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Original Contribution

Associations of Tai Chi, Walking, and Jogging With Mortality in Chinese Men

Na Wang, Xianglan Zhang*, Yong-Bing Xiang, Honglan Li, Gong Yang, Jing Gao, Wei Zheng, and Xiao-Ou Shu

* Correspondence to Dr. Xianglan Zhang, Division of Epidemiology, Department of Medicine, Vanderbilt University School of Medicine, 2525 West End Avenue, Suite 600, IMPH, Nashville, TN 37203 (e-mail: xianglan.zhang@vanderbilt.edu).

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Moderate-intensity exercise has attracted considerable attention because of its safety and many health benefits. Tai Chi, a form of mind-body exercise that originated in ancient China, has been gaining popularity. Practicing Tai Chi may improve overall health and well-being; however, to our knowledge, no study has evaluated its relationship with mortality. We assessed the associations of regular exercise and specifically participation in Tai Chi, walking, and jogging with total and cause-specific mortality among 61,477 Chinese men in the Shanghai Men's Health Study (2002–2009). Information on exercise habits was obtained at baseline using a validated physical activity questionnaire. Deaths were ascertained through biennial home visits and linkage with a vital statistics registry. During a mean follow-up of 5.48 years, 2,421 deaths were identified. After adjustment for potential confounders, men who exercised regularly had a hazard ratio for total mortality of 0.80 (95% confidence interval: 0.74, 0.87) compared with men who did not exercise. The corresponding hazard ratios were 0.80 (95% confidence interval: 0.72, 0.89) for practicing Tai Chi, 0.77 (95% confidence interval: 0.69, 0.86) for walking, and 0.73 (95% confidence interval: 0.59, 0.90) for jogging. Similar inverse associations were also found for cancer and cardiovascular mortality. The present study provides the first evidence that, like walking and jogging, practicing Tai Chi is associated with reduced mortality.

Chinese; jogging; mortality; Tai Chi; walking

Abbreviations: BMI, body mass index; CI, confidence interval; CVD, cardiovascular disease; MET, metabolic equivalent; SMHS, the Shanghai Men's Health Study.

Physical inactivity is one of the most important lifestyle-related factors associated with increased morbidity and mortality from many chronic diseases (1). Recreational activity has been shown in many prospective studies (2–5) to improve health status and reduce the risk of chronic diseases and related mortality. Relatively few studies, however, have examined the health effects of specific types and intensities of exercise, and the studies that have had inconsistent results (6–8). Moderate-intensity exercise, particularly walking, has increasingly attracted the attention of elderly adults because of its safety and many potential health benefits (9–12). In recent years, mind-body exercises, such as Tai Chi, which originated in ancient China, have been gaining popularity worldwide. Tai Chi, often referred to as "meditation in motion," involves not only body movement but also mental focus and breathing control. Regular practice of this type of exercise may have a beneficial impact on both physical and mental well-being. Growing evidence has suggested that practicing Tai Chi may improve muscle strength, balance, and flexibility and reduce the risk of falls (13). It may also help to reduce stress and improve psychological well-being, the immune system, and overall health (14). Tai Chi has been shown to lower blood pressure (15) and improve the outcomes of heart failure (16, 17) and several other chronic diseases, including fibromyalgia (18), osteoarthritis (19) and Parkinson's disease (20). However, no study to date has evaluated the association between Tai Chi and mortality rates.

Tai Chi is one of the most common forms of exercise among Chinese adults (21). We examined its association with all-cause and cause-specific mortality in a population-based cohort of middle-aged and elderly Chinese men from

the Shanghai Men's Health Study (SMHS). Additionally, we examined the associations of mortality with other major types of exercise, including walking and jogging, and with any exercise.

