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Accessibility
Different Physical Activity Subtypes and Risk of Metabolic Syndrome in Middle-Aged and Older Chinese People

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Abstract

Background: The prevalence of metabolic syndrome (MetS) is growing rapidly in China. Tai chi and dancing are common types of exercise among middle-aged and elderly Chinese. It remains unclear whether these activities are associated with a lower risk of MetS.

Methodology/Principal Findings: A total of 15,514 individuals (6,952 men, 8,562 women) aged 50 to 70 years from the Dongfeng-Tongji Cohort in Shiyan, China participated in a cross-sectional study. Physical activity and other lifestyle factors were assessed with semi-structured questionnaires during face-to-face interviews. MetS was defined by the current National Cholesterol Education Program/Adult treatment Panel III criteria for Asian Americans. The prevalence of MetS was 33.2% in the study population. In the multivariable-adjusted logistic regression analyses, total physical activity levels were monotonically associated with a lower odds of MetS [OR 0.75 comparing extreme quintiles, 95% confidence interval (CI) 0.66–0.86, P<0.001]. Compared with non-exercisers in a specific exercise type, jogging (OR 0.82, 95% CI 0.68–1.00, P=0.046), tai chi (OR 0.72, 95% CI 0.60–0.88, P<0.001), and dancing (OR 0.56, 95% CI 0.47–0.67, P<0.001) were associated with significantly lower odds of MetS. Furthermore, each 1–h/week increment in tai chi and dancing was associated with a 5% (95% CI 2%–9%) and a 9% (95% CI 6%, 12%) lower risk of MetS.

Conclusions/Significance: Jogging, tai chi and dancing are associated with a significantly lower risk of having MetS in middle-aged and older Chinese. Future intervention studies should consider the role of jogging, tai chi and dancing in preventing MetS.


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Introduction

With rapid industrialization and urbanization, China is undergoing an epidemiologic transition of disease burdens with a substantial increase in cardiovascular diseases (CVD), which are now the leading cause of death in China [1]. Metabolic syndrome (MetS) is defined as a cluster of risk factors (central obesity, hypertension, dyslipidemia, and hyperglycemia) [2] and plays a critical role in the development of type 2 diabetes and CVD [3,4]. Studies have consistently shown an inverse association between physical activity levels and risk of MetS [5,6,7], and physical inactivity has been indicated as one of the most important preventable risk factors in China [8]. However, most previous research has focused on overall physical activity levels and specific physical activity types were not assessed, and thus the relations of physical activity subtypes with MetS remain unclear.

Certain specific types of exercise, such as tai chi and dancing, are popular among middle-aged and older Chinese people. Tai chi, the Chinese martial art involving slow and rhythmic movement, has been shown to help people maintain balance and strength [9,10]. Recent studies found that tai chi might be a useful treatment for fibromyalgia [11] and Parkinson’s disease [12] most likely due to its effects on enhancing physical, psychological, and psychosocial well-being and overall quality of life. A randomized controlled trial also suggested that tai chi improved body mass index (BMI), serum lipid profile, C-reactive protein (CRP), and oxidative stress levels [13]. Dancing is a unique phenomenon in China and middle-aged and older people gather...
together to dance in open areas such as parks and streets. Aerobic
dancing has been found to be significantly associated with lower
levels of inflammatory markers such as CRP and fibrinogen [14].
However, it remains unclear whether tai chi and dancing are
associated with MetS.

Since tai chi and dancing are unique and relatively common
types of exercise among middle-aged and older Chinese, the aim
of this study was to examine the associations of different physical
activity subtypes with risk of MetS in a middle-aged and older
Chinese population.

Materials and Methods

Study Participants
The Dongfeng-Tongji Cohort (DFTJ cohort) study was
launched in 2008 among retirees of Dongfeng Motor Corporation
(DMC) in Shiyan City, Hubei province [15]. DMC was founded
in 1969 and is one of the 3 largest auto manufacturers in China.
Between 2008 and 2010, 87% (n = 27,009 out of 31,000) of retired
employees who agreed to answer the questionnaires and provide
baseline blood samples were recruited. For this study, participants
were excluded if they were younger than 50 years old, had a history
of cancer, diabetes, CVD, or stroke, had missing data on one of
the exercise subtypes, on one component of MetS diagnostic, or
one of the demographic variables (age, sex, and education).

