Tai Chi And Kung-Fu Practice Maintains Physical Performance But Not Vascular Health In Young Versus Old Participants

By: **Steven McAnulty**, Lisa McAnulty, Scott Collier, Tacito P. Souza-Junior, & Jeffrey McBride

Abstract

Kung-Fu and Tai Chi along with other martial arts are gaining popularity but studies examining the benefits of martial arts on physical fitness, vascular health, nutrition, and psychological wellness are limited. Aging is associated with declines in these health components. The objectives of this study were to examine whether Tai Chi and Kung-Fu training would maintain physical fitness, vascular health, and psychological wellness components on older versus younger practitioners. Seventeen subjects were recruited and divided into Young (age <40 years, n=9) and Old (age 40 years and above, n=8). Participants reported twice for health screens, vascular and nutrition assessment, and fitness tests. Mean differences were compared between groups for all tests using Student's t-tests. Age, months of practice, systolic blood pressure, and cardiovascular augmentation index were significantly greater in Old versus Young (p=0.001, p=0.007, p=0.049, and p=0.011, respectively). Psychologically, old practitioners experienced greater sleep interference (p=0.035) and overall pain (p=0.036). No other differences existed for any variable. Our study indicates that the practice of Tai Chi and Kung-Fu maintains physical fitness in older compared to younger practitioners. However, age associated changes in cardiovascular stiffness, systolic blood pressure, and pain were not prevented.

Steven McAnulty, Lisa McAnulty, Scott Collier, Tacito P. Souza-Junior & Jeffrey McBride (2016): Tai Chi and Kung-Fu practice maintains physical performance but not vascular health in young versus old participants, The Physician and Sportsmedicine, 44:2, 184-189. DOI: 10.1080/00913847.2016.1158623. Publisher version of record available at: http://dx.doi.org/10.1080/00913847.2016.1158623

Tai Chi and Kung-Fu practice maintains physical performance but not vascular health in young versus old participants

Steven McAnulty[a], Lisa McAnulty[b], Scott Collier[a], Tacito P. Souza-Junior[a,c] and Jeffrey McBride[a]

[a]Department of Health, Leisure, and Exercise Science, Appalachian State University, Boone, NC, USA; [b]Department of Nutrition and Health Care Management, Appalachian State University, Boone, NC, USA; [c]Department of Physical Education, Federal University of Parana, Curitiba, PR, Brazil (CNPq Fellowship-Brazil)

ABSTRACT

Objectives: Kung-Fu and Tai Chi along with other martial arts are gaining popularity but studies examining the benefits of martial arts on physical fitness, vascular health, nutrition, and psychological wellness are limited. Aging is associated with declines in these health components. The objectives of this study were to examine whether Tai Chi and Kung-Fu training would maintain physical fitness, vascular health, and psychological wellness components on older versus younger practitioners.

Methods: Seventeen subjects were recruited and divided into Young (age <40 years, n=9) and Old (age 40 years and above, n=8). Participants reported twice for health screens, vascular and nutrition assessment, and fitness tests. Mean differences were compared between groups for all tests using *Student's t-tests*.

Results: Age, months of practice, systolic blood pressure, and cardiovascular augmentation index were significantly greater in Old versus Young (p=0.001, p=0.007, p=0.049, and p=0.011, respectively). Psychologically, old practitioners experienced greater sleep interference (p=0.035) and overall pain (p=0.036). No other differences existed for any variable.

Conclusion: Our study indicates that the practice of Tai Chi and Kung-Fu maintains physical fitness in older compared to younger practitioners. However, age associated changes in cardiovascular stiffness, systolic blood pressure, and pain were not prevented.

KEYWORDS
Martial arts; physical fitness; nutrition; cardiovascular health; psychological health

Introduction

The Chinese martial arts of Tai Chi and Kung-Fu have existed for centuries and are generally accepted as being beneficial for health with little empirical data to support these claims.[1] Kung-Fu was created in the Shaolin Temple in Henan, China by a Buddhist monk around A.D. 520. Over many centuries the many movements were refined and expanded and became advantageous not only for fitness but self-defense as well.[1] Limited comprehensive martial arts studies are available, and there are even fewer studies which have specifically examined the physiological and psychological changes that accompany the practice of Kung-Fu.[1–4]

Bu et al. [3] systematically summarized the literature for the effects of martial arts on health and fitness and attempted to provide a basis for future research on martial arts as an exercise prescription with exercise therapy. Eight databases were searched for the terms 'martial arts', 'health', and 'random' with a final *n* of 5432. Randomized controlled trials and clinical trials, which examined the health effects of martial arts were included in the study. The final review included 28 papers with one in general martial arts, one in Kung-Fu, sixteen in Tai Chi, six in judo, three were in Karate, and one in taekwondo. Tai Chi was the most studied with only one study in Kung-Fu. Research topics varied and included health, injuries, competition, morals and psychology, and herbal medicine. Most studies found positive effects on health, such as increased cognition, muscle strength, flexibility, and balance. Research on judo, karate, and taekwondo mainly focused on improvements to athletes' competitive abilities, rather than on health effects.

