

Comparison of the Effects of Swimming and Tai Chi Chuan on Body Fat Composition in Elderly People

Tung-Yang Yu, MD; Yu-Cheng Pei, MD; Yiu-Chung Lau, MD; Chih-Kuang Chen, MD; Hung-Chih Hsu, MD; Alice M.K. Wong, MD

Background: Accumulation of fat and substantial loss of muscle mass are common phenomena in the elderly. In this study, we observed the effects of Tai Chi Chuan (TCC) and swimming, two exercises suitable for elderly people, on the percentage body fat and fat distribution by measuring subcutaneous adipose tissue thickness and body composition.

Methods: Subjects were divided into three groups: regular swimmers ($n = 20$), regular TCC practitioners ($n = 32$), and age-matched control subjects ($n = 31$). Subcutaneous adipose tissue thickness was taken using a Lange skinfold caliper at the chests, abdomens, and thighs in the men, and the triceps, suprailium, and thighs in the women. Mid-arm circumference (MAC) was measured on the non-dominant upper arm using fiberglass tape. Body composition was analyzed using the Inbody 3.0 logo, a bioelectrical impedance analysis (BIA) system.

Results: No significant differences were found between the three test groups in relation to total body adiposity and arm muscle circumference in the men and women. There was significantly less subcutaneous adipose tissue at the abdomen ($p = 0.011$) and thigh ($p < 0.001$) of TCC-group men and at the thighs ($p < 0.001$) of the swimming group compared with the control group. In women, only the thigh skinfold ($p = 0.002$) showed a decrease in the TCC group compared with the control group.

Conclusion: Swimming and TCC may not decrease total fat adiposity in elderly men and women, however, they may change body fat distribution due to certain muscle group usage. The differences observed in the effects of exercise on body fat distribution between elderly women and men may be gender-related.
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Key words: body composition, fat distribution, swimming, Tai Chi Chuan

Ageing in older adults is usually accompanied by changes in body weight and body composition. Accumulation of fat and substantial loss of muscle mass are common phenomena in the elderly.⁽¹⁾ This increase in body mass and fat mass is probably due

to age-related reductions in energy expenditure that are disproportionately greater than the reductions in energy intake that occur with age.^(2,3)

Several studies directed at women showed that obese people may experience low work capacity dur-

From the Department of Rehabilitation, Chang Gung Memorial Hospital, Taipei; Graduate Institute of Rehabilitation Science, Chang Gung University, Taoyuan.

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Correspondence to: Dr. Alice May-Kuen Wong, Department of Rehabilitation, Chang Gung Memorial Hospital, 5, Fushing St., Gueishan Township, Taoyuan County 333, Taiwan (R.O.C.) Tel.: 886-3-3281200 ext. 3846; Fax: 886-3-3281320; E-mail: walice@adm.cgmh.org.tw

ing daily activity and a decrease in exercise tolerance.⁽⁴⁾ Accumulation of fat is usually related to an increase of chronic diseases, such as cardiovascular disease, hypertension, diabetes mellitus, and cancer.^(5,6) This has been associated with increased risks of morbidity and premature death.⁽⁷⁾

Compared with sedentary women, age-related increases in body weight and in total and regional body fat acquisition are lower or even absent in women who exercise regularly.⁽⁸⁾ This could be due in part to their high physical activity-related energy expenditure;⁽⁹⁾ however, maintenance of higher resting metabolic rates than the sedentary group were also observed.⁽¹⁰⁾ The same results have been reported in men.⁽¹¹⁾

In most studies involving vigorous, long duration (> 6 months) endurance exercise training in people older than 60 years of age, researchers have measured changes in body weight and body composition.⁽¹²⁾ Study results have also indicated that in men there is a preferential loss of fat from the central regions of the body with endurance exercise training.⁽¹³⁾ Vigorous exercises suitable for elderly people, however, are relatively few because of problems such as joint degeneration, poor eyesight, poor balance and cardiovascular limitations. Therefore, gentle exercise such as noncompetitive swimming and Tai Chi Chuan (TCC) are suitable exercises for elderly individuals due to the minimal risk of injury.⁽¹⁴⁾

The objective of this study was to compare body composition of geriatric TCC practitioners with that of sedentary control subjects in addition to subjects participating in swimming. Emphasis was also placed on observing whether there were changes of body fat distribution in the subjects who participated in TCC or swimming.