Data Collection
Baseline data were collected by trained interviewers via semi-
structured questionnaires during face-to-face interviews. The
questionnaire was designed based on 6 pilot surveys among this
population. Information on socio-demographic factors, health
status, and lifestyle practices (including dietary factors and physical
activity) was included in the questionnaire. Standing height, body
weight, and waist circumference were measured with participants
in light indoor clothing and without shoes. Body mass index was
calculated as weight in kilograms divided by height in meters
squared. Two researchers independently entered the baseline data
from questionnaires and data were further checked by a third
researcher when differences were found.

All subjects were examined in the morning after an overnight
fast. Fasting blood was drawn with a vacuum coagulation tube for
serum, with five milliliters in the tube. Serum triglyceride, blood
glucose, and high-density lipoprotein (HDL) cholesterol were
gathered as current smokers, ex-smokers, and nonsmokers. Other
variables were dichotomized as yes or no on the basis of the
responses to questions on current use of alcohol, antihypertensive
drug, aspirin, and antibiotics, and family history of CVD, diabetes mellitus and stroke.

Definition of the Metabolic Syndrome
MetS was defined using the updated National Cholesterol
Education Program/Adult treatment Panel III criteria for Asian
Americans as having ≥3 of the following components: waist
circumference ≥90 cm for men or ≥80 cm for women; triglycerides (TG) ≥1.7 mmol/L; high density lipoprotein (HDL) cholesterol
<1.03 mmol/L for men or <1.30 mmol/L for women;
blood pressure ≥130/85 mmHg or current use of antihypertensive
medications; or fasting glucose ≥5.6 mmol/L [18].

Ethical Considerations
The study was approved by the Medical Ethics Committee of
the School of Public Health, Tongji Medical College, and
Dongfeng General Hospital, DMC. All participants provided
written informed consent.

Statistical Analysis
All statistical analyses were performed using SAS 9.2 software
(SAS institute, Cary, NC). Categorical variables were expressed in
percentages and continuous variables were expressed in means ±
SD for normally distributed data or medians (interquartile ranges)
for skewed parameters. Differences in the variables by different
levels and types of physical activity were assessed by either a
general linear regression model for continuous variables or
a logistic regression model for categorical variables. Multivariable
adjusted odds ratios (ORs) and 95% confidence intervals (CIs) for
MetS and its components with the logistic regression model were
computed. The multivariable model adjusted for age, sex,
education, smoking, alcohol drinking, use of antihypertensive
drugs, aspirin use, the use of glucose lowering or lipid-lowering
medications, family history of CVD, stroke, and diabetes mellitus,
and several dietary factors (daily intakes of meat, fruit, vegetable,
and nuts, all in quintiles). A two-sided P value <0.05 was
considered significant.

Results

Descriptive Characteristics
Based on exclusion criteria, 719 participants younger than
50 years old, 1463 cancer patients, 3197 diabetics, 4343 CVD
patients, 1128 stroke patients, 3698 participants with missing data
on one of the exercise subtypes or one component of MetS
diagnostic criteria, and 390 participants with one of the de-
mographic variables missing were excluded. After excluding these
participants, a total of 15,514 individuals (6952 men, 8562 women)
were included in this study. The prevalence of MetS was 33.2% in
the total sample, 27.4% in men, and 37.8% in women. Characteristics of the study population according to quintiles of
physical activity levels are summarized in Table 1. Individuals with
higher levels of total physical activity were less likely to be current
smokers, and more likely to be current drinkers, use aspirin, and
have a lower body mass index and waist circumference.
The association between weekly duration of activity subtypes and the MetS was also examined. In the multivariate logistic regression, each 1-h/week increment in tai chi and dancing was significantly associated with lower odds of MetS, while the other subtypes were not statistically significant. Moreover, by categorizing exercise frequencies into 5 groups (0, 0.1–2.0, 2.1–3.5, 3.6–6.0, >6.0 hrs/week), only dancing (P for trend <0.001), tai chi (P for trend = 0.002), and jogging (P for trend = 0.044) showed a significant inverse dose-response relationship with risk of having MetS (Table 3).