Since martial arts are widely practiced, the effects on health, changes in muscle physiology, and neurology should be further studied in order to particularly guide older individuals in selecting the best discipline to accomplish increases in health. This can be accomplished by examining the disciplines according to effects on different body systems. Martial arts as an exercise prescription can then move from an experience-based to an evidence-based treatment. This suggests that martial arts might then be used as a component of exercise prescription, once a move from an experience-based to an evidence-based treatment can be established.[3]

Given that most studies evaluating martial arts have found positive effects on health, such as increased cognition, muscle strength, flexibility, and balance [5–7], there could be positive effects on the health of middle-aged and elderly individuals. This is a major concern, given the growing aging population and the rising costs of health care.[8] Aging is also associated with a loss of muscular strength, flexibility, and coordination. Multiple exercise regimes have been employed to investigate

CONTACT Steven McAnulty mcanltysr@appstate.edu Department of Health and Exercise Science, Appalachian State University, Boone, NC 28608, USA

the associated problems of aging. Tai Chi uses slow smooth movements to train the body in balance, endurance, and strength. For this reason, it is known as a soft martial art in that it is non-impact oriented. There are limited studies with the elderly using other martial arts such as Kung-Fu. Although not specifically examining Kung-Fu, Brudnak et al. [9] examined the appropriateness and effects of the Korean martial art known as Tae Kwon-Do on health and fitness parameters in an elderly population. Participants that attended >85% of classes experienced an increase in the average number of push-ups, trunk flexion, and balance time on each foot.

Given that Tai Chi and Kung-Fu involve moderate-to-high-intensity forms of exercise, these arts may confer benefits similar to those attributed to other aerobic training modalities.[10–12] The current evidence examining the practice of Kung-Fu and Tai Chi with physical strength, cardiovascular, neurocognitive, and psychosocial outcomes in older people is lacking. Although this is an emerging and growing area of research, there are limited studies available, which have demonstrated improvements in health functioning, physical and emotional health, and cardiovascular functioning in older adults. Results overall are inconsistent and health improvements are not always evident.[13] Therefore, more studies using advanced techniques, such as augmentation index (AIx) and comprehensive physical testing are warranted.

The use of AIx represents an extremely sensitive and non-invasive measure and indicator of vascular elasticity.[14–17] AIx is determined by the change in pressure between the first and second peaks divided by the pulse pressure ($AIx = \Delta P/PP$). The first peak is obtained when blood ejects from the aorta. The second pressure peak occurs when blood reflects at the aortic bifurcation. The pulse pressure is the overall peak pressure. However, to our knowledge this measure has not been used to evaluate changes in response to Tai Chi and Kung-Fu training. However, Douris et al. [18] found pulse wave velocity and flexibility to be significantly improved in middle aged artists who practicing a Korean martial art versus sedentary controls. Tai Chi and Kung-Fu also involve meditative practices which may lower blood pressure and increase vascular and psychological health, but this has not been assessed in conjunction with AIx.[7] Lu and Kuo et al. [8] found that Tai Chi practice enhanced vagal modulation and lowered sympathetic modulation resulting in lowered arterial blood pressures.

Given the potential benefits of practicing Kung-Fu and Tai Chi in older individuals, the purpose of this study was to determine and compare the overall vascular, physiological, psychological, and nutritional status of young (<40 years) versus old (>40 years) practitioners of Tai Chi and Kung-Fu.[19] We improved and expanded upon previous martial arts studies by including sensitive measures of cardiovascular health such as the measurement of AIx. We hypothesized that the increased time of practice in older participants would minimize differences between young and old in physical, cardiovascular, nutritional, and psychological measures.

Materials and methods

This study was approved by the Institutional Review Board of Appalachian State University (study number 13-0046), and informed consent was obtained from all subjects prior to testing. Seventeen participants aged 18–56 were recruited from the local Kung-Fu school. The school teaches Kung-Fu but due to the large spiritual component and nature, a large amount of Tai Chi is also included in the training. Inclusion criteria were that the participants had practiced Kung-Fu and Tai Chi for a minimum of 1 year and successfully passed the medical screening for participation. Exclusion criteria were a practice time of less than one year and failure of any part of the medical screen that would prohibit the participant from being able to fully and safely execute the physical testing. Participants were divided into young (n = 9, <40 years) and old (n = 8, >40 years) groups. Interestingly, 100% of the participants identified ethnicity as 'Not Hispanic or Latino' and race as 'White'. Forty percent indicated some family history with cardiovascular disease.

