicator of muscular strength), relative peak torque per body weight and average power of the participants' knee and shoulder extension and flexion at angular velocities of 60o.s-1, 180o.s-1 and 300o.s-1 were measured. There were no significant differences in %BF and tibial and radial SOS of legs and arms among sedentary control, wushu and taekwondo groups. Besides, fat free mass was significantly higher ($p< 0.05$) in wushu and taekwondo groups compared to sedentary control group respectively. In general, wushu and taekwondo groups showed statistically significant higher values in most of the muscular peak torque and powers measurements compared to sedentary control group. Wushu group showed statistically significant ($p< 0.05$) higher values of isokinetic knee extension relative peak torque per body weight at 60o.s-1, 180o.s-1 and 300o.s-1 compared to taekwondo group. In addition, wushu group also showed significantly ($p<0.05$) higher values than taekwondo group in most of the isokinetic shoulder extension peak torque and power measured parameters. However, taekwondo group showed significantly ($p<0.05$) higher values than wushu group in almost all the isokinetic shoulder flexion peak torque and power measured parameters. In conclusion, engagement in wushu and taekwondo could enhance muscular strength and power compared to sedentary lifestyle. Besides, these findings imply that isokinetic knee and shoulder extension strength and power are essential muscular performance variables in wushu, whereas isokinetic shoulder flexion strength and power are essential muscular performance variables in taekwondo. Hence, the findings obtained from this study can be used to guide the sports bodies and coaches in planning specific training programmes, which focus on improving muscular performance variables in martial arts, i.e. wushu and taekwondo in Malaysia.

Keywords
Bone, muscle, body composition, wushu, taekwondo.

Introduction

'Martial arts' is a general term that includes a series of disciplines which have their own traditions of training and forms of self-defense. Today, martial arts are studied for sports, fitness, combat skills, meditation, character development and self-confidence. The term "martial arts" do not only refer to Chinese traditional martial arts, but also others such as judo and karate which were originated from Japan, taekwondo which was originated from Korea, and boxing and wrestling which were originated from the Western countries[1].

Wushu which is also known as "kung fu" and taekwondo are two of the most well-known martial arts practiced all over the world[2]. Both systems offer healthy physical conditioning, nevertheless their training regimens employ different movements and strikes. Wushu was originated in the Shaolin Temple in Henan, China that initially as exercise to strengthen the health and fitness. Over the centuries, these movements were refined and modified, and they became not only exercise for enhancing health and fitness, but also self-defense and combat purpose. Throughout its course of development, many different styles of other martial art schools including taekwondo, karate and judo were formed[3].

In general, wushu and taekwondo utilize different striking techniques and quick hand strikes. These can be delivered as open-handed slices and finger pokes, as well as close-fisted punches. Meanwhile, Tai chi uses purposeful, circular and fluid motions, which is characterized as a soft style wushu can make blocks and strikes appear soft, but they are completed with snaps of the wrists and elbows, which elicit power[4]. More recently, wushu competitions have become known for flying acrobatics (high level spinning and jumping kicks) than previously.

Taekwondo which was originated in Korea incorporate straight line powerful blocking, kicking, punching techniques as a major component, which characterize it as hard style martial art[5]. Taekwondo involves moves of lower limb like striking with the legs, employing fast spinning kicks from various angles designed to attack an opponent's legs, abdomen, collar bone and head[6].

In a previous study, Fong and Ng[7] reported that taekwondo training can improve some aspects of physical fitness, such as flexibility and muscle strength. It was reported that adolescent taekwondo athletes had higher isokinetic peak torque values for knee extension and flexion during high velocity movement of 240o.s-1, compared with the control participants[8]. Taekwondo is dominated by kicks and punches with points scored by delivering blows to the opponent. According to Kim et al.[9], as muscle training is velocity specific, isokinetic testing therefore is an appropriate method to differentiate muscular strength at different velocities of movement in taekwondo practitioners.

According to Ito et al.[10], the authors stated the beneficial effect of sports practice on bone mass gain during human growth. Meanwhile, Wolff developed a theory relating physical forces and bone structure which states that bone will optimize structure to withstand functional loading and metabolic efficiency of locomotion[11]. Martial arts include high-magnitude forces through muscle pulling on the bone, ground reaction forces intensified by the absence of footwear to attenuate impact shocks and high-impact loading of the skeleton due to repeated falls on the ground[10].