Table 4 showed the associations of weekly exercise duration with biomarkers, blood pressures, and waist circumference. Total physical activity levels were inversely associated with risk of MetS (Q5 vs. Q1 OR 0.75, 95% CI 0.66–0.86; P for trend <0.001), as displayed in Figure 1. The association between specific types of physical activity and risk of MetS (Table 2) was further assessed. In this analysis, all the subtypes of physical activity were entered into the model simultaneously. Brisk walking was the most common type of physical activity (80.3% of the participants reported that they walked regularly, n = 12437). The percentage of regularly participating in other types of physical activity ranged from 0.9% for swimming to 18.8% (n = 2923) for climbing mountains or stairs. Approximately 6.2% (n = 962) and 8.0% (n = 1236) of participants engaged in tai chi and dancing, respectively. Among those who reported specific types of activity, the mean weekly duration of exercise subtypes varied from 3.1 hrs/week for swimming to 6.0 hrs/week for walking, with most weekly durations being around 4 hrs/week. In the multivariable-adjusted model, only jogging, tai chi and dancing were found to be significantly associated with lower odds of MetS, and the respective corresponding ORs were 0.82 (95% CI 0.68–1.00), 0.72 (95% CI 0.60–0.88) and 0.56 (95% CI 0.47–0.67), comparing people who performed jogging, tai chi and dance with participants who did not.

Relations between Physical Activity Subtype and the MetS

Multivariate logistic regression model indicated that total physical activity levels were inversely associated with risk of MetS (Q5 vs. Q1 OR 0.75, 95% CI 0.66–0.86; P for trend <0.001), as displayed in Figure 1. The association between specific types of physical activity and risk of MetS (Table 2) was further assessed. In this analysis, all the subtypes of physical activity were entered into the model simultaneously. Brisk walking was the most common type of physical activity (80.3% of the participants reported that they walked regularly, n = 12437). The percentage of regularly participating in other types of physical activity ranged from 0.9% for swimming to 18.8% (n = 2923) for climbing mountains or stairs. Approximately 6.2% (n = 962) and 8.0% (n = 1236) of participants engaged in tai chi and dancing, respectively. Among those who reported specific types of activity, the mean weekly duration of exercise subtypes varied from 3.1 hrs/week for swimming to 6.0 hrs/week for walking, with most weekly durations being around 4 hrs/week. In the multivariable-adjusted model, only jogging, tai chi and dancing were found to be significantly associated with lower odds of MetS, and the respective corresponding ORs were 0.82 (95% CI 0.68–1.00), 0.72 (95% CI 0.60–0.88) and 0.56 (95% CI 0.47–0.67), comparing people who performed jogging, tai chi and dance with participants who did not.