MATERIALS AND METHODS

Study population

The SMHS is a population-based, prospective cohort study of 61,491 men who were 40–74 years of age at baseline (22). Study participants were recruited from 2002 to 2006 from urban communities in Shanghai. Trained interviewers used a roster of community residents provided by the community office to identify and approach potential participants. Participants with previously diagnosed cancer were excluded. Of the eligible men approached for the study, 61,582 completed an in-person interview, with a response rate of 74.1%. Reasons for nonparticipation included refusal (21%), serious health problems (2%), and absence during the study period (3%). Men who refused to participate in the study were slightly younger than those who enrolled in the study (51.3 years vs. 54.9 years). A structured questionnaire was used to collect information on demographic characteristics, lifestyle habits, dietary intake, occupational history, disease history, and physical activity level. Anthropometric measurements were also taken at baseline. The study protocols were approved by the relevant institutional review boards of all institutes involved. Written informed consent was obtained from all participants.

Assessment of physical activity level

At baseline, participants were asked by trained interviewers who were using a structured physical activity questionnaire to provide information on exercise participation within the 5 years before the interview. Participants were first asked whether they participated in any form of exercise on a weekly basis. Regular exercise was defined as engaging in leisure-time exercise of any type and intensity at least once per week. Men who exercised regularly were further asked to list the 3 exercises in which they most frequently engaged and then were asked questions about the average amount of time spent per week on each exercise and the number of years of participation. In addition to exercise participation, information was also obtained from all participants on other forms of physical activity, including household-, transportation-, and occupation-related physical activity. To assess exercise intensity, a standard metabolic equivalent (MET) score was assigned to each exercise according to previously established criteria (walking, 3.3 METs; Tai Chi, 4.0 METs; jogging, 7.0 METs, etc.) (23). We calculated MET-hours per day for each type of exercise and each other form of physical activity by multiplying the MET score by time spent on the activity. The total MET-hours per day were then estimated by summing the MET-hours per day for each activity.

The reproducibility and validity of the physical activity questionnaire used in the SMHS were evaluated in a random sample of 196 participants and found to be reasonably high (24). The test-retest correlation for exercise participation assessed using the physical activity questionnaire at dates 1 year apart was 0.68. The correlations of exercise reported on the second physical activity questionnaire with exercise reported on 7-day recalls and on activity logs were 0.62 and 0.71, respectively.

Outcome ascertainment

All participants were followed-up for major chronic diseases and vital status through both biennial in-home surveys and data linkage to the Shanghai Cancer Registry and the Shanghai Vital Statistics Registry. The primary endpoint for this analysis was death from any cause that occurred after the baseline survey but before December 31, 2009. Follow-up for participants' vital status was 99% complete. The underlying cause of death was determined based on death certificates and coded according to the *International Classification of Disease, 9th Revision*. In addition to total mortality, we also examined deaths from cancer (codes 140–208) and cardiovascular disease (CVD) (codes 390–459), 2 major causes of death in our study population.

Statistical analysis

We excluded 14 men who were lost to follow-up shortly after study enrollment, leaving 61,477 men for the analyses. A Cox proportional hazard model with age as the time scale was used to estimate hazard ratios and 95% confidence intervals for all-cause and cause-specific mortality in relation to regular exercise and common types of exercise (including Tai Chi, walking, and jogging). Entry time was defined as age at baseline, and exit time was defined as age at death or the end of follow-up (December 31, 2009), whichever came first. Covariates for which we adjusted in multivariable analyses included age; educational level (elementary school or less, middle school, high school, and college or above); income (monthly per capita family income <500, 500–999, 1,000–1,999, and ≥2,000 Chinese Yuan); occupation (professional, clerical, and manual workers); cigarette smoking (tertiles of pack-years of smoking); alcohol intake (0, 0.1–1.0, 1.1–2.0, and >2.0 drinks/day); daily physical activity other than exercise (quintiles); body mass index (BMI; measured as weight (kg)/height $(m)^2$) (quintiles); and previous history of CVD (coronary heart disease, heart failure, and stroke), chronic liver disease, diabetes, hypertension, and pulmonary disease (asthma, emphysema, and chronic bronchitis). We also adjusted for daily intake of total energy, red meat, vegetables, and fruits (continuous). As described previously (22), intake of nutrients was calculated based on the amount of food consumed, which was estimated using a validated food frequency questionnaire, and the Chinese Food Composition Table. We applied the restricted cubic spline function in Cox regression analyses to evaluate the association of time (hours per week) spent on total exercise and the most common types of exercise with mortality. In these analyses, 5 knots were used and placed at the 10th, 25th, 50th, 75th, and 90th percentiles. Finally, we performed sensitivity analyses to assess the potential influence of pre-existing disease on the associations by excluding men who died during the first year of