It is generally known that there is close relationship between bone mineral density and muscular strength and power (Samsudin and Ooi)[11], and measurement of bone speed of sound can be used to reflect bone mineral density (Li et al. 2017)[12]. In a recent study carried out by Goh et al. [13], a statistically significant positive correlations were found between tibia bone speed of sound and knee muscular flexion average power at 300°.s-1 and knee muscular extension average power at 300°.s-1, respectively, in Malaysian young badminton players (Goh et al. 2024)[13]. It was reported by Li et al. [12] that there were moderate relationships between quantitative ultrasound measurement of the bones with muscular strength. It was found that correlation coefficient (r) between non-dominant tibial SOS and muscular peak torque at 600.s-1 and 1800.s-1 in female participants was 0.448 (p=0.009) and 0.388 (p=0.026) respectively. In males, moderate correlation was found between non-dominant tibial SOS and muscular peak torque at 1800.s-1 knee flexion (r=0.419, p=0.015). It is speculated that the mechanism of close relationship between bone mineral density, muscular strength and power is that the rhythmic nature of dynamic loading caused by exercise can increase muscular strength, and strong muscle can impose higher force on the bone for stimulating bone formation, consequently exercise increases muscular performance and bone health[14].

Regarding taekwondo and body composition, it is believed that low body fat percentage and high fat-free mass are the body composition factors that can serve as indicators of athletic performance in weight division events and its characteristics found in excellent taekwondo athletes[7]. Several previous studies have shown that both amateur and elite taekwondo athletes had lower percentage of body fat than the population norm of the same sex[15-16].

To our knowledge, to date published data on bone health status, muscular performance and body composition of taekwondo and wushu practitioners in Malaysia are lacking. Therefore, the aims of this study are to determine the differences of bone health status, isokinetic muscular strength and power, and body composition among young male taekwondo and wushu practitioners in Malaysia.

Materials and Methods

Study design and study participants
This is a cross-sectional study with opportunistic sampling method. Thirty participants of young males with age ranged between 14-16 years old were recruited in this study. They were age matched and then were assigned into three groups with 10 participants per group, i.e. sedentary control group (n=10), wushu group (n=10) and taekwondo group (n=10).

The inclusion criteria for the taekwondo and wushu participants were Malaysian who had practiced taekwondo or wushu at least 2 times per week for at least 2 years. Inclusion criteria for sedentary participants were those who exercised fewer than 2 times per week, and who were not involved in any competitive sports. Individuals who had acute and chronic diseases or any injury before the start of the study were excluded.

This research was carried out in the Sport Science Laboratory, Health Campus, Universiti Sains Malaysia. This study was approved by the Research and Human Ethics Committee of Universiti Sains Malaysia (Ethical approval code: USM/JEPeM/16090330).

Sample Size Calculation
The sample size was calculated using GPower software. The power of the study was set at 80% with a 95% confident interval, i.e. alpha = 0.05 and the effect size was set at 0.60 for the three study groups. The total number of participants calculated was 30. Since three groups of participants were recruited, 10 participants were recruited for each group.

Anthropometric and body composition measurements

All participants' body weight (kg) and body height (cm) were measured by using a stadiometer (Seca 220, Hamburg, Germany). Body composition components of participants such as percent body fat (% BF) and fat-free mass (FFM, kg) were measured using a "foot-to-foot" body composition analyser (Tanita TBF-140, Japan).

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

In this study, participants' quantitative ultrasound measurements of bone speed of sound (SOS, m.s-1) which can reflect bone mineral density were measured using a bone sonometer (Sunlight Mini OmniTM, Petah Tikva, Israel). This device consists of a main unit and hand-held probes designed to measure SOS at specific skeletal sites.

The participant's bone SOS were measured at middle shaft tibia of dominant and non-dominant legs and distal radius of dominant and non-dominant arms. The dominant limb was determined by asking the subject which hand he preferred for writing and which leg he preferred for kicking. The region of measurement for the tibia of the leg was defined as the mid-point between the distance of the plantar surface of the heel and the proximal edge of the knee while the participant was in a sitting position. The region of measurement for the radius of the arms was defined as the mid-point between the distance of the olecranon process of the elbow and the tip of the middle finger. Prior to the measurement, system quality verification of the bone sonometer was carried out. The scan site was then marked using a skin marker. Scanning process began by moving a probe from the lateral side to the medial site of the measured limbs. The results of bone speed of sound (SOS) were then recorded.[12] The Sunlight ultrasound systems have been reported to be reliable (intraoperator precision at distal radius: 0.36%) and precise (in vivo precision: 0.4%–0.8%) in previous study.[17]