The association between weekly duration of activity subtypes and risk of MetS was also examined. In the multivariate logistic regression, each 1-h/week increment in tai chi and dancing was associated with a 5% (95% CI 2%–9%) and a 9% (95% CI 6%–12%) lower risk of MetS, while the other subtypes were not statistically significant. Moreover, by categorizing exercise frequencies into 5 groups (0, 0.1–2.0, 2.1–3.5, 3.6–6.0, >6.0 hrs/week), only dancing (P for trend <0.001), tai chi (P for trend = 0.002), and jogging (P for trend = 0.044) showed a significant inverse dose-response relationship with risk of having MetS (Table 3).
physical activity was associated with lower TG and blood glucose levels; each 5 MET-hrs/week increase was associated with 0.009 mmol/L (95% CI 0.005–0.013) decrease in TG, 0.008 mmol/L (95% CI 0.003–0.013) decrease in blood glucose, and 0.1 cm decrease in waist circumference. Furthermore, each 1-h/week increment in dancing was significantly associated with lower TG (−0.023 mmol/L, 95% CI −0.035–0.012, P<0.001), blood glucose (−0.024 mmol/L, 95% CI −0.040–0.008, P=0.003), systolic (−0.430 mmHg, 95% CI −0.646–0.214, P<0.001) and diastolic blood pressures (−0.177 mmHg, 95% CI −0.308–0.046, P=0.008), waist circumference (−0.305 cm, 95% CI −0.417–0.194, P<0.001), and higher HDL (0.008 mmol/L, 95% CI 0.003–0.013, P=0.003). For tai chi, each 1-h/week increment was associated with lower TG (−0.023 mmol/L, 95% CI −0.039–0.008, P=0.003), blood glucose (−0.014 mmol/L, 95% CI −0.034–0.006, P=0.17), systolic (−0.059 mmHg, 95% CI −0.341–0.223, P=0.68) and diastolic blood pressures (−0.198 mmHg, 95% CI −0.369–0.028, P=0.023), waist circumference (−0.325 cm, 95% CI −0.471–0.180, P<0.001), and higher HDL (0.004 mmol/L, 95% CI −0.003–0.011, P=0.22). In addition, each 1-h/week increment in jogging was significantly associated with lower TG (−0.019 mmol/L, 95% CI −0.034–0.004, P=0.015), lower waist circumference (−0.219 mmol/L, 95% CI −0.362–0.075, P=0.003), and higher HDL (0.008 mmol/L, 95% CI 0.001–0.0014, P=0.023).

**Discussion**

We found a significant inverse association between total physical activity levels and risk of MetS among middle-aged and older Chinese people. Among subtypes of activities, the benefits of tai chi and dancing were particularly pronounced. Furthermore, there was a dose-response relationship between weekly duration (hrs/wk) of tai chi and dancing and lower risk of MetS. To the best of our knowledge, this is the first study to investigate different physical activity subtypes, especially the unique activities among

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**Table 2.** Odds ratio and 95% CI for MetS by types of physical activity.

<table>
<thead>
<tr>
<th>Subtype of physical activity</th>
<th>No (%)</th>
<th>Frequency (hrs/wk)</th>
<th>MetS, Model 1a</th>
<th>MetS, Model 2b</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>OR (95% CI)</td>
<td>OR (95% CI)</td>
</tr>
<tr>
<td>Walking</td>
<td>12437 (80.2)</td>
<td>6.0±4.9</td>
<td>1.03 (0.95, 1.12)</td>
<td>0.90 (0.80, 1.03)</td>
</tr>
<tr>
<td>Biking</td>
<td>1160 (7.5)</td>
<td>3.9±3.3</td>
<td>0.89 (0.77, 1.02)</td>
<td>0.91 (0.76, 1.09)</td>
</tr>
<tr>
<td>Dancing</td>
<td>1236 (8.0)</td>
<td>4.5±3.4</td>
<td>0.59 (0.52, 0.68)</td>
<td>0.56 (0.47, 0.67)</td>
</tr>
<tr>
<td>Tai chi</td>
<td>962 (6.2)</td>
<td>4.0±3.0</td>
<td>0.71 (0.61, 0.82)</td>
<td>0.72 (0.60, 0.88)</td>
</tr>
<tr>
<td>Gym</td>
<td>492 (3.2)</td>
<td>3.3±2.4</td>
<td>0.96 (0.76, 1.22)</td>
<td>1.00 (0.78, 1.28)</td>
</tr>
<tr>
<td>Ball games</td>
<td>959 (6.2)</td>
<td>4.2±3.3</td>
<td>0.81 (0.70, 0.94)</td>
<td>0.91 (0.75, 1.09)</td>
</tr>
<tr>
<td>Jogging</td>
<td>948 (6.1)</td>
<td>3.9±3.0</td>
<td>0.79 (0.68, 0.92)</td>
<td>0.82 (0.68, 1.00)</td>
</tr>
<tr>
<td>Swimming</td>
<td>145 (0.9)</td>
<td>3.1±2.4</td>
<td>0.88 (0.60, 1.28)</td>
<td>0.82 (0.50, 1.34)</td>
</tr>
<tr>
<td>Climbing</td>
<td>2923 (18.8)</td>
<td>4.3±3.4</td>
<td>0.99 (0.90, 1.08)</td>
<td>1.06 (0.95, 1.19)</td>
</tr>
</tbody>
</table>

*aModel 1: adjusted for age, sex, education levels. Physical activity subtypes were treated as bivariate and nonexercisers in the subtype were set as reference group.