A typical training session involved warm-up by five minutes of running followed by 100 jumping jacks, 50 pushups, comprehensive stretching, and 30 situps. The class then participated in group kicking and punching exercises with additional Tai Chi meditative exercises. The class then separated by rank to practice various animal forms, stick and staff training, and attack and defense techniques. Classes generally lasted for 1 h twice per week.

Participants were asked to report to the laboratory on two separate occasions to investigate multiple dependent variables which were chosen to give the most complete analysis of overall nutrition habits, body composition, strength, aerobic and anaerobic capacities, psychological, and vascular health. During Visit 1, informed consent, Health Medical History screen, and the American College of Sports Medicine (ACSM) health screening questionnaire were administered. Participants received instructions on recording and keeping a 3-day diet record. Diet records were analyzed using ESHA Food Processor (Salem, OR Version 11) for energy, macronutrient, and specific micronutrients. Participants also underwent a vascular assessment for arterial pulse wave velocity and aortic blood pressure waveforms (PWV, ABPWs respectively), which was used to determine the AIx and a $VO_{2\ max}$ test to determine aerobic fitness. Participants returned for Visit 2 1-week later for tests of arm and leg muscle strength, anaerobic power, flexibility, and vertical jump.

Visit 1 tests

Vascular assessment

Arterial PWV and ABPW were measured using the Sphygmacor Cardiovascular Management System and used to determine the AIx. All measurements were conducted in accordance with guidelines set forth by the Clinical Application of Arterial Stiffness, Task Force III. The applanation tonometer (Sphygmacor, Sydney, Australia) was used to derive the ascending ABPW and a range of central arterial indices. The Sphygmacor is used with a tonometer over a radial artery calibrated with a standard cuff blood pressure measurement.

The PWV (measure of arterial distensibility) module of the Sphygmacor was used to obtain indices of arterial stiffness. The Sphygmacor system obtained the pulse wave: (1) between the left common carotid artery and the left femoral artery, (2) between the left femoral and the ipsilateral dorsalis pedis pulse, and (3) between the left common carotid artery and the left radial artery. Distance from the carotid sampling site to the mid-point of the manubrium sterni, manubrium sternum to femoral artery, and femoral artery to dorsalis pedis was then measured between these points as straight lines with a measuring tape. The distance from the carotid artery to the manubrium sterni was subtracted from the manubrium to femoral artery distance PWV and determined from the foot-to-foot flow wave velocity. The foot of the pressure wave was identified visually as the point of systolic upstroke. The time delay between a minimum of 15 simultaneously recorded flow waves was averaged. PWV can then be calculated from the distances between measurement points and the measured time delay (Dt) between proximal and distal foot waveforms as follows: PWV = D/Dt (m/s), where D is distance in meters and Dt is the time interval in seconds. Values attained from carotid to femoral artery were taken as an index of central compliance while values attained from the carotid and radial artery along with the measurement from the femoral to dorsalis pedis were taken as an index of peripheral compliance.

AIx is determined by the change in pressure between the first and second peaks divided by the pulse pressure (AIx = $\Delta P/PP$). The first peak is obtained when blood ejects from the aorta. The second pressure peak occurs when blood reflects at the aortic bifurcation. The pulse pressure is the overall peak pressure. All data were stored and analyzed off-line after completion of testing.

Blood pressures using the finometer beat to beat blood pressure machine

Blood pressure variability was determined by using beat-to-beat blood pressures measured using finger plethysmography (FMS, Amsterdam). Blood pressure peaks were detected via an established spectral peak detection algorithm. The sequence of the systolic peaks was then interpolated to provide a continuous data stream, and the resulting systolic peak data detrended using a robust locally weighted regression procedure. The resulting data were split in sections and each section tapered using a split cosine window. Finally, fast Fourier transform algorithms were used to convert the data into frequency spectra and smoothed across blocks of frequencies to produce a spectrum. The power of the systolic peaks was calculated by measuring the area under the peak of the power spectra. Power spectra within the 0.04–0.15 Hz range are defined as low-frequency components and are considered to be representative of sympathetic vasomotor modulation.

Height weight and body composition

Height was determined using a stadiometer and weight using a digital scale. Percent body fat was determined using the BOD POD air displacement plethysmograph (ADP). Similar in principle to underwater weighing, the BOD POD measured body mass (weight) and volume by having the subject sit inside the BOD POD for 250-s increments of air measurement. Body density was then calculated. Participants were instructed not to workout 2-h prior or eat or drink 1-h prior to testing. No jewelry or eye glasses were allowed and hair was covered by a swim cap. Minimal compression type clothing, such as spandex, lycra, or under armor was worn by the subjects.

