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# Musculoskeletal profile of middle-aged Ving Tsun Chinese martial art practitioners

## A cross-sectional study

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**Abstract**

This cross-sectional exploratory study aimed to quantify and compare the axial and appendicular bone mineral density (BMD), muscle mass, and muscle strength of middle-aged practitioners of Ving Tsun (VT; a hard-style Chinese martial art) with those of nonpractitioners.

Eighteen VT practitioners (mean age ± standard deviation = 51.8 ± 17.7 years; 12 men and six women) and 36 active controls (mean age ± standard deviation = 58.7 ± 11.0 years; 18 men and 18 women) participated in the study. All participants underwent a 1-day battery of musculoskeletal examinations. The BMD of the total radius, total hip, femoral neck, and lumbar spine was measured using dual-energy X-ray absorptiometry, as was the lean mass of the arm, leg, and trunk. Muscle strength of the upper and lower limbs was assessed using a Jamar dynamometer and an isokinetic dynamometer at 60°/second, respectively.

VT-trained participants had a 11.5% higher total radius BMD ($P = 0.023$), a 17.8% higher leg lean mass ($P = 0.014$), a 56.4% higher isokinetic body weight-adjusted peak torque of the knee extensors ($P < 0.001$), a 60.8% higher isokinetic body weight-adjusted peak torque of knee flexors ($P < 0.001$), and a 31.4% shorter time to reach peak torque in the knee flexors ($P = 0.001$) than the active controls. No significant differences were found in any of the other musculoskeletal outcomes between the 2 groups ($P > 0.05$).

Middle-aged VT practitioners displayed a higher total radius BMD and leg lean mass and better knee extensor and flexor muscular performances than their healthy active counterparts. Healthcare professionals may consider using this alternative method of training to improve the musculoskeletal health of middle-aged adults.

**Abbreviations:** BMD = bone mineral density, DXA = dual-energy X-ray absorptiometry, MANOVA = multivariate analysis of variance, VT = Ving Tsun.

**Keywords:** bone mineral density, martial exercise, muscle mass, muscle strength

## 1. Introduction

The human aging process, from maturity to senescence, is widely acknowledged to be associated with a reduction in bone mineral content and bone mineral density (BMD)[1–3] and with a loss of skeletal muscle mass and muscle strength.[1–4] The loss of bone begins in the 3rd or 4th decade of life,[3] while the loss of skeletal muscle mass commences at around 50 years of age and accelerates thereafter.[3,4] Preventive interventions must therefore be started early in life.

Exercise training, specifically strength or resistance training, can effectively attenuate the normal decline in bone mineral content and BMD[1,3,5] and increase the size and strength of the trained muscles through hypertrophy of muscle fibers[1,3,5] in middle-aged and older adults. However, the bone and muscle strengthening effects of resistance training is site-specific.[6,7] For example, Adami et al[6] have suggested a 6-month single-site (isolated) resistance training program, which includes press-ups and lifting a 500-g weight using exclusively the forearm muscles for 30 minutes per day, to strengthen the forearm bone (radius) and muscle (brachioradialis). Although the results are encouraging, a functional, whole-body (multisites) strengthening exercise program may be preferable, particularly for middle-aged and older populations.[8]

A previous study investigated whether Tai Chi, a traditional Chinese martial art and whole-body exercise, improved the musculoskeletal health of older adults. However, the effects observed were modest and might not be clinically useful.[9] Therefore, alternative training methods to Tai Chi and resistance training that can improve musculoskeletal health of the middle-aged population should be explored.

Ving Tsun (VT) or Wing Chun, a hard-style Chinese martial art and a whole-body strengthening exercise, is a high-impact combat sport, the popularity of which has been increasing among younger and older adults worldwide.[10] The training regime of

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**Figure 1.** Ving Tsun wooden dummy training.