METHODS

Subjects

In total, 83 community-dwelling senior volunteers, who were older than 60 years and led active lifestyles, were enrolled in the study. None had history of falls during the 3 months prior to participating in this study. Informed consent forms were signed by each subject before participation. All procedures applied in this study were in accordance with the ethical standards of the Institutional Board for

Experimentation with Human Subjects.

The subjects were divided into three groups: the swimming subjects were recruited from a swimming club; TCC subjects were recruited from a TCC club; and control subjects were recruited from a volunteer group at the Chang Gung Memorial Hospital (CGMH). The all subjects in the swimming group were currently engaged in regular swimming programs at least three times a week, with each session longer than 30 minutes, for more than two years; all the subjects in the TCC group had been regularly practicing classical Yang TCC for at least 3 years.

All subjects were predominantly healthy and were examined by the same physician. Subjects with history of significant cardiovascular, pulmonary, metabolic, or musculoskeletal disease (e.g., joint fracture, joint replacement), or neurological disease (e.g., stroke, Parkinson's disease, dementia, poor vision) were excluded from this study.

Procedures

Body weight was measured on a mechanical dial spring scale (NAGATA, Young Thai Scale Co.) to the nearest 0.1 kg. Height was measured barefoot to the nearest 0.1 cm using a stadiometer (NAGATA). The calibration of all measurement equipment was routinely checked. Body mass index (BMI) was calculated using the formula: body weight (kg)/body height (m)².

Anthropometric measurements were taken for each subject. Skinfold thickness was measured using a Lange caliper (Cambridge Scientific Instruments, Cambridge, MD) and three Site Skinfold Measurements (ExRx.net) were performed on the chests, abdomens, and thighs of the men, and for the women at their triceps, suprailium, and thighs.⁽¹⁵⁾ The anatomical landmarks used to locate the sites in a reproducible manner were those described by The Second National Health and Nutrition Examination Survey (NHANES II).⁽¹⁶⁾ All sites were marked using a wax-based cosmetic pencil. The skinfold measurement was made on the right side of the body and was performed by one technician to eliminate inter-observer error.

Circumferences were measured using fiberglass tape at the non-dominant upper arm. Mid-arm muscle circumference (MAMC or AMC) is considered an index of muscle mass and caloric adequacy. The mid-arm circumference (MAC or AC) is the circum-

ference of the non-dominant arm midway between the shoulder and the elbow.⁽¹⁶⁾ Triceps skinfold thickness (TSF) in millimeters was measured using a Lange skinfold caliper. Assuming the mid-arm muscle mass is a cylinder surrounded by a circumferential layer of skinfold, the MAMC can be calculated from TSF and MAC, according to the formula of MAC (cm) - [0.314 x TSF (mm)].⁽¹⁸⁾

Skinfold and circumference measures were obtained at each site, then duplicate measures were taken. If values did not agree within 1.0 mm for skinfold thickness or 0.5 cm for circumference, additional measures were made. Any outlying values (> 4.0 mm for skinfold thickness and > 1.5 cm for circumference) for a site were eliminated and remaining values were averaged.⁽¹⁷⁾

Body composition analysis was measured using the Inbody 3.0 logo (Biospace), a bioelectrical impedance analysis (BIA) system with input of the subjects' demographic data. Bioelectrical impedance was used to estimate total body water (TBW) and free fat mass (FFM) by measuring the resistance of the body to a small alternating electric current. At multiple frequencies bioelectrical impedance can differentiate the proportions of intra- and extracellular fluid volume. Body composition estimates from single and multi-frequency bioelectrical impedance in healthy individuals are well established.⁽¹⁹⁾ Body composition, including total body weight (kg), intracellular fluid (L), extracellular water (L), body fat (kg), percentage of body fat (%), degree of obesity (%) and lean body mass (kg) were calculated automatically and printed on the result sheet.