*bModel 2: additionally adjusted for smoking, alcohol drinking, use of antihypertension drugs, aspirin, glucose lowering drugs and lipid-lowering drugs, family history of CVD, stroke and diabetes mellitus, and meat intake quintile, fruit and vegetable intake quintile, and consumption of nuts quintile.

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<table>
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<th>Physical activity subtypes</th>
<th>Physical activity levels (hrs/wk)</th>
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<tr>
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<td>0</td>
<td>0.1–2.0</td>
<td>2.1–3.5</td>
<td>3.6–6.0</td>
<td>&gt;6.0</td>
</tr>
<tr>
<td>Dancing</td>
<td>No. of cases</td>
<td>4845</td>
<td>77</td>
<td>92</td>
<td>75</td>
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<tr>
<td></td>
<td>No. of persons</td>
<td>14310</td>
<td>275</td>
<td>342</td>
<td>320</td>
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<tr>
<td></td>
<td>Model 1^a OR (95% CI)</td>
<td>1.00</td>
<td>0.72 (0.55, 0.95)</td>
<td>0.65 (0.51, 0.83)</td>
<td>0.55 (0.42, 0.72)</td>
</tr>
<tr>
<td></td>
<td>Model 2^b OR (95% CI)</td>
<td>1.00</td>
<td>0.59 (0.40, 0.86)</td>
<td>0.68 (0.50, 0.93)</td>
<td>0.54 (0.39, 0.75)</td>
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<td>Tai chi</td>
<td>No. of cases</td>
<td>4877</td>
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<td>104</td>
<td>48</td>
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<td>No. of persons</td>
<td>14570</td>
<td>227</td>
<td>338</td>
<td>197</td>
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<td></td>
<td>Model 1^a OR (95% CI)</td>
<td>1.00</td>
<td>0.66 (0.49, 0.89)</td>
<td>0.80 (0.63, 1.01)</td>
<td>0.59 (0.42, 0.82)</td>
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<td>Model 2^b OR (95% CI)</td>
<td>1.00</td>
<td>0.59 (0.40, 0.88)</td>
<td>0.83 (0.61, 1.13)</td>
<td>0.62 (0.41, 0.94)</td>
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<tr>
<td>Biking</td>
<td>No. of cases</td>
<td>4846</td>
<td>88</td>
<td>88</td>
<td>50</td>
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<td></td>
<td>No. of persons</td>
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<td>348</td>
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<td>1.00</td>
<td>0.90 (0.70, 1.16)</td>
<td>1.08 (0.85, 1.36)</td>
<td>0.70 (0.51, 0.96)</td>
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<td>Model 2^b OR (95% CI)</td>
<td>1.00</td>
<td>0.88 (0.63, 1.22)</td>
<td>1.23 (0.91, 1.65)</td>
<td>0.78 (0.52, 1.18)</td>
</tr>
<tr>
<td>Walking</td>
<td>No. of cases</td>
<td>1080</td>
<td>619</td>
<td>937</td>
<td>738</td>
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<td></td>
<td>No. of persons</td>
<td>3347</td>
<td>227</td>
<td>338</td>
<td>197</td>
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<tr>
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<td>0.97 (0.86, 1.09)</td>
<td>0.98 (0.86, 1.09)</td>
<td>1.00 (0.89, 1.12)</td>
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<tr>
<td></td>
<td>Model 2^b OR (95% CI)</td>
<td>1.00</td>
<td>0.86 (0.73, 1.02)</td>
<td>0.90 (0.76, 1.06)</td>
<td>0.93 (0.77, 1.11)</td>
</tr>
<tr>
<td>Gym</td>
<td>No. of cases</td>
<td>4997</td>
<td>55</td>
<td>52</td>