**Figure 2.** Ving Tsun long pole strength training.

**Figure 3.** Ving Tsun knife practice.

VT is unique and comprises VT form training,[11] sticking hand (sparring) exercises,[12] wooden dummy training (Fig. 1), long pole training (Fig. 2), and VT knife training (Fig. 3) (Table 1).[10] All of these training elements stress the upper and lower limb bones and muscles. Therefore, VT might be a suitable alternative training method for improving the musculoskeletal health of middle-aged and older adults. Indeed, our previous studies found that older advanced VT practitioners had greater ultrasonic radial bone strength,[12,13] handgrip strength,[12] lower limb muscle strength (as measured by the 5 times sit-to-stand test),[13] and elbow extensor muscle strength (as measured by a hand-held dynamometer)[11] than nonpractitioners. However, in a recent prospective study, we found no improvements in these musculoskeletal outcomes after 3 months of VT training.[14] We concluded that this might be due to measurement error or the insensitivity of the tests, because we primarily used clinical tests to measure the outcomes, and the use of accurate laboratory measurements is necessary to explore the potential effects of VT training to improve musculoskeletal health in middle-aged populations. Using gold standard tests in this study, we aimed to document and compare the BMD, muscle mass, and muscle strength of the upper limbs, lower limbs, and trunk of middle-aged VT practitioners with those of nonpractitioners. These findings may shed light on the use of VT exercise to improve the physical condition and musculoskeletal health of middle-aged individuals.

## 2. Methods

### 2.1. Study design

This was a cross-sectional exploratory study.

**Table 1**

**A typical Ving Tsun training protocol for experienced practitioners.[10].**

| Type of exercise | Description | Frequency | Intensity | Duration | Potential benefits |
|---|---|---|---|---|---|
| VT form training – Siu Lim Tau, Chum Kiu, and Biu Chee forms | Practice the basic arm techniques, kicking maneuvers, stances, and footwork | | Mild sweating | 20 minutes | May stimulate the cardiovascular system |
| Sticking hand exercises | Application of the arm techniques and footwork through sparring with a partner | | Moderate impact | 30 minutes | May strengthen the bones and stimulate the sensorimotor system |
| Break | | | | 5 minutes | |
| Wooden dummy training | Practice striking techniques and body positioning. | 2–3 times/week | Moderate to high impact | 20 minutes | May strengthen the bones |
| Long pole training | Familiar with the use of weapon (a long pole). A total body strengthening exercise | | High (8–12 repetitions or till muscle fatigue) | 20 minutes | May strengthen the upper and lower limb muscles |
| Break | | | | 5 minutes | |
| VT knife training | Familiar with the use of weapon (2 knives). A total body strengthening exercise | | High (8–12 repetitions or till muscle fatigue) | 20 minutes | May strengthen the upper and lower limb muscles |

### 2.2. Sample size calculation

Sample size calculations were based on a statistical power of 0.8 and a 2-tailed alpha level of 0.05. In our previous VT studies,[12–15] the effect sizes for the bone strength indices ranged from 0.06 to 1.20, while the effect sizes for the muscle strength scores ranged from 0.14 to 1.33. Therefore, assuming a relatively large effect size of 0.97, the minimum sample size required to detect significant between-group differences in the musculoskeletal outcomes was 18 per group in the present study. G*Power software version 3.1.0 (Franz Faul, University of Kiel, Germany) was used to perform all of the calculations.

### 2.3. Participants

Between October 2015 and May 2016, a convenience sample of VT practitioners was recruited from local martial art associations through advertising posters and personal invitations. All of the volunteers were screened based on the following inclusion and exclusion criteria by 2 physiotherapists. The inclusion criteria were as follows: had trained in VT for a minimum of 1 year, had regular VT training >2 hour per week, aged between 35 and 60 years, had normal cognitive and sensorimotor functions, premenopausal for female participants, could ambulate independently without using an assistive device, and were able to communicate and follow commands. The exclusion criteria were as follows: had chronic or unstable medical conditions such as poorly controlled diabetes mellitus or symptomatic arthritis, had a significant musculoskeletal, neurological, or cardiopulmonary disorder that might affect test performance, had a metal implant, had suffered recent injuries, had experience in martial arts other than VT, and smoked.