Table 1. Age-adjusted Baseline Characteristics of the Study Population According to Exercise Status, the Shanghai Men's Health Study, 2002–2006

Characteristic	All Participants ($n = 61,477$)		Nonexercisers ($n = 39,630$)		Exercisers ($n = 21,847$)		*P* Value
	Mean	%	Mean	%	Mean	%	
Age, years	55.4		52.7		60.3		<0.001
Body mass index[a]	23.7		23.7		23.9		<0.001
MET-hours/day[b]	7.5		7.5		7.7		<0.001
≤Middle school education		41.1		43.3		35.9	<0.001
Low income[c]		55.3		56.5		51.6	<0.001
Manual laborer		51.6		53.8		46.2	<0.001
Ever smoked		69.6		73.3		62.6	<0.001
Ever drank alcohol		33.7		34.4		31.5	<0.001
History of cardiovascular disease		4.5		4.5		4.9	0.03
History of diabetes		6.3		5.9		7.1	<0.001
History of hypertension		29.9		28.5		31.7	<0.001
History of chronic liver disease		2.8		2.8		2.8	0.75
History of pulmonary disease		6.8		7.2		6.8	0.02

Abbreviation: MET, metabolic equivalent task.
[a] Weight (kg)/height $(m)^2$.
[b] Physical activity other than exercise.
[c] Monthly per capita family income less than 1,000 Chinese Yuan.

follow-up and men with a history of coronary heart disease, heart failure, or stroke. We also conducted stratified analyses to investigate the potential effect modification by BMI (<25 vs. ≥25) and cigarette smoking (ever vs. never). All analyses were performed using SAS software, version 9.1 (SAS Institute, Inc., Cary, North Carolina), and all tests of statistical significance were based on 2-side probability.

RESULTS

Of the 61,477 men in the SMHS, 35.5% (21,847) regularly engaged in 1 or more exercises, and 57.3% (12,520) of those men spent an average of more than 30 minutes per day on exercise. The most common types of exercise included walking, Tai Chi, and jogging. The age-adjusted baseline characteristics of participants according to regular exercise participation are summarized in Table 1. Compared with men who did not exercise, men who participated in regular exercise were older, had a higher socioeconomic status, and were less likely to have ever drunk alcohol or smoked cigarettes. Regular exercisers tended to have a higher prevalence of CVD, diabetes, and hypertension but a lower prevalence of pulmonary disease.

During a mean follow-up of 5.48 years, 2,421 deaths were documented, including 1,053 from cancer, 800 from CVD, and 568 from other causes. In the initial analyses, which were adjusted for age only, regular participation in any exercise was associated with a 28% reduction in total mortality (hazard ratio = 0.72; 95% confidence interval (CI): 0.66, 0.78). After adjustment for socioeconomic status, BMI, smoking, alcohol consumption, dietary factors, baseline medical conditions, and physical activity other than exercise, the inverse association persisted, with a hazard ratio of 0.80 (95% CI: 0.74, 0.87) (Table 2). The multivariable adjusted hazard ratios for total mortality were 0.80 (95% CI: 0.72, 0.89) for Tai Chi, 0.77 (95% CI: 0.69, 0.86) for walking, and 0.73 (95% CI: 0.59, 0.90) for jogging (Table 2). Regular participation in both Tai Chi and walking was associated with an adjusted hazard ratio for total mortality of 0.69 (95% CI: 0.58, 0.83). Similar associations were also found for cancer mortality and CVD mortality (Table 2).