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<tr>
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<td>No. of persons</td>
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<td>166</td>
<td>92</td>
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<td>Model 1^a OR (95% CI)</td>
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<td>1.11 (0.79, 1.54)</td>
<td>0.95 (0.68, 1.32)</td>
<td>0.69 (0.43, 1.12)</td>
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<td>Model 2^b OR (95% CI)</td>
<td>1.00</td>
<td>1.32 (0.88, 1.97)</td>
<td>0.99 (0.65, 1.50)</td>
<td>0.52 (0.27, 0.99)</td>
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<tr>
<td>Ball games</td>
<td>No. of cases</td>
<td>4881</td>
<td>70</td>
<td>79</td>
<td>56</td>
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<td>No. of persons</td>
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<td>271</td>
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<td>0.79 (0.60, 1.04)</td>
<td>0.83 (0.63, 1.08)</td>
<td>0.80 (0.59, 1.10)</td>
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<td>0.95 (0.66, 1.35)</td>
<td>0.92 (0.65, 1.30)</td>
<td>0.95 (0.64, 1.42)</td>
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<td>Jogging</td>
<td>No. of cases</td>
<td>4903</td>
<td>73</td>
<td>75</td>
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<td>No. of persons</td>
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<td>294</td>
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<td>1.00</td>
<td>0.86 (0.66, 1.13)</td>
<td>0.75 (0.58, 0.99)</td>
<td>0.73 (0.52, 1.02)</td>
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<td>1.00</td>
<td>0.90 (0.64, 1.26)</td>
<td>0.80 (0.57, 1.13)</td>
<td>0.77 (0.50, 1.19)</td>
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<tr>
<td>Swimming</td>
<td>No. of cases</td>
<td>5106</td>
<td>18</td>
<td>11</td>
<td>7</td>
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<tr>
<td></td>
<td>No. of persons</td>
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<td>60</td>
<td>42</td>
<td>25</td>
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<tr>
<td></td>
<td>Model 1^a OR (95% CI)</td>
<td>1.00</td>
<td>1.06 (0.61, 1.86)</td>
<td>0.88 (0.44, 1.77)</td>
<td>1.04 (0.43, 2.50)</td>
</tr>
<tr>
<td></td>
<td>Model 2^b OR (95% CI)</td>
<td>1.00</td>
<td>1.14 (0.56, 2.35)</td>
<td>1.38 (0.57, 3.34)</td>
<td>0.39 (0.12, 1.32)</td>
</tr>
<tr>
<td>Climbing</td>
<td>No. of cases</td>
<td>4254</td>
<td>216</td>
<td>289</td>
<td>206</td>
</tr>
<tr>
<td></td>
<td>No. of persons</td>
<td>12658</td>
<td>698</td>
<td>925</td>
<td>630</td>
</tr>
<tr>
<td></td>
<td>Model 1^a OR (95% CI)</td>
<td>1.00</td>
<td>1.00 (0.85, 1.18)</td>
<td>0.98 (0.85, 1.14)</td>
<td>1.07 (0.90, 1.27)</td>
</tr>
<tr>
<td></td>
<td>Model 2^b OR (95% CI)</td>
<td>1.00</td>
<td>1.10 (0.89, 1.37)</td>
<td>1.06 (0.88, 1.28)</td>
<td>1.13 (0.90, 1.41)</td>
</tr>
</tbody>
</table>

*aModel 1: adjusted for age, sex, education levels.
*bModel 2: additionally adjusted for smoking, alcohol drinking, use of antihypertension drugs, aspirin, glucose lowering drugs and lipid-lowering drugs, family history of CVD, stroke and diabetes mellitus, and meat intake quintile, fruit and vegetable intake quintile, consumption of nuts quintile, and other physical activity types.