Participants were recruited for the healthy active control group from the Active Ageing Service of the Hong Kong Christian Service's Elderly Core Business and the local community through posters and social media advertising during the same recruitment period. They had to fulfill the same inclusion and exclusion criteria described above except that they should have no experience of VT. Informed, written consent was obtained from each eligible participant. The study was approved by the Human Research Ethics Committee of the University of Hong Kong and conducted according to the Declaration of Helsinki guidelines.

### 2.4. Outcome measurements

All measurements were taken by 2 physiotherapists and 2 research assistants who were licensed to perform the dual-energy X-ray absorptiometry (DXA) scans. The assessments took place in the DXA laboratory and the physical activity laboratory at the University of Hong Kong. The participants were asked to provide their demographic information (eg, age and sex) and medical history, if any. Their exercise habit/physical activity levels (in metabolic equivalent hours per week), including the volume of VT training, were calculated based on their exercise intensity level (light, moderate, or hard), duration (hours/session), and frequency (sessions/week) and the assigned metabolic equivalent value of the activity according to the Compendium of Physical Activities.[16] Sunlight exposure was also estimated according to the time spent on outdoor activities every week. After these demographic data and potential confounding factors were recorded, each participant underwent the following physical tests in a random order within the same day.

### 2.5. Primary outcome measures

**2.5.1. Bone mineral density and lean mass.** Each participant underwent 3 scans – a whole-body scan, a hip scan (on the dominant side), and a forearm scan (on dominant side) – on the same day using a DXA scanner (Horizon A, Hologic Inc., Bedford, MA). All of the scans were performed by 2 licensed technicians following standardized procedures as described in the Hologic users' manual.[17] The BMDs (in g/cm$^2$) of the total radius, total hip, femoral neck, and lumbar spine were determined automatically using the region of interest program of the DXA scanner. The lean (muscle) mass of the dominant arm, dominant leg, and trunk was also derived using the same program. All of these bone and muscle parameters were documented for analysis. With regard to the precision of the Horizon A DXA scanner in vivo, the coefficients of variation for the femoral neck BMD and the spine BMD were 1.5% and 1.2%, respectively.[18]

### 2.6. Secondary outcome measures

**2.6.1. Lower limb muscle performance.** The isokinetic concentric muscle strength of the knee extensors (quadriceps) and knee flexors (hamstrings) in each participant's dominant leg was tested using a Biodex System 4 Pro™ isokinetic dynamometer (Biodex Medical Systems Inc., Shirley, NY), which is a valid and reliable tool for measuring muscle strength and performance.[19] Before the test, each participant engaged in a 5-minute jogging exercise to warm up, and then sat on the chair of the isokinetic machine with the hips kept at 85° flexion. The knee joint axis, demarcated by the lateral epicondyle of the femur, of the dominant leg was aligned with the rotational axis of the dynamometer. The participant's trunk and thigh of the dominant leg were stabilized with straps to ensure that an isolated knee flexion/extension movement was performed with a starting position at 90° of knee flexion. The standardized testing procedures recommended by the manufacturer were followed.[19] The testing range of motion was the participant's full knee flexion–extension range and a test velocity of 60°/second was adopted. To eliminate the effect of gravity on muscle torques, gravity effect torque correction was performed at 30°.[19] A familiarization trial with 5 submaximal knee flexion/extension repetitions was included before the actual test was performed. Thereafter, 5 maximal concentric contractions of the knee extensors and flexors were performed as a test ensemble. All participants were provided with consistent verbal encouragement to ensure maximal contraction of the knee muscles. The average body weight-adjusted peak torque (%) and time to peak torque (in millisecond) of the knee flexor and extensor muscles were recorded and used for analysis.[19]