Aerobic test

Participants performed a maximal, progressive running test to exhaustion on a motor driven treadmill. Following a standardized warm-up, the test began at a speed of 2.5 mph and an elevation of 0.0%. Treadmill speed was increased by 1 mph every 2 min until a comfortable pace was established. This speed was maintained for the remainder of the test while treadmill grade was increased by 2.5% every 2 min until volitional exhaustion. Expired air was collected throughout the test and analyzed using a Parvomedics TrueOne metabolic cart (Parvomedics, Sandy, UT) calibrated to manufacturer's specification. Heart rate was measured during the final 30 s of each stage using a Polar Heart Rate Monitor (Polar Electro Inc., Woodbury, NY). Criteria for a maximal effort included a maximal heart rate similar to age-predicted max (220 – age), a plateau in oxygen consumption with an increase in work rate, and an RER value of >1.15.[20]

Visit 2 tests

Vertical jump test

The vertical jump test evaluated leg muscle power. Initial reach was recorded by having participant stand erect with feet flat on floor. The participant then warmed-up by rehearsing submaximal jumps and stretching until the participant felt ready. Then, the participant reached as high as possible on the taper with the fingers fully extended. This was the beginning height. The participant then brought their arms down and backwards while bending the knees and then jumped as high as possible with arms upward and touched the highest metal phlange. Three trials were performed. The beginning height was subtracted from the highest jump. The following equation was used to calculate leg power (kg·m/s): = 2.21 × weight (kg) × √vertical jump (m).[20]

Muscle strength tests

1-RM bench press

The bench press 1-RM was used to test the strength of the muscles involved in arm extension (triceps, pectoralis major, anterior deltoid). The subject was allowed to become familiar with and warm-up for the test by lifting some light weights and stretching. The subject lay on their back gripping the bar approximately shoulder width apart. The bar was lowered until touching the chest and then extended until the arms were straight up and locked again. A spotter was used for safety. The participant was allowed as many trials as necessary to achieve a true max. One to three minutes was allowed between efforts. The best lifting score was divided by the person's weight to obtain a ratio.[20]

1-RM leg press

To determine leg strength, each subject's one repetition maximal strength in the squat was determined. Again, subjects were allowed to stretch and then began a warm-up protocol involving two sets of 8–10 repetitions at 30%, 4–6 repetitions at 50%, 2–4 repetitions at 70%, and 1 repetition at 90% of an estimated 1-RM or 1.5–2.5 times their bodyweight, depending on training status. The load prescription was subject to the research assistant's discretion as well as the load to be used for each set. Subjects were allowed up to 3–4 attempts at increasing weights to obtain their 1-RM. Subjects began the squat by standing with their feet shoulders width apart and the barbell positioned on their upper back. Subjects squatted down to 80° as determined by the researcher, and then returned to a standing position. The knee angle was measured prior to attempts and adjustable stoppers were set at this point.[20]

Grip strength test

The grip strength test was used to measure the static strength of both hands. A hand dynamometer was used to measure both left and right hands. The subject assumed a slightly bent forward position with the hand to be tested out in front. The hand and arm should be hanging free and not touching anything. The test involved a maximum gripping effort for 2–3 s. No swinging or pumping of the arm is allowed. The purpose of the test is to measure the static strength of the grip squeezing muscles. The score was the sum of the best left and right hand score from 2–4 trials.[20]

Anaerobic power test

The 30-s, upper-body Wingate test was performed on a Monark model 874 E cycle ergometer (Monark, Vansbro, Sweden) modified for hand-crank exercise. The participant was positioned so that the center of the ergometer bottom bracket was at the level of the mid-sternum and an approximate 15° bend in the elbow occurred when the cranking handle was at the furthest position from the participant in the cranking cycle. The test was preceded by a 5-min warm-up during which the participant cranked at 60 W and 60 rpm. The warm-up was followed by a 2-min passive rest period. To begin the test, the participant reached a cadence of 60 rpm against no load. Once 60 rpm was reached, a testing load of 7.5% of the participant's body mass was applied and the participant began cranking as fast as possible for the duration of the test. Power output was measured each second using SMI Wingate software (SMI Industries, St. Cloud, MN) and were used to determine corrected peak power in Watts·kg·bm^{-1} and time to peak power.[20] Only one trial was performed for this test.