Statistical analysis

Data were examined using SPSS statistical software. Descriptive characteristics of the group variables were expressed as mean values and standard

deviations (SD). One-way analysis of variance (ANOVA) was adopted to compare the differences in age, body weight, body height, and body compositions among the three groups. Tukey's Honestly Significant Differences (Tukey's HSD) test was used for post hoc comparisons. The accepted level of statistical significance was $p < 0.05$.

RESULTS

Physical characteristics of the subjects are presented in Table 1. Twenty swimming practitioners (10 men; 10 women; age, 65.4 ± 5.5 years), 31 TCC practitioners (14 men; 17 women; age, 67.8 ± 6.7 years), and 32 healthy and active non-exercise practitioners (14 men; 18 women; age, 67.4 ± 5.7 years) were enrolled in this study. There were no significant differences in age, sex, body height, and body weight among the three groups.

The regional adiposity results measured using a skinfold caliper are shown in Table 2. There was significantly less subcutaneous adipose tissue in the TCC group than the control group at the abdomen ($p = 0.011$) and thighs ($p < 0.001$) of elderly men. Significantly less subcutaneous adipose tissue was found in the swimming group compared with the control group in the thighs for men ($p < 0.001$). Differences in subcutaneous adiposity values between the swimming and TCC groups were not

Table 1. Demographic Data in the Three Groups

	TCC	Control	Swimming	<i>p</i> value
Number	31	32	20	
Gender (M/F)	14/17	14/18	10/10	0.905
Age (years)	67.8 (6.7)	67.4 (5.7)	65.4 (5.5)	0.299
Body weight (kg)	61.6 (10.2)	60.2 (9.6)	62.6 (7.8)	0.691
Body height (cm)	158.5 (8.8)	157.2 (7.0)	157.8 (5.3)	0.752

$p > 0.05$ in groups' comparisons.

Table 2. Fat at Various Parts of the Body Using the Skinfold Measurement among the Three Groups

		TCC	Control	Swimming	<i>p</i> value
Men	Chest (mm)	19.1 (6.4)	24.2 (8.4)	18.6 (7.0)	0.109
	Abdomen (mm)	23.3 (5.3)	29.5 (8.5)	21.0 (5.2)	0.009 [†] (TC*)
	Thigh (mm)	19.5 (5.5)	35.4 (12.9)	15.0 (4.7)	< 0.001 [†] (TC [†] , CS [†])
Women	Triceps (mm)	26.2 (6.5)	29.6 (9.2)	26.2 (4.0)	0.310
	Suprailium (mm)	32.3 (6.5)	27.7 (8.0)	33.8 (7.3)	0.058
	Thigh (mm)	24.9 (8.2)	37.1 (9.6)	29.0 (10.8)	0.001 [†] (TC [†])

Abbreviations: TC: comparison between TCC and control groups; CS: comparison between swimming and control groups; * $p < 0.05$; [†] $p < 0.01$.

statistically significant. In the elderly women, only the skinfold results at the thighs were obviously decreased in the TCC group compared with the control subjects ($p = 0.002$).

As seen in Table 3, muscle weight, fat weight, body fat percentage, and AMC are different between men and women of each group ($p < 0.05$); there were no significant differences between groups, however.

DISCUSSION

There are many different methods used to estimate body fat. Hydrostatic weighing is perhaps the most accurate noninvasive method currently available.⁽²⁰⁾ It is also, however, the most cumbersome technique, and does not measure regional adiposity. Other practical indirect methods for body fat estimation are the use of a skinfold caliper (SC), bioelectrical impedance analysis (BIA), magnetic resonance imaging (MRI), and soft tissue ultrasound (US) measurement.⁽²¹⁾ Dual-energy X-ray absorptiometry (DEXA) may offer an alternate method to estimate total body composition with additional information regarding bone mineral content and density.⁽²²⁾ It is, however, more expensive to use and radiation exposure would have to be closely monitored.

The use of a skinfold caliper is an easy and non-invasive technique for estimating body fat. Calipers can be used to obtain reliable measures of mean fat thickness based on correlations with MRI findings.⁽²¹⁾ Limitations of this method include the inability to palpate the fat-muscle interface and the impossibility of obtaining interpretable measurements on very obese subjects.⁽²⁰⁾

BIA has been clinically proven to be a simple, reliable, and accurate method of assessing percent of

body fat in men and women in the clinical setting.⁽²³⁾ The Inbody 3.0, is accurate regardless of the status of body water distribution, body type or body condition (weak points of traditional BIA). Inclusion of circumference measurement equations added substantially to the accuracy of the impedance method, which makes it an ideal technique that can be implemented in research laboratories as well as non-research clinical settings.