### 2.7. Upper limb muscle performance

Maximal handgrip strength of the dominant arm was assessed using a Jamar dynamometer (Sammons Preston, Mississauga, ON) following standardized procedures.[20] The participants were seated with the shoulder to be tested adducted and neutrally rotated, elbow flexed at 90°, and the forearm in a mid-prone and wrist in a neutral position. Before the actual measurement, each participant was allowed to squeeze the dynamometer twice (ie, 2 familiarization trials were given) followed by a 10-second break. The participants were then instructed to squeeze the dynamometer once using maximal effort during the actual test. The highest handgrip strength value was recorded.[20] The interrater reliability (ICC=0.98) and intrarater reliability (ICC=0.94–0.98) of this handgrip strength test were good to excellent.[20]

### 2.8. Statistical analyses

Statistical analyses were performed using SPSS 20.0 software (IBM, Armonk, NY). Descriptive statistics were used to describe all demographic and outcome variables. Kolmogorov–Smirnov tests and/or histograms were used to check the normality of continuous data before parametric statistics were performed. Independent *t* tests and chi-square tests were used to compare the continuous and categorical demographic variables, respectively, between the VT and control groups. To compare the outcome parameters between the 3 groups while controlling for an inflation of type I error associated with multiple *t* tests, multivariate analysis of variance (MANOVA) was performed for each category of outcomes (ie, upper limb musculoskeletal outcomes, lower limb musculoskeletal outcomes, and trunk musculoskeletal outcomes). In addition, to avoid the problem of multicollinearity in the MANOVA analyses, bivariate associations between individual outcome variables within each category of outcome were checked using Pearson correlation coefficients. An overall alpha level of 0.05 (2-tailed) was set. Effect sizes (partial eta-squared) were also calculated. By convention, partial eta-squared values of 0.01, 0.06, and 0.14 indicate small, medium, and large effect sizes, respectively.

## 3. Results

Eighteen VT practitioners with an average of 10.9 years of VT training experience and 36 healthy active controls were eligible to participate in the study. No significant between-group differences were found for any of the participants' demographic characteristics or physical activity levels ($P > 0.05$). Table 2 summarizes the characteristics of the participants.

As the upper limb bone and muscle outcomes were highly correlated, an independent *t* test was performed to compare the total radius BMD between the 2 groups. The results revealed that the VT group had a higher total radius BMD (11.5%) than the control group ($P = 0.023$), whereas MANOVA results showed no significant difference in the upper limb muscle outcomes between the 2 groups (Hotelling trace = 0.042; $F(2, 51) = 1.083$; $P = 0.346$) (Table 3).

Multivariate analysis results for the lower limb musculoskeletal characteristics revealed an overall significant difference between the 2 groups (Hotelling trace = 0.655; $F(7, 45) = 4.208$; $P = 0.001$). When each individual bone and muscle outcome was considered, the between-group difference remained significant for the leg lean mass (VT group: 17.8% higher, $P = 0.014$), isokinetic body weight-adjusted peak torque of knee extensors (VT group: 56.4% higher, $P < 0.001$) and knee flexors (VT group: 60.8% higher, $P < 0.001$), and knee flexor time to peak torque (VT group: 31.4% faster, $P = 0.001$). No significant between-group differences were observed for any of the other lower limb musculoskeletal outcomes ($P > 0.05$). In addition, no significant differences were found in the trunk musculoskeletal characteristics (Hotelling trace = 0.023; $F(2, 39) = 0.445$; $P = 0.644$) between the VT and control groups (Table 3).

**Table 2**

**Characteristics of participants.**

| | VT group (n = 18) | Control group (n = 36) | *P* |
|---|---|---|---|
| Age, years | 51.8 ± 17.7 | 58.7 ± 11.0 | 0.143 |
| Sex, n | 12 men/6 women | 18 men/18 women | 0.245 |
| Weight, kg | 65.2 ± 11.0 | 67.8 ± 13.0 | 0.466 |
| Height, cm | 166.4 ± 5.5 | 164.1 ± 9.8 | 0.287 |
| Body mass index, kg/m$^2$ | 23.5 ± 3.6 | 25.3 ± 4.3 | 0.133 |
| VT experience, years | 10.9 ± 12.3 | 0 | – |
| Physical activity level, MET hours per week | 8.2 ± 15.9 | 4.4 ± 7.9 | 0.342 |
| Time spent in outdoor activities (sunlight exposure), hours per week | 2.4 ± 3.2 | 2.2 ± 3.1 | 0.816 |

Values are mean ± standard deviations unless otherwise specified. MET = metabolic equivalent, VT = Ving Tsun.