Flexibility

To determine flexibility, the sit and reach test was used. The purpose of this test was to evaluate the flexibility of the lower back and posterior leg muscles. The individual warmed-up using static stretching and then removed their shoes. The feet were fully extended and flat against the flexibility box. The arms were extended straight forward with the hands on top of each other with fingertips even. The person reached directly forward with palms down maximally for four times and held the position. The score was the most distant point reached on the fourth trial determined to the nearest centimeter.[20] Statistical analysis was conducted using the Instat statistical analysis software (GraphPad Software, Inc. La Jolla, CA, USA). Group means within each group were compared for all tests using Student's *t*-tests. Statistical significance was set at $P \leq 0.05$, and all values were reported as means ± standard deviation (SD). The Kolmogorov and Smirnov method was utilized to test whether the data followed normal Gaussian distributions. The observed statistical power to detect a difference in the significantly different variables of age, AIx, months of training, and systolic blood pressure was 1.000, 0.985, 0.990, and 0.990, respectively. Sleep interference pain and overall pain statistical power was 0.990 and 0.200, respectively.

Results

Significant differences existed between groups for age and months of practice (Table 1). Participants in the old group were significantly older (p = 0.001) and had more months of practice time (p = 0.017) compared to the young group. The old group also exhibited a significantly higher systolic blood pressure and AIx compared to young (p = 0.049 and p = 0.001, respectively) (Table 1). However, it was surprising that no differences existed between groups for any physical performance or dietary measure (Tables 2 and 3, respectively). Psychological and physical well-being tests indicated old practitioners exhibited significantly greater sleep interference compared to young (p = 0.047) (Table 4). Outside of Kung-Fu/Tai Chi training, no significant differences existed for responses to Health History questions regarding self-ratings of physical fitness, daily engagement of exercise that increased breathing and heart rate for at least 20 min, or hard physical work required on jobs (data not shown). Positive Pearson product correlations existed for age versus rank (r = 0.542, p = 0.024, N = 17) and age versus systolic blood pressure (r = 0.713, p = 0.001, N = 17).

Discussion

We had hypothesized that increased months of practice in Kung Fu/Tai Chi would minimize differences between young and old in physical, cardiovascular, nutritional, and psychological measures. Specifically, we hypothesized that the increased months of practice would decrease body fat, increase body strength, and increase power and flexibility, thereby compensating for the effects of aging. Aging is associated with progressive failure of molecular mechanisms that create disorder within various systems. Accumulation of molecular disorders over time cause progressive changes in the structure and function of various systems such as the heart and arteries. Many effects of aging on the physical health and the cardiovascular system can be delayed or attenuated by changes in lifestyle, diet, and exercise.[21] The practice of

Table 1. Subject descriptives.

	Young	Old	*p*-value
Height (m)	1.76 ± 0.10	1.76 ± 0.04	0.999
Weight (kg)	71.88 ± 15.27	75.42 ± 9.34	0.579
Age (years)	30.0 ± 7.29*	46.6 ± 6.30	≤0.001
BMI (kg/m^2)	22.66 ± 3.18	24.2 ± 2.70	0.302
Body fat (%)	13.83 ± 5.24	18.82 ± 6.51	0.100
Months of practice	60.77 ± 49.77*	144.40 ± 62.07	0.007
AIx	8.77 ± 11.20*	26.73 ± 4.30	0.011
Systolic pressure (mmHg)	124.22 ± 7.62	136.0 ± 14.49	0.049
Diastolic pressure (mmHg)	78.44 ± 5.0	77.4 ± 7.09	0.727

Values are means ± SD. Young (age <40 years) (n = 9), old (age ≥40 years) (n = 8). m – meters, kg – kilograms, BMI – body mass index, AIx – augmentation index, mmHg – millimeters of mercury. *Significantly different from old ($p \leq 0.05$).

Table 2. Performance variables.

	Young	Old	*p*-value
VO_2max (ml·kg·min^{-1})	50.14 ± 8.8	48.0 ± 5.0	0.554
Vertical jump power (kg·m·s $^{-1}$)	112.2 ± 28.2	121.0 ± 10.1	0.417
Combined grip strength (L&R kg)	98.55 ± 21.9	110.24 ± 8.8	0.179
Wingate relative average power (w/kg)	3.62 ± 0.6	3.34 ± 0.4	0.282
Time to peak power Wingate (s)	9.33 ± 1.8	7.5 ± 4.2	0.251
Sit and reach (cm)	42.71 ± 13.3	42.36 ± 15.6	0.960
Bench press 1-RM (kg)	63.12 ± 20.0	74.42 ± 10.2	0.171
Bench press 1-RM strength to body weight ratio	0.87 ± 0.22	0.98 ± 0.06	0.192
Bench press 1-RM peak power (watts)	833 + 865	1253 + 1158	0.406
Squat 1-RM (kg)	77.0 ± 24.7	85.8 ± 8.9	0.356
Squat 1-RM strength to body weight ratio	108.6 ± 24.2	114.6 ± 13.5	0.544
Squat 1-RM Peak Power (watts)	963.1 ± 293.7	908.3 ± 371.0	0.738