The dose-response relationships among time spent on total exercise, Tai Chi/walking, and mortality are depicted in Figures 1 and 2. The associations appeared to follow a nonlinear pattern. The lowest mortality rate was seen in men who exercised 5–6 hours per week; further increases in exercise time did not appear to convey additional benefits.

The inverse associations of exercise with total and cause-specific mortality remained when participants with a history of CVD and those with less than 1 year of follow-up were excluded (Table 3). In addition, the inverse associations did not differ significantly by BMI, cigarette smoking, or MET-hours per day from activities other than exercise (data not shown in tables). For example, the hazard ratios for exercisers versus those who did not exercise were 0.82 (95% CI: 0.72, 0.92) in men with a BMI of less than 25 and 0.85 (95% CI: 0.73, 1.00) in men with a BMI of 25 or higher (*P* for interaction = 0.48).

DISCUSSION

In the present large, prospective cohort study of Chinese men, we found that regular participation in exercises that were largely of moderate intensity was associated with a

Table 2. Hazard Ratios for Total and Cause-specific Mortality According to Exercise,[a] the Shanghai Men's Health Study, 2002–2009

	No. of Participants	Cause of Death								
		All Causes			Cancer			CVD		
		No. of Deaths	HR	95% CI	No. of Deaths	HR	95% CI	No. of Deaths	HR	95% CI
Frequency of exercise										
No regular exercise	39,630	1,306	1.00	Referent	572	1.00	Referent	419	1.00	Referent
Any type of exercise	21,847	1,115	0.80	0.74, 0.87	481	0.81	0.71, 0.92	381	0.78	0.66, 0.91
<13.9 MET-hours/week	10,365	424	0.81	0.73, 0.91	180	0.81	0.68, 0.96	147	0.82	0.68, 1.00
≥13.9 MET-hours/week	11,482	691	0.79	0.72, 0.88	301	0.81	0.69, 0.94	234	0.76	0.64, 0.90
Major types of exercise										
Tai Chi[b]	9,726	602	0.80	0.72, 0.89	253	0.78	0.66, 0.91	202	0.77	0.64, 0.92
Walking[b]	10,030	548	0.77	0.69, 0.86	246	0.84	0.72, 0.99	190	0.73	0.61, 0.88
Jogging[b]	3,214	99	0.73	0.59, 0.90	44	0.69	0.51, 0.94	33	0.74	0.52, 1.06
Other exercise	2,027	35	0.78	0.56, 1.10	14	0.65	0.38, 1.10	9	0.72	0.37, 1.40
Both Tai Chi and walking[b]	2,166	134	0.69	0.58, 0.83	62	0.78	0.59, 1.02	41	0.57	0.41, 0.80
Tai Chi without walking[b]	7,560	468	0.84	0.75, 0.93	191	0.79	0.66, 0.94	161	0.83	0.69, 1.01
Walking without Tai Chi[b]	7,864	414	0.79	0.71, 0.89	184	0.87	0.73, 1.04	149	0.78	0.65, 0.95

Abbreviations: CI, confidence interval; HR, hazard ratio; MET, metabolic equivalent.

[a] Adjusted for age; educational level; income; occupation; alcohol consumption; pack-years of smoking; daily intake of energy, red meat, fruits, and vegetables; daily physical activity other than exercise; body mass index; and history of cardiovascular disease, diabetes, hypertension, chronic liver disease, or pulmonary disease.

[b] Additionally adjusted for exercise other than the specific type presented.

significantly reduced risk of death from any cause, CVD, and cancer. In addition, we found the first evidence that practicing Tai Chi was related to reduced mortality, similar to what has been seen with walking and jogging. When performed approximately 5–6 hours per week, these exercises showed the greatest benefit.