Isokinetic muscular peak torque (strength) and power measurements

Isokinetic muscular performance measurements were carried out to determine the participant's isokinetic knee and shoulder extension and flexion absolute peak torque (strength) and power by using an isokinetic dynamometer (BIODEX Multi-Joint System 3 Pro, New York). All procedures were performed according to the assessment protocol suggested by the BIODEX isokinetic dynamometer manufacturer, such as positioning of the participant, calibration, correction for gravity, familiarisation and strong verbal encouragement. In this study, the isokinetic knee extension and flexion absolute peak torque (strength) and power were assessed at 3 angular velocities of movement, i.e. 60o.s-1, 180o.s-1 and 300o.s-1 with a rest period of 20 seconds between the trials. Testing at each velocity consisted of 5 sub-maximal followed by 2-3 maximal repetitions for warm-up purposes. Five maximal repetitions were performed at 60o.s-1, ten maximal repetitions were performed at 180o.s-1 and 300o.s-1. Once completed for the dominant leg, the same steps were repeated for non-dominant leg. The aforementioned protocol was repeated for the measurements of dominant arm and non-dominant arm of the participants. Values for absolute peak torque (PT), relative peak torque per body weight (PT/BW) and average power (AVG.P) were recorded.

Statistical Analyses

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

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Results

Anthropometry, body composition and quantitative ultrasound measurement of bone speed of sound (SOS) of dominant and non-dominant upper and lower limbs of the participants

Table 1 shows the mean age, body weight, body height, percentage body fat (%BF), body mass index (BMI) and quantitative ultrasound measurement of bone speed of sound (SOS) of dominant and non-dominant upper and lower limbs among sedentary control, wushu and taekwondo groups. The present study found that there were statistically significant higher body height ($p < 0.01$) and body weight ($p < 0.05$) in taekwondo group compared to sedentary group. Wushu group and taekwondo group showed significantly greater values ($p < 0.05$) in fat free mass than sedentary control group respectively. However, there were no significant differences in the percentage of body fat and fat free mass between wushu and taekwondo group as well as no significant differences observed in the percent body fat (%BF) and body mass index (BMI) among all the groups.

Regarding bone speed of sound (SOS), there were no significant differences observed in the mean values of radial and tibial SOS of dominant and non-dominant upper and lower limbs among all the groups.

Table 1: Physical characteristic, body composition, bone speed of sound of arms and legs among sedentary control, wushu and taekwondo groups

	Groups (N=30)			*p*-value		
	Sedentary group (n=10)	Wushu group (n=10)	Taekwondo group (n=10)	Wushu versus Sedentary	Taekwondo versus Sedentary	Taekwondo versus Wushu
Age (years)	15.6 (1.4)	15.5 (2.0)	15.6 (1.3)	1.000	1.000	1.000
Body height (cm)	**158.9 (7.3)**	163.6 (7.1)	**170.5 (7.3)** **	0.487	**0.004**	0.127
Body weight (kg)	**45.9 (10.5)**	53.8 (9.5)	**62.6 (16.9)** *	0.533	**0.020**	0.392
%Body Fat (%)	19.9 (7.6)	18.8 (5.8)	24.2 (9.5)	1.000	0.683	0.396
Fat Free Mass (kg)	**36.2 (5.2)**	**43.3 (5.4)** *	**46.2 (7.5)** **	**<0.05**	**<0.01**	0.899
Body mass index (BMI)	18.1 (3.3)	20.0 (2.5)	21.4 (4.9)	0.836	0.179	1.000
Bone speed of sound dominant radius ($m.s^{-1}$)	3635.1 (205.5)	3747.5 (203.5)	3698.4 (245.1)	0.783	1.000	1.000
Bone speed of sound non-Dominant radius ($m.s^{-1}$)	3062.3 (226.4)	3770.2 (217.4)	3707.4 (165.4)	0.719	0.849	1.000
Bone speed of sound dominant tibia ($m.s^{-1}$)	3737.2 (112.8)	3683.0 (244.4)	3786.9 (166.7)	1.000	1.000	1.000
Bone speed of sound non-dominant tibia ($m.s^{-1}$)	3758.8 (128.4)	3634.6 (167.4)	3706.8 (200.6)	0.330	1.000	1.000

Note: Values are expressed as means (SD). Bold numbers indicate statistically significant.

*, p< 0.05, **, p< 0.01, significantly different from sedentary group
Abbreviations: %BF = Percent Body Fat; BMI = Body Mass Index

Isokinetic muscular strength (peak torque) and average power

Table 2 exhibits the mean values of both isokinetic knee extension and flexion absolute peak torque (PT), relative peak torque (PT/BW), and average power (AVG.P) at 60°.s-1, 180°.s-1 and 300°.s-1 in sedentary control, wushu and taekwondo groups respectively.