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middle-aged and older Chinese including tai chi and dancing, and risk of MetS.

Our results are consistent with previous studies of total physical activity levels in relation to risk of MetS [5,6,7]. They are also consistent with previous analyses showing benefits of moderate and vigorous intensity activity on MetS [19]. In a previous study, tai chi improved patients’ serum lipid profile including TG and HDL cholesterol [13]. Our study extended the literature showing tai chi improved patients’ serum lipid profile including TG and HDL cholesterol [13]. However, risk of MetS [20,21]. As a mind-body exercise, tai chi may improve immune function and reduce anxiety and mood disturbance, which can lead to enhanced physical, psychological, and psychosocial well-being and overall quality of life [22,23]. Dancing has also been shown to produce improvements in psychological well-being and has been used as a psychotherapy [24,25]. Furthermore, unlike individual sports like biking, jogging, and swimming, dancing is a popular group exercise among middle-aged and older Chinese; individuals form organized dancing groups and perform a variety of dances (ballroom and folk dancing are most common) in open spaces such as parks and streets in the mornings and evenings. In addition to increased physical activity levels, the group members are likely to have enhanced social support and exert positive influences on each other’s lifestyles. A recent study has shown the important effect of social networks on dietary patterns [26].

Our findings have important public health implications. The prevalence of type 2 diabetes and CVD has increased dramatically in the past several decades in countries that are undergoing rapid nutrition transitions such as China [27,28], and the control of non-communicable diseases has become a bottleneck to China’s social and economic development [29]. It has been noted that total physical activity levels are declining dramatically in China due to urbanization [16,30]. However, rapid industrialization and

Table 4. Differences in biomarkers and blood pressure by physical activity subtypes.

<table>
<thead>
<tr>
<th>MET</th>
<th>TG (mmol/L)</th>
<th>HDL (mmol/L)</th>
<th>Glucose (mmol/L)</th>
<th>SBP (mm Hg)</th>
<th>DBP (mm Hg)</th>
<th>WC (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MET</td>
<td>–0.009</td>
<td>0.001</td>
<td>–0.008</td>
<td>–0.021</td>
<td>–0.038</td>
<td>–0.099</td>
</tr>
<tr>
<td>P&lt;0.001</td>
<td>0.15</td>
<td>0.033</td>
<td>0.56</td>
<td>0.07</td>
<td>–0.001</td>
<td></td>
</tr>
<tr>
<td>Walking</td>
<td>–0.001</td>
<td>0.002</td>
<td>0.009</td>
<td>–0.015</td>
<td>–0.013</td>
<td>–0.013</td>
</tr>
<tr>
<td>P</td>
<td>0.65</td>
<td>0.38</td>
<td>0.80</td>
<td>0.48</td>
<td>0.47</td>
<td></td>
</tr>
<tr>
<td>Biking</td>
<td>–0.015</td>
<td>0.002</td>
<td>–0.018</td>
<td>–0.068</td>
<td>0.047</td>
<td>–0.029</td>
</tr>
<tr>
<td>P</td>
<td>0.037</td>
<td>0.06</td>
<td>0.61</td>
<td>0.56</td>
<td>0.68</td>
<td></td>
</tr>
<tr>
<td>Dancing</td>
<td>–0.023</td>
<td>0.008</td>
<td>–0.024</td>
<td>–0.430</td>
<td>–0.177</td>
<td>–0.305</td>
</tr>
<tr>
<td>P</td>
<td>&lt;0.001</td>
<td>0.003</td>
<td>&lt;0.001</td>
<td>0.008</td>
<td>&lt;0.001</td>
<td></td>
</tr>
<tr>
<td>Tai chi</td>
<td>–0.023</td>
<td>0.004</td>
<td>–0.014</td>
<td>–0.059</td>
<td>–0.198</td>
<td>–0.325</td>
</tr>
<tr>
<td>P</td>
<td>0.003</td>
<td>0.22</td>
<td>0.68</td>
<td>0.023</td>
<td>&lt;0.001</td>
<td></td>
</tr>
<tr>
<td>Gym</td>
<td>–0.010</td>
<td>0.013</td>
<td>–0.017</td>
<td>0.088</td>
<td>–0.057</td>
<td>–0.209</td>
</tr>
<tr>
<td>P</td>
<td>0.44</td>
<td>0.07</td>
<td>0.69</td>
<td>0.09</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ball games</td>
<td>–0.007</td>
<td>0.003</td>
<td>–0.019</td>
<td>–0.156</td>
<td>–0.087</td>
<td>–0.148</td>
</tr>
<tr>
<td>P</td>
<td>0.30</td>
<td>0.21</td>
<td>0.24</td>
<td>0.20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jogging</td>
<td>–0.019</td>
<td>0.008</td>
<td>–0.007</td>
<td>–0.066</td>
<td>–0.011</td>
<td>–0.219</td>
</tr>
<tr>
<td>P</td>
<td>0.015</td>
<td>0.52</td>
<td>0.64</td>
<td>0.90</td>
<td>0.003</td>
<td></td>
</tr>
<tr>
<td>Swimming</td>
<td>–0.003</td>
<td>0.002</td>
<td>–0.048</td>
<td>0.151</td>
<td>0.167</td>
<td>0.193</td>
</tr>
<tr>
<td>P</td>
<td>0.89</td>
<td>0.13</td>
<td>0.73</td>
<td>0.52</td>
<td>0.38</td>
<td></td>
</tr>
<tr>
<td>Climbing</td>
<td>–0.006</td>
<td>0.004</td>
<td>–0.017</td>
<td>0.149</td>
<td>0.014</td>
<td>0.065</td>
</tr>
<tr>
<td>P</td>
<td>0.15</td>
<td>0.004</td>
<td>0.06</td>
<td>0.76</td>
<td>0.11</td>
<td></td>
</tr>
</tbody>
</table>