Tai Chi is a multicomponent mind-body exercise that combines body movement with mental focus and controlled breathing. It evolved from ancient Chinese martial arts and is widely practiced in middle-aged and elderly Chinese adults. There is a growing interest in the potential health benefits of Tai Chi. It has been suggested that practicing Tai Chi improves strength, balance, flexibility, physical function, psychological well-being, the immune system, and overall health (25, 26). Tai Chi has also been shown to have a beneficial impact on several chronic health conditions (13), including heart failure (16),

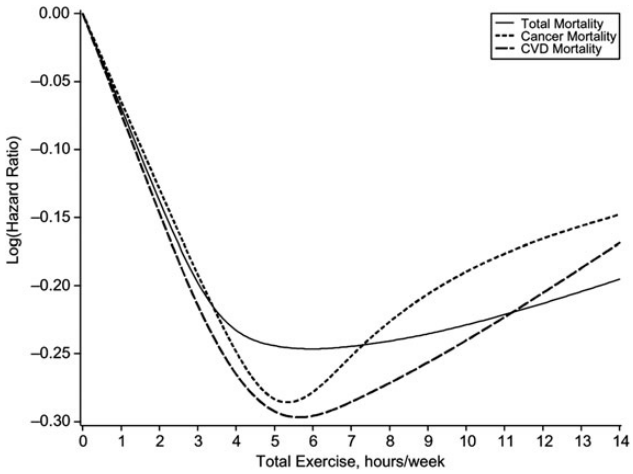

Figure 1. Dose-response relationships between total time spent exercising and total and cause-specific mortality, the Shanghai Men's Health Study, 2002–2009. CVD, cardiovascular disease.

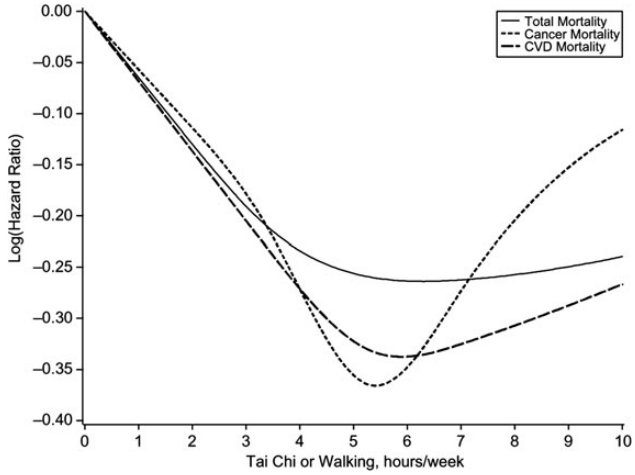

Figure 2. Dose-response relationships between time spent on Tai Chi or walking and total and cause-specific mortality, the Shanghai Men's Health Study, 2002–2009. CVD, cardiovascular disease.

Table 3. Hazard Ratios for Total and Cause-specific Mortality by Exercise[a,b] ($n = 58,505$), the Shanghai Men's Health Study, 2002–2009

	No. of Participants	Cause of Death								
		All Causes			Cancer			CVD		
		No. of Deaths	HR	95% CI	No. of Deaths	HR	95% CI	No. of Deaths	HR	95% CI
No regular exercise	38,288	964	1.00	Referent	493	1.00	Referent	244	1.00	Referent
Any type of exercise	20,217	820	0.83	0.75, 0.92	399	0.80	0.70, 0.93	229	0.83	0.69, 1.01
<13.9 MET-hours/week	9,754	309	0.84	0.73, 0.95	149	0.80	0.66, 0.97	85	0.86	0.67, 1.11
≥13.9 MET-hours/week	10,463	511	0.82	0.73, 0.93	250	0.81	0.68, 0.95	144	0.82	0.66, 1.03
Major types of exercise										
Tai Chi[c]	8,892	440	0.81	0.72, 0.92	207	0.76	0.64, 0.91	121	0.79	0.63, 1.00
Walking[c]	9,085	387	0.80	0.70, 0.90	198	0.83	0.70, 0.99	107	0.79	0.62, 1.00
Jogging[c]	3,116	85	0.79	0.63, 0.99	42	0.74	0.54, 1.02	26	0.90	0.60, 1.36
Other exercise	1,993	30	0.83	0.58, 1.20	14	0.73	0.43, 1.25	7	0.83	0.39, 1.76
Both Tai Chi and walking[c]	1,929	92	0.68	0.55, 0.85	50	0.76	0.55, 1.03	22	0.55	0.35, 0.87
Tai Chi without walking[c]	6,963	348	0.86	0.75, 0.98	157	0.77	0.64, 0.94	99	0.86	0.67, 1.10
Walking without Tai Chi[c]	7,156	295	0.84	0.73, 0.96	148	0.86	0.71, 1.04	85	0.87	0.67, 1.12

