Original Article

Negative Association of Domestic Activity and Active Commuting with Metabolic Syndrome in a Chinese Population Aged 35-64 Years*

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Abstract

Objective To understand the associations of physical activity domains with metabolic syndrome among a middle-aged Chinese population.

Methods In all, 3326 professional adults aged 35-64 years from Beijing and Zhejiang province were recruited with a cluster random sampling method. The Global Physical Activity Questionnaire was modified, and the recommended Asia-Pacific cut-offs of waist circumstance were introduced into the criteria for metabolic syndrome from the Adult Treatment Panel III. A binary logistic regression model was applied to examine the association of all physical activity domains with the risk of the syndrome.

Results Participants who engaged in domestic activity for ≥1176 MET-min/week had a 41.6% less chance of having metabolic syndrome [odds ratio (OR), 0.584; 95% confidence interval (CI), 0.480-0.710] than those without this activity. In adjusted models, adults who actively commuted for ≥33 MET-min/week but <528 MET-min/week had a 25% less chance of having the syndrome (OR, 0.750; 95% CI, 0.582-0.966) than those who did not. No interaction was detected between the two domains of activity and the syndrome.

Conclusion This study highlighted the independently negative association of traffic and house activity with the prevalence of the syndrome in this sample with a generally low level of moderate activity.

Key words: Physical activity; Activities of daily living; Metabolic syndrome X

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INTRODUCTION

Insufficient physical activity contributes to 3.2 million deaths and 69.3 million disability-adjusted life years (DALYs) around the world each year[1], ranked higher even than smoking, obesity, or high blood pressure among the causes of heart disease[2]. Even in China, it accounted for about 5% DALYs in 2010[3]. Metabolic syndrome (MS) is defined as a pattern of metabolic disturbances[4], and people with this syndrome are at increased risk of developing diabetes mellitus and cardiovascular diseases (CVDs)[5-6]. It is evident that physical activity (PA) plays a role in preventing and controlling MS[7], and all domains of PA have been advocated when considering approaches to reduce the risk of MS[8]. In

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China, approximately one-fifth of adults have this disorder[9], warranting urgent action through national strategies to manage the increased burden. Although lower level of total PA has been identified as an independent risk factor for MS in China[10], studies of the effects from all domains of PA are still limited. This study aimed to examine the association of PA domains with MS among a 35-64-year-old Chinese population.

METHODS

Study Population

This analysis was within the framework of a cohort study project named Study on Major Chronic Disease Risk Assessment System and Related Technology Developing and Application, one of the key projects in the National Science & Technology Pillar Program during the Eleventh Five-year Plan Period in China. A cluster random sampling method was used in this project. At the first step, two districts in Beijing-Haidian and Shunyi-and two cities in Zhejiang province-Jiaxing and Tongxiang-were selected. At the second step, two separate and economically similar streets/townships in each district/city were determined. At the third step, in each street/township, two or three adjacent communities/villages were chosen. At the last step, about 2000 apparently healthy adults aged 35-64 years were hoped to be recruited from each community/village. Finally, a total of 7800 adults aged 35-64 years from Zhejiang province and Beijing with informed consent were involved in the baseline survey, which was conducted from April to June in 2010. The study protocols were approved by the Ethical Review Committee of the National Center for Chronic and Noncommunicable Disease Control and Prevention, Chinese Center for Disease Control and Prevention. All the participants signed informed consent after comprehensive interpretation.

We aimed to understand the association of all PA domains with MS in this study, and because agricultural work in China was often shaped by seasonal constraints, only those employees who were never engaged in any agricultural work during the previous year were selected for this present analysis. In the end, a total of 3326 adult employees were included.

Assessment of PA

The Global Physical Activity Questionnaire (GPAQ)[11] was revised in this project. During a face-to-face interview, researchers inquired about the frequency and accumulated minutes of at least 10 min per day of occupational activity (OA), domestic activity (DA), active commuting (AC), and leisure time physical activity (LTPA) during a typical week. For each PA domain, the accumulated minutes of moderate or vigorous activity were asked according to the GPAQ.