Generalizations of the findings in the present study were limited by several factors. The main limitation of the present study was the cross-sectional design employed. It is possible that genetic factors and lifestyle practices, like diet and housework, influenced the results of the comparisons. To minimize these potential influences, a longitudinal study design may be a better choice. A second factor that may have affected results was subject sampling. The non-probability sampling procedure (with all the subjects being volunteers) may have introduced bias. In addition, the amount of weekly exercise was self-reported. Most importantly, the control group of sedentary subjects, despite their reluctance to participate in TCC or other sports, may lead very active lives- perhaps evidenced by their volunteer work at CGMH. These factors may, in part, explain the minimal significant improvement in the parameters in the intervention groups compared with the control subjects, as has been reported in other studies. Furthermore, the accuracy of BIA and skinfold anthropometry may be biased in the elderly because of inherent assumptions about cellular hydration.⁽²⁰⁾

Swimming and TCC are both popular exercises practiced by the elderly in Taiwan because of their low impact and low to moderate intensity, which can improve the physical fitness. Physical activity, par-

Table 3. Body Composition among the Three Groups

	Men			Women			<i>p</i> value between gender	<i>p</i> value among groups
	TCC	Control	Swimming	TCC	Control	Swimming		
Muscle weight (kg)	47.9 (6.4)	46.2 (5.2)	46.9 (2.3)	35.3 (5.3)	35.9 (3.8)	37.5 (3.9)	< 0.001 [†]	0.661
Fat weight (kg)	16.5 (4.4)	17.3 (3.9)	15.0 (3.6)	19.4 (6.6)	17.2 (4.7)	21.0 (5.9)	0.012*	0.823
Body fat %	24.3 (3.9)	26.0 (3.3)	23.0 (4.1)	33.4 (5.0)	30.7 (5.1)	32.9 (5.4)	< 0.001 [†]	0.786
DO %	114.2 (11.5)	122.9 (14.3)	119.2 (10.3)	121.5 (17.0)	116.4 (16.7)	126.9 (14.1)	0.394	0.566
BMI (kg/m ²)	24.3 (2.7)	25.5 (2.2)	24.9 (2.0)	24.3 (3.7)	23.4 (3.1)	25.6 (3.7)	0.512	0.377
AMC (cm)	22.9 (2.0)	23.3 (1.6)	23.7 (1.0)	20.4 (1.8)	20.4 (1.4)	21.4 (1.3)	< 0.001 [†]	0.150
AC (cm)	29.1 (2.4)	29.8 (2.0)	29.5 (1.7)	28.6 (2.5)	27.7 (2.2)	29.5 (2.9)	0.111	0.477

Abbreviations: DO: degree of obesity; BMI: body mass index; AMC: arm muscle circumference; AC: arm circumference; * $p < 0.05$; † $p < 0.01$.

ticularly endurance exercises, appears to be related to decreased total fat accumulation and less body adiposity in women who remain active as they grow older.⁽¹⁰⁾ In our study, however, there were no significant differences in total body fat among the subjects in the TCC group, swimming group, and control group. Apart from the reason of control-subjects selection bias, energy expenditure may play a role. It is known that vigorous, long duration endurance exercise may decrease body fat;⁽¹²⁾ the exercise intensity of classical TCC, however, is moderate and aerobic in nature.⁽²⁴⁾

In view of the exercise style, TCC and swimming are quite different. Swimming is performed in water without weight bearing, and requires more effort in the upper limbs than lower limbs.⁽²⁵⁾ Tuuri et al. showed that endurance swimming was mildly associated with body adiposity in women.⁽²⁶⁾ Our study, however, showed no differences in the subcutaneous fat of the chests of the men and the triceps of the women. Both styles of exercise and regions of muscle usage may affect the body fat distribution. Swimming styles, like breaststroke, free style and the butterfly all use distinct muscle groups; unfortunately, this influence was not considered when subjects were enrolled.