## 4. Discussion

The major findings of this study were that middle-aged adults who practiced VT regularly (>2 hours per week) for at least 1 year displayed higher total radius BMD and leg lean mass and better knee extensor and flexor muscular performances than matched healthy active participants. These findings suggest that the long-term practice of VT may be beneficial for the musculoskeletal system in middle-aged adults. Such favorable

**Table 3**

**Comparison of bone mineral density, skeletal muscle mass, and muscle strength in Ving Tsun practitioners and nonpractitioners.**

| | VT group (n = 18) | Control group (n = 36) | *P* | Effect size |
|---|---|---|---|---|
| Upper limb (dominant side) | | | | |
| Total radius BMD, g/cm$^2$ | 0.58 ± 0.09 | 0.52 ± 0.10 | 0.023* | 0.095 |
| Arm lean mass, g | 2442.92 ± 536.91 | 2343.82 ± 611.51 | 0.562 | 0.007 |
| Handgrip strength, kg | 35.29 ± 9.41 | 31.58 ± 8.23 | 0.143 | 0.041 |
| Lower limb (dominant side) | | | | |
| Total hip BMD, g/cm$^2$ | 0.99 ± 0.17 | 0.91 ± 0.17 | 0.114 | 0.048 |
| Femoral neck BMD, g/cm$^2$ | 0.80 ± 0.17 | 0.72 ± 0.15 | 0.090 | 0.055 |
| Leg lean mass, g | 7370.43 ± 1487.70 | 6258.51 ± 1508.52 | 0.014* | 0.113 |
| Isokinetic body weight-adjusted peak torque (60°/second), % | | | | |
| Knee extensors | 218.44 ± 63.63 | 139.63 ± 48.98 | <0.001* | 0.329 |
| Knee flexors | 102.44 ± 32.60 | 63.71 ± 31.56 | <0.001* | 0.256 |
| Time to peak torque (60°/second), millisecond | | | | |
| Knee extensors | 664.44 ± 178.83 | 755.14 ± 211.73 | 0.127 | 0.045 |
| Knee flexors | 717.78 ± 258.36 | 1046.29 ± 327.56 | 0.001* | 0.211 |
| Trunk | | | | |
| Lumbar spine BMD, g/cm$^2$ | 0.99 ± 0.17 | 0.97 ± 0.16 | 0.693 | 0.004 |
| Trunk lean muscle mass, g | 22,789.92 ± 3902.93 | 21,061.31 ± 5267.13 | 0.345 | 0.022 |

Values are mean ± standard deviations unless otherwise specified. *$P < 0.05$. BMD = bone mineral density, VT = Ving Tsun.

muscle and bone adaptations may be explained by the unique training methods of VT as described below.

VT practitioners often train with a wooden dummy that resembles a static sparring partner and practice striking techniques through sparring with this wooden partner (Fig. 1). Therefore, their forearm bones (radius and ulna) are subjected to mechanical loads in different directions.[12,13] According to Wolff law, which states that the remodeling of bone is modulated and influenced by mechanical stresses,[21] VT practitioners' forearm bones could have been remodeled (ie, increased in cancellous and/or cortical bone) to meet the mechanical demands placed on them during wooden dummy training.[12,13] This may explain our finding that VT practitioners had a higher total radius BMD than the active controls.