*For 5 MET hrs/week increase. Adjusted for age, sex, education levels, smoking, alcohol drinking, use of antihypertension drugs, aspirin, glucose lowering drugs and lipid-lowering drugs, family history of CVD, stroke and diabetes mellitus, and meat intake quintile, fruit and vegetable intake quintile, and consumption of nuts quintiles. Adjusted for age, sex, education levels, smoking, alcohol drinking, use of antihypertension drugs, aspirin, glucose lowering drugs and lipid-lowering drugs, family history of CVD, stroke and diabetes mellitus, and meat intake quintile, fruit and vegetable intake quintile, consumption of nuts quintiles, and other physical activity types.

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lifestyle changes may also influence the popularity of traditional Chinese exercises, such as tai chi and Chinese folk dancing. Interestingly, western ballroom dancing has increasingly gained popularity in China in recent years. Since these activities are likely to have beneficial effects on both physical health and psychosocial well-being, they can be widely recommended to the general population, especially to the middle-aged and older individuals who are at higher risk of developing MetS.

This study has several limitations. First, the cross-sectional nature of the study design limits a causal inference because it is possible that individuals who were diagnosed with chronic diseases such as hypertension or dyslipidemia might have changed their physical activity levels. However, we excluded patients with diabetes, CVD, stroke, or cancer were excluded from the analyses. Second, the role of unmeasured or residual confounding cannot be ruled out although the multivariate models adjusted for a wide range of CVD risk factors as well as several dietary factors that have been implicated in the development of MetS or its individual subtypes.

In conclusion, this study has shown that tai chi and dancing are associated with a significantly lower risk of MetS in a middle-aged and older Chinese population, with additional benefits as exercise frequency increases. Future intervention studies should consider the role of these activities in prevention of MetS and CVD.

Author Contributions
Conceived and designed the experiments: MH X. Min XZ PY XL Y. Liu JY WC LZ WF Y. Liang YW X.iao ML PZ DL HG HY FH TW. Performed the experiments: MC MH X. Min AP XZ PY XL Y. Liu JY WC LZ WF Y. Liang YW X.iao ML PZ DL HG HY FH TW. Analyzed the data: MC AP. Wrote the paper: MC FH TW.

References