Regarding isokinetic knee extension, wushu groups exhibited statistically significant higher values (p< 0.05) in all measured knee extension parameters, i.e., absolute peak torque, relative peak torque and AVG.P in dominant and non-dominant legs at 60°.s-1, 180°.s-1 and 300°.s-1 compared to sedentary control group. Besides, taekwondo group showed statistically significant higher values (p< 0.05) in all the measured knee extension parameters, except for dominant relative peak torque at 60˚.s-1, 180˚.s-1and 300˚.s-1and non-dominant relative peak torque at 60˚.s-1 and 300˚.s-1 when compared to sedentary control group (p <0.05). Wushu group showed statistically significant higher values (p< 0.05) in dominant and non-dominant knee extension relative peak torque at 60˚.s-1(26.3%) and 180˚.s-1 (30.0%) as well as non-dominant relative peak torque at 300˚s-1 (28.0%) when compared to taekwondo group (Table 2).

In terms of isokinetic knee flexion, when wushu group compared with sedentary group, wushu group showed significantly higher values in dominant and non-dominant absolute peak torque, relative peak torque and AVG.P at 60°.s-1, as well as dominant absolute PT and non-dominant AVG.P at 180°.s-1. There were significantly higher values in taekwondo group than sedentary control group in dominant AVG.P, non-dominant absolute peak torque and AVG.P at 60˚.s-1, dominant absolute peak torque and AVG.P as well as non-dominant AVG.P at 180˚.s-1, dominant AVG.P and non-dominant absolute peak torque at 300˚.s-1. There was statistically significant difference in dominant knee flexion relative peak torque at 60°.s-1 (p<0.05) (Table 2).

Table 3 exhibits the mean values of both isokinetic shoulder extension and flexion absolute peak torque (PT), relative peak torque (PT/BW), and average power (AVG.P) at 60°.s-1, 180°.s-1 and 300°.s-1 in wushu, taekwondo and sedentary group.

Regarding isokinetic shoulder extension, there were statistically significant higher mean values of all measured parameters for isokinetic shoulder extension in wushu groups compared to sedentary group (p< 0.05), except for both dominant and non-dominant relative peak torque at 300°s-1. Taekwondo group showed significantly higher values than sedentary control group in shoulder extension dominant AVG.P at 60˚.s-1, dominant absolute peak torque and relative peak torque, as well as non-dominant absolute peak torque at 180˚.s-1. Comparison between wushu and taekwondo groups showed that wushu group showed statistically significant higher values than taekwondo group in all the isokinetic shoulder extension measured parameter, except for dominant shoulder absolute PT and non-dominant PT at 180˚.s-1, dominant and non-dominant absolute peak torque and relative peak torque at 300˚.s-1 (Table 3).

In terms of isokinetic shoulder flexion measured parameter, there were statistically significant values (p< 0.05) in wushu group than sedentary control group in dominant and non-dominant absolute peak torque and PT/BW, and non-dominant AVG.P at 60˚.s-1, dominant and non-dominant absolute peak torque and relative peak torque at 180˚.s-1, dominant and non-dominant relative peak torque at 300˚.s-1. Taekwondo group showed significantly higher values than sedentary control group in dominant PT/BW at 60˚.s-1 (28.1%) and 180˚.s-1(28.7%). Taekwondo group also showed significant higher values than wushu group in all the isokinetic shoulder flexion absolute peak torque, relative peak torque and AVG.P measured parameters except for dominant relative peak torque and dominant absolute peak torque and relative peak torque at 300˚.s-1 (Table 3).

Discussion

Anthropometry and body composition of the participants

The present study found that wushu group and taekwondo groups showed significantly greater values in fat free mass than sedentary control group. This finding implied that engagement in wushu and taekwondo training may elicit beneficial effects on fat free mass, which reflect muscle mass, compared to inactive lifestyle. The observed high levels of fat free mass in wushu and taekwondo practitioners in the present study are consistent with previous study by Mala et al. [18] which reported that martial art practitioners had greater relative fat free mass than participants of athletes from other sports.

Regarding previous martial arts studies on body composition, Sadowski et al.[19] reported that medal winners had high levels of body mass index (BMI) and low amounts of body fat percentage which demonstrate the importance of mesomorphic components of somatotype. Kim et al.[9] found that competitive junior taekwondo athletes exhibited a lower range of body fat than their recreational counterparts. Chaabene et al.[20] mentioned that top level male karate athletes are typified by low body fat. Besides, Tsang et al. [21] reported that after 6 months of kungfu training, there were statistically significant reduction in percent of body fat when compared with placebo control group. Nevertheless, the present study did not find significant difference in percent of body fat (% BF) among sedentary control, wushu and taekwondo groups, which are not in line with the aforementioned previous studies.