Values are means ± SD. Young (*n* = 9), old (*n* = 8). ml·kg·min^{-1} – milliliters of oxygen per kilogram per minute, cm – centimeters, kg·m·s^{-1} – kilograms per meter per second, L&R kg – left and right hand grip pressures combined in kilograms, w/kg – Watts per kilogram, sec – seconds, RM – repetition maximum, Wt – weight, strength to body weight ratio (1-RM/body weight).

Table 3. Dietary intake.

	Young	Old	*p*-value
kcal	2441 ± 789.5	3223.2 ± 1183	0.125
Protein (g)	86.7 ± 24.2	108.9 ± 22.4	0.069
Percent of total kcal protein	14.4 ± 2.2	14.3 ± 3.4	0.942
Carbohydrate (g)	300.7 ± 108.7	398.6 ± 152.8	0.145
Percent of total kcal carbohydrate	48.4 ± 6.2	47.7 ± 2.9	0.774
Fat (g)	94.1 ± 31.2	134.0 ± 54.6	0.098
Percent of total kcal fat	42.0 ± 9.3	42.5 ± 6.3	0.897
Sodium (mg)	3749 ± 1454	16966 ± 22375	0.139
Potassium (mg)	1907 ± 1035	2735 ± 992	0.114
Magnesium (mg)	233 ± 131	292 ± 121	0.352
Calcium (mg)	1026 ± 669	927 ± 202	0.693
Vitamin D (IU)	190 ± 274	215 ± 92	0.809

Values are means ± SD. Young (*n* = 9), old (*n* = 8). kcal – kilocalories, g – grams, mg – milligrams, IU – International Units.

Table 4. Psychological and physical well-being.

	Young	Old	*p*-value
[1]Sleep interference pain	0.77 ± 1.39*	3.25 ± 2.86	0.035
[1]Enjoyment of life interference pain	1.0 ± 1.0	1.25 ± 1.63	0.704
[1]Relationship with people interference pain	0.66 ± 0.86	0.50 ± 0.86	0.707
[1]Average mood interference pain	1.44 ± 1.5	1.75 ± 1.78	0.702
[1]Overall average pain	1.66 ± 1.22*	3.25 ± 1.63	0.036
[1]Feelings of anger	1.33 ± 1.0	1.8 ± 1.3	0.413
[1]Coping with Problems	1.0 ± 0.5	1.2 ± 1.3	0.674
[1]Feelings of stress and nervousness	1.77 ± 0.97	2.2 ± 1.48	0.484
[2]Feelings of confidence	3.22 ± 0.66	3.2 ± 0.44	0.943

Values are means ± SD. Young (*n* = 9), old (*n* = 8). Item 1 uses scale 1–5, reflecting better to worse. Item 2 uses scale 1–5, reflecting worse to better. *Significantly different from old $p \leq 0.05$.

Kung Fu/Tai Chi represents a form of exercise that encompasses multiple aspects of conditioning. As such, the practice of Kung-Fu/Tai Chi might prevent many of the negative aspects of aging.

We also hypothesized that due to advanced meditative practices, increased time of practice would allow older participants to exhibit a lower AIx, or at least a comparable AIx compared to younger, but this was not the case. Our older participants exhibited a higher AIx typically associated with aging.[22] In support of our findings, Fong et al. [23] concluded that martial arts training may have some benefits in body composition (fat loss), balance, and flexibility. Toskovic et al. [24] found that Tae Kwon Do black belts were more athletically fit as compared with that of novice Tae Kwon Do practitioners of the same sex despite the fact that male and female black belts were older than their novice counterparts. Comparison across groups indicated that experienced Tae Kwon Do subjects were stronger than novice subjects, as measured by lower body strength, and showed better aerobic performance capacity as well as lower percent body fat. Additionally, black belts demonstrated higher flexibility. This supports our study observation that older participants did not differ in most measurements when compared to younger participants.