The load on the bones is known to be accomplished by both internal muscle activities and external impact forces,[22] and a positive correlation exists between BMD and muscle force[23] and muscle size (cross-sectional area).[24] In this study, we found that the arm lean mass and forearm muscle (handgrip) strength were similar in both VT practitioners and nonpractitioners. This suggests that the higher total radius BMD found in the VT practitioners could be mainly attributable to the external impact forces acting on the forearm bones during VT training rather than the forearm muscle pulls. However, further studies using electromyography to detect forearm muscle activities during VT training are needed to confirm our postulation.

This was the first study to quantify the lower limb bone strength of VT practitioners. Interestingly, we found that the total hip BMD and femoral neck BMD were not greater in the VT group than in the control group despite the fact that VT is a type of weight-bearing exercise.[10,11] This may be because all VT footwork (eg, pivoting, advancing, and retreating) emphasizes stability and smoothness. Bouncing and jumping movements are prohibited during VT training.[10] As a result, the loading on the lower limb bones due to gravity is predominantly static in nature. According to Turner rule,[25] bone adaptation is driven by dynamic, but not static, loading. Therefore, training in VT may not be able to improve the hip BMD of middle-aged adults.

However, training in VT may strengthen the lower limb muscles as shown in the present study and our previous study,[13] and may increase the leg lean (muscle) mass. VT practice involves a large number of semisquatting exercises (eg, pole and knife stances and footwork) (Figs. 2 and 3) that facilitate the co-contraction of knee extensor and flexor muscles.[26] Holding the heavy VT weapons (eg, a long pole or double knives) in the hand and maintaining a semisquatting posture add additional load/resistance to the leg muscles (Figs. 2 and 3) and may further strengthen them. The long-term practice of these VT high-intensity strengthening exercises (using upper body weight and the weight of the VT weapons as resistance and repeat the movements till volitional fatigue) (Table 1) may overload the lower limb antigravity muscles, activate a hypertrophic response in the leg muscles,[27] and hence increase both muscle strength and muscle mass.[27] This special training method may explain our finding that long-term VT practitioners had greater body weight-adjusted peak torques during isokinetic knee flexion and extension movements than the active controls. Certainly, further randomized controlled trials are needed to establish the causal relationship between VT training, leg muscle strength, and muscle mass.

Our results also revealed that the time required to reach peak force, specifically in the knee flexor muscles, was shorter in the VT group than in the control group. This finding is in line with our previous study showing that the time taken to reach peak force in the elbow extensor muscles decreased by 9.9% after VT training in a group of middle-aged and older adults.[15] A shorter time to reach peak force in the VT practitioners may be related to better motor coordination and muscle power generation associated with martial arts training.[28] However, why such an improvement was not observed in the knee extensor muscles is still not known. Further studies are required to explore the mechanisms and characteristics of muscle force production speed associated with VT martial arts training.

With regard to the lumbar spine BMD and trunk lean (muscle) mass, VT practitioners did not differ from the controls because VT training focuses on body positioning rather than trunk/core strength development or loading the vertebral column.[10,11] Therefore, VT may not be an appropriate exercise to strengthen the spine (vertebrae) and trunk muscles, but an experimental study is needed to confirm this.

This study has several limitations. First, a cross-sectional study design was employed and a cause-and-effect relationship between VT training and the musculoskeletal outcomes could not be established. A randomized controlled trial will be necessary to confirm the aforementioned beneficial effects of VT training in middle-aged and older adults. Second, we did not take 3 potential confounding factors – family history of osteoporosis,[29] dietary habits, and lifestyle[30] – into account when analyzing the BMD results. Third, our results may not be generalizable to elderly or diseased populations. Fourth, our participants' length of VT training varied from 1 to 40 years. Further studies should control this factor to document the physical changes during specific time periods. Finally, further exploration is warranted into the relationship between VT, musculoskeletal health, and health-related quality of life in the aging population.

## 5. Conclusion

Middle-aged VT practitioners displayed a higher total radius BMD and leg lean mass and better knee extensor and flexor muscular performances than their control counterparts. VT martial arts may be an alternative and enjoyable training method for attenuating the decrease in BMD, muscle mass, and muscle strength associated with aging.

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