The participants in the present study were adolescent male taekwondo and wushu practitioners with mean age of 15 years old. They were not high performers as national level athletes, had at least 2 times of training per week, and the average duration of involvement in wushu and taekwondo was 2 years. The present study finding on fat free mass and percentage of body fat may reflect that when compared to sedentary lifestyle, wushu and taekwondo training elicited greater on muscle mass, but not body fat in male adolescents with the aforementioned training status in this study. In wushu and taekwondo, the training program is intense and involving explosive movement generally. This kind of training may induce positive changes with muscle growth in muscle fiber and size. Therefore, higher level of fat free mass can be observed in the wushu and taekwondo practitioners in this study.

Sport-specific requirements should be considered when evaluating the athletes' relative total body fat. Excess body mass, especially in the form of fat, may be detrimental to performance because of its negative effect on the weight-to-strength ratio[22]. This study also found that there was no significant difference in percent of body fat and fat free mass between wushu and taekwondo practitioners. This finding implies that both wushu and taekwondo elicited similar results on body composition of the participants in this study.

Bone speed of sound

In the present study, there were no statistically significant differences observed in the tibial and radial quantitative ultrasound measurement of bone speed of sound (SOS) at dominant and non-dominant upper and lower limbs. It is known that bone speed of sound can reflect bone mineral density among sedentary control, wushu and taekwondo groups. The present finding was inconsistent with Shin et al. [23] which mentioned that martial arts such as judo, taekwondo, tai-chi and karate, which are forms of weight-bearing

Table 2: Isokinetic knee extension and flexion absolute peak torque (PT), relative peak torque (PT/BW) and average power (AVG.P) among sedentary control, wushu and taekwondo groups

			Knee Extension			Knee Flexion		
			Sedentary (n=10)	**Wushu (n=10)**	**Taekwondo (n=10)**	**Sedentary (n=10)**	**Wushu (n=10)**	**Taekwondo (n=10)**
60°.s^{-1}	D	PT (Nm.)	**113.5 (29.1)**	**175.5 (46.3)***	**158.2 (34.1)***	**51.8 (18.0)**	**78.0 (17.0)****	70.3 (18.0)
		PT/BW (%)	**249.4 (46.3)**	**326.2 (58.6)****	**258.2 (28.0)$^{\#\#}$**	**112.0 (23.9)**	**146.5 (22.3)****	**114.8 (22.7)$^{\#}$**
		AVG.P (W)	**66.9 (17.4)**	**109.6 (27.6)****	**99.1 (21.6)***	**31.0 (12.3)**	**56.7 (14.9)****	**48.2 (13.3)***
	ND	PT (Nm.)	**92.8 (22.4)**	**158.7 (44.0)****	**144.0 (35.0)****	**44.6 (17.5)**	**70.6 (15.7)****	**67.0(16.7)***
		PT/BW (%)	**204.1 (35.7)**	**293.2 (43.5)*****	**234.7 (31.0)$^{\#\#}$**	**96.1 (27.2)**	**131.5 (17.8)****	110.4 (25.8)
		AVG.P (W)	**55.6 (14.6)**	**96.0 (26.7)****	**91.4 (21.8)****	**27.1 (14.1)**	**49.6 (14.0)****	**45.2 (9.5)***
180°.s^{-1}	D	PT (Nm.)	**81.4 (25.8)**	**136.6 (32.0)****	**120.5 (29.4)***	**53.6 (13.8)**	**74.1 (14.6)***	**75.5 (19.7)***
		PT/BW (%)	**177.1 (33.3)**	**254.6 (36.5)*****	**195.9 (22.3)$^{\#\#}$**	117.5 (18.8)	139.5 (21.8)	123.4 (25.1)
		AVG.P (W)	**115.9 (39.2)**	**207.8 (46.6)*****	**191.6 (51.6)****	**60.9 (31.5)**	103.9 (27.1)	**105.1 (27.3)****
	ND	PT (Nm.)	**68.6 (25.5)**	**123.5 (34.3)****	**112.1 (28.8)****	49.7 (22.6)	69.2 (20.4)	68.9 (13.8)
		PT/BW (%)	**148.2 (35.2)**	**229.1 (42.9)*****	**182.3 (25.8)**,$^{\#}$**	104.9 (31.6)	129.1 (30.7)	112.8 (14.1)
		AVG.P (W)	**100.5 (39.8)**	**204.0 (61.2)*****	**174.8 (46.1)****	**51.4 (40.3)**	**102.0 (35.8)****	**90.8 (15.2)***
300°.s^{-1}	D	PT (Nm.)	**74.8(25)**	**110.3 (27.4)***	**109.9 (22.7)***	68.8 (21.9)	78.8 (16.8)	82.9 (13.1)
		PT/BW (%)	**163.1 (39.0)**	**206.1 (37.9)***	180 (23.0)	150.2 (37.1)	151.0 (37.9)	138.8 (29.2)
		AVG.P (W)	**119.0 (46.5)**	**222.8 (59.4)****	**204.6 (62.7)****	**67.5 (55.1)**	102.4 (44.1)	**122.4 (30.1)***
	ND	PT (Nm.)	**64.4 (24.8)**	**104.0 (25.4)****	**93.0 (20.9)***	**59.3 (22.2)**	78.6 (20.4)	**82.3 (16.8)***
		PT/BW (%)	**139.2 (38.4)**	**195.1(39.0)****	**152.4 (24.3)$^{\#}$**	127.0 (31.9)	149.1(40.0)	135.4 (22.1)
		AVG.P (W)	**111.9 (45.7)**	**222.8 (63.7)*****	**190.2(47.0)****	64.4 (50.5)	108.9 (47.6)	95.2 (22.3)