TCC was developed originally as a martial art and has been used for centuries in China as an exercise that promotes health. The basic exercise of TCC is a series of individual graceful movements in a slow, continuous, circular pattern with the constant body movement of shifting from foot to foot while in a semi-squatting posture.⁽²⁷⁾ It can be hypothesized that the continual isotonic semi-squat posture may have contributed to strong lower extremity muscles. As this study showed, the percentage of fat decrease was higher at waist level and at the lower extremities. The strong lower extremity muscle force may also play a role in better balance as observed in the TCC practitioners.

Women of the TCC group had decreased skin fold at the thighs compared with the control group. It can be hypothesized as to why only the thigh was significantly reduced in women in the TCC group. Prior studies indicate that women tend to have gluteal-femoral fat distribution. The prevalence of abdominal fat distribution was far greater in men than women,⁽²⁸⁾ so that men experience a preferential loss of fat from the central regions of the body due to

endurance exercise training,^(1,13) but women lost from the thighs. Prospective studies reinforce this observation.⁽¹⁷⁾

Conclusion

Exercise training is frequently used during the course of a weight-reduction program. Its beneficial effects on fitness are well accepted. The effect of exercise on body fat loss has been investigated frequently and, despite the large amount of data accumulated, uncertainly still persists concerning what may constitute an 'exercise prescription' for elderly people. High intensity exercise is associated with a preferential mobilization of abdominal fat; moderate aerobic exercise, however, like classical Yang TCC and swimming may be more suitable. Both swimming and TCC were apparently not related to the decrease of total fat accumulation in elderly men and women, as perhaps not enough energy was consumed. Considering the importance of abdominal and thigh fat, however, as correlated with the metabolic complications of obesity,⁽³⁰⁾ the effects of TCC and swimming on the proportion of abdominal or thigh fat could have beneficial effects on the health profile of sedentary individuals.

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游泳及太極拳運動在老年族群體脂肪組成之比較

游東陽 裴育晟 劉耀宗 陳智光 許宏志 黃美涓

背景：脂肪的堆積及肌肉實質的喪失是老年人常見的現象。這項研究是藉由測量皮下脂肪的厚度及身體組成，來觀察太極拳及游泳這兩種適合老年人的運動，對於身體體脂肪比率及分布的影響。

方法：受測者包含規律的游泳者 (20 名)，規律的太極拳運動者 (32 名)；至於對照組則是一些健康且活躍的老年人 (31 名)。皮下脂肪厚度是以 Lange 皮脂夾 (skinfold caliper) 分別量取男性受測者的胸部、腹部和大腿，及女性的上臂、髂骨上和大腿的皮膚皺折厚度；手臂中段周長 (mid-arm circumference) 是以皮尺量取非慣用手的上臂中段周長；至於身體組成是則是用 Inbody 3.0 logo，一種生物電阻分析系統 (Bioelectrical Impedance Analysis, BIA) 來測量。

結果：無論男女老年族群，其體脂肪及手臂肌肉周長在游泳組、太極拳組或對照組之間都沒有明顯差異。男性老年族群且有規律打太極拳者，其腹部 ($p = 0.011$) 和大腿 ($p < 0.001$) 皮下脂肪明顯較正常人為少；而游泳組則是在大腿有明顯的差異 ($p < 0.001$)。至於女性老年族群只有在太極拳組大腿皮下脂肪較對照組為少 ($p = 0.002$)。

結論：無論是打太極拳或游泳運動的老年人似乎都無法減少體內脂肪的量；然而藉由不同部位肌肉的運用，卻可以改變身體脂肪的分布。至於同樣的運動在男女本身對於脂肪的分布也可能有不同的影響。
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關鍵詞：身體組成，脂肪分布，游泳，太極拳

長庚紀念醫院 台北院區 復健科；長庚大學 復健科學研究所

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通訊作者：黃美涓醫師，長庚紀念醫院 復健科。桃園縣333龜山鄉復興街5號。Tel.: (03)3281200轉3846; Fax: (03)3281320; E-mail: walice@adm.cgmh.org.tw