Sbriccoli et al. [25] support the notion of improved neuromuscular function with time of training in elite karate practitioners as indicated by higher isokinetic knee flexion torque when compared to amateurs. Furthermore, elite practitioners demonstrated a typical neuromuscular activation strategy that was task and skill level dependent. Knee flexion torque and average muscle fiber conduction velocity results suggested the presence of an improved ability of elite practitioners to recruit fast motor units as a part of training induced neuromuscular adaptation. Our findings and some current literature suggest that, unless the martial artist is engaged in competition, there are typically no differences in most physical performance measures between advanced and beginner students.[23,26] Heller et al. [27] collected baseline physiological and kinanthropometric data for 11 male and 12 female elite Tae Kwon Do athletes for evaluation of anthropometry, aerobic and anaerobic capacities, strength, visual reaction time, pulmonary function, flexibility and explosive power of the lower limbs (vertical jump). Both male and female black belts demonstrated low adiposity, above average muscular strength and aerobic power, and high flexibility and anaerobic performance.

Of particular interest is our observation of no significant differences in upper and lower body strength between the old versus young practitioners. This indicates that Kung-Fu and Tai Chi practice maintain strength. This likely translates into a reduced fall risk and the preservation and enhancement of strength and balance has been observed in other martial arts studies.[9,28–31] Falls are known to be a leading cause of death in the elderly which is commonly associated with a loss of muscular strength, flexibility, and coordination.[9]

Regarding diet, Artioli et al. [2] found that elite male Olympic Kung-Fu practitioners consumed a high-fat, low-carbohydrate diet, whereas women consumed a moderate to high-carbohydrate diet. Our subjects consumed a typical diet of macronutrients, with the exception that fat intake was slightly above recommendations.[32]

Bu et al. [3] suggested that since martial arts are widely practiced, the effects on physiology and morphology should be further studied in order to help people to select the best discipline or style to accomplish their purposes. Douris et al. [33] have observed increased aerobic capacity, balance, flexibility, muscle endurance, and strength, and less body fat in martial artists compared to sedentary controls matched for age and sex. These findings support our observations of preservation of physiological and physical attributes by Kung-Fu practice despite being older. An important element of future studies would be categorizing and classifying the disciplines and styles according to effects on different physiological outcomes such as AIx. Martial arts might eventually be considered as an exercise prescription.

Conclusion/Summary

Our study indicates that the practice of Kung-Fu/Tai Chi martial arts maintains levels of body composition, aerobic capacity, anaerobic power, flexibility, and upper and lower body strength similar to those of younger practitioners. However, Kung-Fu/Tai Chi practice does not prevent changes in cardiovascular stiffness and pain index, as indicated by a higher augmentation index and pain ratings in older participants. Based upon our assessments, we conclude that martial arts training, specifically Kung-Fu/Tai Chi can be considered an excellent form of exercise for the promotion of fitness in adults. Health professionals should be aware that there are alternative methods to traditional exercise that can increase the physical fitness and health of young and middle aged populations. Martial arts can also be practiced virtually anywhere and anytime without the need for expensive equipment or large spaces. In conclusion, not only does the practice of Kung-Fu and Tai Chi provide a practical aspect of self-defense, but based upon our findings also maintains aerobic, anaerobic, strength, and flexibility components as one ages. However, this art does not appear to protect against adverse cardiovascular changes as determined by AIx and systolic blood pressure.

Financial and competing interests disclosure

The authors have no relevant affiliations or financial involvement with any organization or entity with a financial interest in or financial conflict with the subject matter or materials discussed in the manuscript. This includes employment, consultancies, honoraria, stock ownership or options, expert testimony, grants or patents received or pending, or royalties.