Note: Values are expressed as means (SD). Bold numbers indicate statistically significant.
*, p< 0.05, **, p< 0.01, ***, p< 0.001, significantly different from sedentary group
$^{\#}$, p< 0.05, $^{\#\#}$, p< 0.01, significantly different from wushu group
Abbreviations: D= Dominant limb; ND= Non-Dominant limb; PT= Peak Torque; PT/BW= Peak Torque/Body Weight; AVG.P= Average Power.

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Table 3: Isokinetic shoulder extension and flexion absolute peak torque (PT), relative peak torque (PT/BW) and average power (AVG.P) among sedentary control, wushu and taekwondo groups

			Shoulder Extension			Shoulder Flexion		
			Sedentary (n=10)	Wushu (n=10)	Taekwondo (n=10)	Sedentary (n=10)	Wushu (n=10)	Taekwondo (n=10)
60°.s-1	D	PT (Nm.)	**29.1 (11.0)**	**58.9 (11.2)*****	**36.4 (17.3)##**	**69.3 (12.7)**	**46.9 (12.1)***	**71.0 (22.5)##**
		PT/BW (%)	**65.1 (24.7)**	**112.0 (23.6)****	**64.9 (34.4)##**	**153.8 (24.9)**	**79.7 (27.5)*****	**120.1 (26.3)*,##**
		AVG.P (W)	**1.5 (2.4)**	**34.9 (8.0)*****	**16.5 (15.0)**,##**	46.6 (10.6)	**32.3 (9.2)**	**51.3 (20.9)#**
	ND	PT (Nm.)	**16.1 (10.6)**	**50.9 (11.0)*****	**26.5 (14.3)###**	**66.9 (14.0)**	**46.2 (9.5)***	**76.3 (26.1)##**
		PT/BW (%)	**34.7 (18.7)**	**95.5 (13.5)*****	**47.4 (30.1)###**	**147.0 (18.0)**	**86.3 (10.3)*****	**127.4 (25.8)###**
		AVG.P (W)	**1.7 (2.5)**	**28.8 (7.3)*****	**11.2 (12.9)###**	**47.3 (11.0)**	**29.2 (7.4)***	**54.5 (21.7)##**
180°.s-1	D	PT (Nm.)	**39.1 (17.5)**	**80.4 (17.1)*****	**64.9 (18.1)****	**89.2 (21.8)**	**57.6 (13.6)****	**89.0 (27.3)#**
		PT/BW (%)	**86.6 (37.9)**	**154.0(45.3)*****	**114.7 (40.0)***	**196.2 (39.9)**	**109.8 (28.6)*****	**152.4 (39.8)*,#**
		AVG.P (W)	**1.6 (2.6)**	**68.0 (29.1)*****	**23.2 (31.6)##**	85.6 (31.0)	**50.2 (18.0)**	**106.9 (52.0)##**
	ND	PT (Nm.)	**25.4 (12.0)**	**68.8 (17.0)*****	**50.9 (20.7)****	**88.2 (15.6)**	**55.2 (16.8)****	**93.5 (28.7)##**
		PT/BW (%)	**55.1 (20.9)**	**132.1 (44.4)*****	**88.3 (39.5)##**	**195.9 (31.4)**	**103.4 (27.6)*****	**158.8 (44.2)##**
		AVG.P (W)	**1.7 (3.3.)**	**64.2 (23.8)*****	**17.3 (27.6)###**	85.2 (36.2)	**47.2 (21.7)**	**118.1 (55.5)##**
300°.s -1	D	PT (Nm.)	**68.7 (23.5)**	**109.0 (35.1)***	87.3 (37.5)	113.2 (28.5)	**87.3 (24.0)**	**126.4 (38.7)##**
		PT/BW (%)	153.6 (56.1)	210.7 (86.1)	152.4 (68.2)	**248.5 (48.0)**	**166.9 (52.1)****	214.9 (56.5)
		AVG.P (W)	**1.9 (2.7)**	**74.5 (51.5)*****	**21.8 (27.5)##**	92.4 (41.1)	**62.8 (18.1)**	**114.7 (58.0)#**
	ND	PT (Nm.)	**57.0 (22.3)**	**98.8 (34.3)***	73.0 (32.9)	107.9 (32.1)	80.9 (26.5)	111.6 (43.7)
		PT/BW (%)	129.8 (59.6)	189.7 (75.2)	127.2 (58.9)	**234.8 (48.2)**	**151.4 (40.4)****	187.3 (63.4)
		AVG.P (W)	**2.1 (2.8)**	**63.0 (34.3)*****	**16.5 (28.0)##**	85.0 (41.6)	**65.3 (21.9)**	**120.0 (63.0)#**