Abbreviations: CI, confidence interval; HR, hazard ratio; MET, metabolic equivalent.

[a] Adjusted for age; educational level; income; occupation; alcohol consumption; pack-years of smoking; daily intake of energy, red meat, fruits, and vegetables; daily physical activity other than exercise; body mass index; and history of cardiovascular disease, diabetes, hypertension, chronic liver disease, or pulmonary disease.

[b] Excluding participants who reported a history of CVD at baseline or died within the first year of follow-up.

[c] Additionally adjusted for exercise other than the specific type presented.

fibromyalgia (18), osteoarthritis (19), and Parkinson's disease (20). A systematic review of 22 published studies on Tai Chi and blood pressure indicated that practicing Tai Chi was effective in reducing blood pressure (15). To our knowledge, our study is the first to evaluate Tai Chi in relation to mortality; our finding suggests a potential role of regular Tai Chi practice in reducing mortality.

Our findings of reduced mortality associated with walking and jogging in Chinese men are generally consistent with those of previous studies, which have largely been conducted in Western populations (12, 27). The Harvard Alumni Study (6) demonstrated an inverse association of mortality with walking and with moderate levels of physical activity (4–6 METs); the strongest association was found for vigorous physical activity levels (≥6 METs). A meta-analysis of 18 prospective cohort studies showed that walking was related to a 31% reduced risk of CVD events and a 32% reduced risk of all-cause mortality (9). Prospective studies have also found an association between walking and reduced mortality among persons with type 2 diabetes mellitus (28). Relatively few studies have evaluated physical activity level and mortality in Asian populations. In the Japan Collaborative Cohort Study for Evaluation for Cancer Risk (JACC) study (11), walking and participation in sports were associated with a 20%–50% reduction in mortality from coronary heart disease, stroke, and total CVD. Results from a prospective cohort study in Taiwan (29) revealed that a minimum amount of 15 minutes/day or 90 minutes/week of moderate-intensity exercise was associated with a 14% reduced risk of total mortality. Taken together, these data indicate that regular participation in moderate-intensity exercise increases longevity.

The strengths of our study include the population-based prospective design, large sample size, and high response rates for baseline and follow-up surveys. Information on exercise was collected using a validated questionnaire. Information was also available for a wide range of lifestyles and other potential confounding factors. To our knowledge, this is the first report on Tai Chi in association with mortality. Our study also has some limitations. As with many large-scale epidemiologic studies, in our study, self-reports were used to assess physical activity levels, which could have led to random misclassification and thus an underestimation of the associations. The current analysis examined only physical activity levels assessed at baseline; changes in physical activity over time were not taken into account. Although our sensitivity analyses indicated that pre-existing diseases were unlikely to have seriously biased our findings, we cannot dismiss the possibility of reverse causality completely. In conclusion, our results suggest that regular participation in moderate-intensity exercise, including Tai Chi, walking, and jogging, promotes longevity.

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Author affiliations: Division of Epidemiology, Department of Medicine, Vanderbilt University School of Medicine, Nashville, Tennessee (Na Wang, Xianglan Zhang, Gong Yang, Wei

Zheng, Xiao-Ou Shu); Department of Epidemiology, Shanghai Cancer Institute, Shanghai, China (Yong-Bing Xiang, Honglan Li, Jing Gao); and Department of Epidemiology, School of Public Health, Fudan University, Shanghai, China (Na Wang).

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