References

1. Tsang TW, Kohn M, Chow CM, et al. Health benefits of Kung Fu: a systematic review. J Sports Sci. 2008;26:1249–1267.
2. Artioli GG, Gualano B, Franchini E, et al. Physiological, performance, and nutritional profile of the Brazilian Olympic Wushu (Kung-Fu) team. J Strength Cond Res. 2009;23:20–25.
3. Bu B, Haijun H, Yong L, et al. Effects of martial arts on health status: a systematic review. J Evid Based Med. 2010;3:205–219.
4. Koh TC. Chinese medicine and martial arts. Am J Chin Med. 1981;9:181–186.
5. Itamar N, Schwartz D, Melzer I. Postural control: differences between youth judokas and swimmers. J Sports Med Phys Fitness. 2013;53:483–489.
6. Wolfson L, Whipple R, Derby C, et al. Balance and strength training in older Adults: intervention gains and Tai Chi maintenance. J Am Geriatr Soc. 1996;44:498–506.
7. Young DR, Appel LJ, Jee S, et al. The effects of aerobic exercise and Tai Chi on blood pressure in older people: results of a randomized trial. J Am Geriatr Soc. 1999;47:277–284.
8. Lu WA, Kuo CD. Comparison of the effects of Tai Chi Chuan and Wai Tan Kung exercises on autonomic nervous system modulation and on hemodynamics in elder adults. Am J Chin Med. 2006;34:959–968.
9. Brudnak MA, Dundero D, Van Hecke FM. Are the 'hard' martial arts, such as the Korean martial art, taekwon-Do, of benefit to senior citizens? Med Hypotheses. 2002;59:485–491.
10. Campos FA, Bertuzzi R, Dourado AC, et al. Energy demands in taekwondo athletes during combat simulation. Eur J Appl Physiol. 2012;112:1221–1228.
11. Franchini E, Panissa VL, Julio UF. Physiological and performance responses to intermittent uchi-komi in judo. J Strength Cond Res. 2013;27:1147–1155.
12. Pesic S, Jakovljevic V, Djordjevic D, et al. Exercise-induced changes in redox status of elite karate athletes. Chin J Physiol. 2012;55:8–15.
13. Blake H, Hawley H. Effects of Tai Chi exercise on physical and psychological health of older people. Curr Aging Sci. 2012;5:19–27.
14. Yapei Y, Xiaoyan R, Sha Z, et al. Clinical significance of arterial stiffness and thickness biomarkers in type 2 diabetes mellitus: an up-to-date meta-analysis. Med Sci Monit. 2015;21:2467–2475.
15. Schultz MG, Hughes AD, Davies JE, et al. Associations and clinical relevance of aortic-brachial artery stiffness mismatch, aortic reservoir function, and central pressure augmentation. Am J Physiol Heart Circ Physiol. 2015;309:H1225–33.
16. Kosmala W, Marwick TH, Stanton T, et al. Guiding hypertension management using central blood pressure: effect of medication withdrawal on left ventricular function. Am J Hypertens. 2015;29(3):319–325.
17. Karasavvidou D, Pappas K, Stagikas D, et al. 4c.05: Pwv is an independent determinant of cognitive dysfunction in ckd patients. J Hypertens. 2015;33(Suppl 1):e57.
18. Douris PC, Ingenito T, Piccirillo B, et al. Martial arts training attenuates arterial stiffness in middle aged adults. Asian J Sports Med. 2013;4:201–207.
19. Lee SB, Cha EJ, Lee TS. Analysis of physical activities in taekwondo pumsae. Conf Proc IEEE Eng Med Biol Soc. 2008;2008:5164–5167.
20 Nieman DC. Exercise Ttesting and prescription. 5th ed. New York: McGraw Hill; 2003.
21. Lakatta EG. So! What's aging? Is cardiovascular aging a disease? J Mol Cell Cardiol. 2015;83:1–13.
22. van Dijk SC, Swart KM, Ham AC, et al. Physical fitness, activity and hand-grip strength are not associated with arterial stiffness in older individuals. J Nutr Health Aging. 2015;19:779–784.
23. Fong SS, Ng GY. Does taekwondo training improve physical fitness? Phys Ther Sport. 2011;12:100–106.
24. Toskovic NN, Blessing D, Williford HN. Physiologic profile of recreational male and female novice and experienced tae kwon do *practitioners*. J Sports Med Phys Fitness. 2004;44:164–172.
25. Sbriccoli P, Camomilla V, Di Mario A, et al. Neuromuscular control adaptations in elite athletes: the case of top level karateka. Eur J Appl Physiol. 2010;108:1269–1280.
26. Franchini E, Nunes AV, Moraes JM, et al. Physical fitness and anthropometrical profile of the Brazilian male judo team. J Physiol Anthropol. 2007;26:59–67.
27. Heller J, Peric T, Dlouhá R, et al. Physiological profiles of male and female taekwon-do (Itf) black belts. J Sports Sci. 1998;16:243–249.
28. Krampe RT, Smolders C, Doumas M. Leisure sports and postural control: can a black belt protect your balance from aging? Psychol Aging. 2014;29:95–102.
29. Marie-Ludivine CD, Papouin G, Saint-Val P, et al. Effect of adapted karate training on quality of life and body balance in 50-year-old men. Open Access J Sports Med. 2010;1:143–150.
30. Nowalk MP, Prendergast JM, Bayles CM, et al. A randomized trial of exercise programs among older individuals living in two long-term care facilities: the fallsfree program. J Am Geriatr Soc. 2001;49:859–865.
31. Pons van Dijk G, Lenssen AF, Leffers P, et al. Taekwondo training improves balance in volunteers over 40. Front Aging Neurosci. 2013;5:10.
32. American Dietetic A, Dietitians of C, American College of Sports M, et al. American college of sports medicine position stand. Nutrition and athletic performance. Med Sci Sports Exerc. 2009;41:709–731.
33. Douris P, Chinan A, Gomez M, et al. Fitness levels of middle aged martial art practitioners. Br J Sports Med. 2004;38:143–147. discussion 47.