Values are expressed as means (SD). Bold numbers indicate statistically significant.
*, p< 0.05, **, p< 0.01, ***, p< 0.001, significantly different from sedentary group
#, p< 0.05, ##, p< 0.01, and ###, p< 0.001 significantly different from wushu group
Abbreviations: D= Dominant limb; ND= Non-Dominant limb; PT= Peak Torque; PT/BW= Peak Torque/Body Weight; AVG.P= Average Powe

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exercise enable to stimulate osteogenic process and improve bone health. The present finding was not in agreement with a cross-sectional study by Ito et al.[10] which showed that judo, karate, wrestling, fencing, taekwondo, kung fu and boxing practitioners have stronger bones, and more muscle mass compared to untrained control group, water ball players and cyclists.

Ito et al.[10] reported that kung-fu and judo practitioners presented a significant relationship between weekly training load and upper limb BMD when compared to the control group. Meanwhile, in 2017 of extended study by Ito et al.[24] which compare bone mineral density (BMD) gains in adolescents of both genders stratified according to different martial art styles and the authors found that male judoists presented higher gains in BMD-spine than control group, but there was no effect of martial art on BMD gains among girls. Similarly, Nasri et al.[25] reported that judo and taekwondo practitioners presented higher bone mineral density than runners.

Another previous study by Abidin et al.[26] determined the differences in bone health status of Malay adolescent male state boxing, Muay Thai and silat athletes. This study found that Muay Thai athletes exhibited significantly greater radial bone SOS value compared to sedentary controls. Logerstedt et al.[27] and Santos et al.[28] mentioned that weight bearing activities lead to increasing BMD and they expressed that mechanical loading lead changes in bone formation, if the stretch values are more than bone tolerance. This mechanism can stimulate the bone cell and may increase BMD.

Kohrt et al.[29] mentioned that American College of Sports Medicine recognises the beneficial effect of sports practice on bone mass gain during human growth, nevertheless it was also mentioned that research results showed that martial arts have positive aspects related to BMD gain, but the findings are mainly based on elite athletes, and it is not clear if this relationship occurs in general practitioners [30-31]. The present study finding of absence of significant differences in bone speed of sound among sedentary individuals, wushu and taekwondo practitioners could be due to volume and frequency of training program underwent by wushu and taekwondo practitioners were not high enough for eliciting discernible differences in bone health status. Differences in genetic, age, dietary intake patterns, duration and/or intensity of training, as well as habitual activity levels may have contributed to differences in the results on bone health status of the present study and previous studies. Future studies are warranted to consider these factors to the potential osteogenic potential effects on wushu and taekwondo practitioners.

Isokinetic muscular peak torque (strength) and average power

The present study found that both wushu and taekwondo groups exhibited statistically significant higher values in majority of the measured knee extension parameters, i.e., absolute peak torque, relative peak torque and average power in dominant and non-dominant legs at 60°.s-1, 180°.s-1 and 300°.s-1 compared to sedentary control group. This finding implies that wushu and taekwondo are more effective in enhancing muscular strength of the legs than sedentary lifestyle. This study finding was consistent with study by Abidin et al.[26] which showed that boxing athletes exhibited significantly greater arm isokinetic muscular strength and power than silat athletes, and greater arm isokinetic muscular power than Muay Thai athletes respectively. Our finding was also similar to a previous study carried out by Machado et al.[30], it was observed that taekwondo athletes presented higher peak torque values for flexors and extensors in comparison to kickboxing athletes. In addition, a previous kinematic study reported a maximum knee angular velocity of 874.3o.s-1 for a roundhouse kick[29]. Thus, taekwondo-trained adolescents may demonstrate higher knee muscular strength during high velocity movement than their untrained peers because muscle training is velocity specific. Strengthening a muscle at high angular velocities facilitates the development of fast-contracting muscle fibers, preferentially improving high-velocity muscular strength[32].

One of the notable findings of the present study was that wushu group had statistically significant higher values of isokinetic knee extension relative peak torque at 60°.s-1, 180°.s-1 and 300°.s-1 compared to taekwondo groups. This result implied that wushu training was associated with higher muscular strength of the knee compared to taekwondo training. Our present finding was inconsistent with Fong and Tsang[9] which reported that adolescent taekwondo practitioners had higher isokinetic peak torque values for knee extension and flexion compared with the control participants. It is speculated that wushu participants of the present study have been involved in hard-style martial arts such as Chang Quan, which can elicit great strength in their knee flexor and extensor muscles as tested by isokinetic testing. Chang Quan is characterized by fast and vigorous movements where the demands on the joints, muscles and ligaments develop as the intensity of the movement's progress, especially stances which are more focused on lower limbs. For instance, the bow stance requires that the front leg is bent at 90° and the back leg is straight, and the riding stance that required practitioners to stand with feet parallel, feet apart, knees bent as well as upper leg nearly parallel to the ground. Regarding taekwondo, Kim et al.[9] mentioned that taekwondo athletes require muscular strength and power to effectively sustain the technical and tactical actions in a match including kicking, punching, blocking, holding and pushing. The differences in the training style, movement and techniques between wushu and taekwondo may have contributed to the difference in the finding on isokinetic strength of these two martial arts.

Another notable finding of the present study was that almost all of the isokinetic shoulder extension measured parameters, i.e., peak torque, peak torque per body weight and average power were significantly higher in the wushu groups than the taekwondo groups. This finding implies that wushu practitioners showed higher muscular shoulder extension compared to taekwondo groups. The reason for this observation could be wushu training involves many upper limb striking movements with repeated high peak forces and impacts. Besides, this may be attributed to the repeated practice of punching (e.g., vertical fist or "one-inch punch") and grasping (e.g., grappling-hand) techniques during wushu training[33]. Therefore, extrinsic and intrinsic hand muscles might have been strengthened through this kind of gripping exercises compared with taekwondo training which emphasises more on kicking techniques.

Another main finding of the present study was that almost all absolute peak torque, relative peak torque and average power isokinetic shoulder flexion peak torque measured parameters were significantly higher in taekwondo group than the wushu group. This implies that taekwondo training was associated with higher muscular strength of the shoulder flexion compared to wushu training. One of the possible explanations is that blocks of upper limbs are fast taekwondo motion that may contribute to the muscle strength in shoulder joint. High section block is one of the strong taekwondo moves that involves primary shoulder flexion, which is intended to stop and deflect an attack that comes from above, such as a downward strike.

Age is an important factor in determining torque, velocity and power characteristics of skeletal muscle and dynamic strength reaches the peak values at the age group of 20-30 years[34]. In the present study, the mean age of our participants was 15 years old. Endocrinological changes with puberty, training history and related physiological alterations may have caused different results on muscular performance between the present study and other previous studies with participants from various age categories.

Conclusion

In conclusion, there were no significant differences in body composition and bone health status between wushu and taekwondo practitioners. However, engagement in wushu and taekwondo could enhance muscular strength and power compared to sedentary lifestyle. Wushu practitioners showed higher isokinetic knee extension peak torque of the legs and shoulder extension peak torque and power of the arms than taekwondo practitioners. In contrast, taekwondo practitioners showed higher isokinetic shoulder flexion peak torque and power than wushu practitioners. These findings imply that isokinetic knee and shoulder extension strength and power are essential muscular performance variables in wushu, whereas isokinetic shoulder flexion strength and power are essential muscular performance variables in taekwondo. The findings obtained from this study can be used to guide the decisions of sports bodies and coaches in planning specific training programmes, which focus on improving muscular performance variables of wushu and taekwondo athletes, particularly in Malaysia. In addition, the present findings could add new information on bone health status, isokinetic muscular peak torque and power, and body composition of Malaysian young male taekwondo and wushu practitioners into the field of sports medicine.

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Conflict of Interest Disclosure

None to declare.

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