For OA, the participants were asked, '*What is the intensity of your occupational activity*?', and four choices was given: (i) Reading or talking while sitting during most working day; (ii) Light-intensity activity with upper and lower limbs involved (e.g., sewing or selling) during most working days; (iii) Moderate-intensity activity without great effort (e.g., construction) during most working days; and (iv) High-intensity activity with great effort during most working days (e.g., manual handling and lifting). According to the *Compendium of Physical Activities*[12] and the GPAQ, metabolic equivalents (METs) of 1.5, 2.3, 2.8, and 3.8 were assigned to the above four types of OA, respectively. Because only 94 adults (2.82%) reported engaging in 'High-intensity activity with great effort during most working days,' the intensity categories of OA were sedentary (1.5 METs), light (2.3 METs), and moderate (2.8 METs or 3.8 METs) in this analysis.

Accordingly, 4.0 METs and 3.3 METs were defined for bicycling and walking with 4.0 METs and 8.0 METs for moderate and vigorous intensity LTPA, respectively. For the DA intensity, we summarized the most common types of activities listed in the Compendium, and an average 2.8 METs was assigned. Then, the activity volume (MET-min/week) for each PA domain was calculated: activity volume = minutes performed $\times$ METs value $\times$ days.

Assessment of MS Components

Height, weight, and waist circumference (WC) were measured in the morning before breakfast by using standard methods according to the survey procedures, with the participants wearing light clothing and without shoes. Blood pressure was measured with a calibrated mercury sphygmomanometer from the right arm after sitting for 5 min before the measurement. Overnight fasting blood specimens were collected for measurement of serum lipids and plasma glucose. Participants who did not fast for at least 10 h did not have their blood drawn. The laboratory in each study field was quality controlled with unified blind from the national project group. Blood specimens were processed at

the examination center and measured using a designated automatic biochemistry analyzer. Glucose and lipid levels were measured within 6 h of sample separation.

Criteria for MS

According to the National Cholesterol Education Program Expert Panel (NCEP) Adult Treatment Panel III (ATP III)[13], MS criteria were defined as the presence of three or more of the following risk factors: WC greater than 102 cm in men or greater than 88 cm in women, serum triglyceride concentration of 1.7 mmol/L or greater, HDL-cholesterol concentration of less than 1.0 mmol/L in men or less than 1.3 mmol/L in women, blood pressure 130/85 mmHg or greater, or serum glucose concentration of 6.1 mmol/L or greater. Individuals using anti-hypertensive or anti-diabetic medications during the previous 2 weeks met the criteria for high blood pressure or high fasting glucose. To avoid potential underestimation of the prevalence of MS in Chinese people[14], the recommended regional WC cut-offs greater than 90 cm for men and greater than 80 cm for women were introduced according to WHO definitions[15].

Assessment of Confounders

Body mass index (BMI) was calculated as the weight in kilograms divided by the square of height in meters. Smoking status was classified as current smokers or not. Alcohol drinking was coded if the patient had consumed alcohol at least once per week during the previous year. Education was measured in years, and the study participants were assigned into the following three categories: (i) Low: illiterate or primary school, (ii) Middle: secondary school, and (iii) High: university. Self-reported house income per capita was measured in renminbi(RMB), and participants were assigned into three categories according to tertiles of house income per capita: (i) Low: <10,000 RMB, (ii) Middle: 10,000-19,000 RMB, and (iii) High: 20,000-80,000 RMB.

Statistical Analysis

The baseline characteristics stratified by sex and MS status were compared. Proportions were tested using the stratified Mantel Haenszel test, and means were compared by using the *t*-test. For non-parametric analysis, the Mann-Whitney U test was used to compare the medians between two independent groups. A binary logistic regression model was applied to examine the association of all PA domains with MS risk. The odds ratio (OR) and 95% confidence interval (CI) were calculated. In the initial model, no covariate was adjusted. The second model was adjusted for age (continuous) and sex. In the first multivariate model, we further adjusted for smoking status (current or not), alcohol consumption (current or not), BMI, and house income per capita. In the second multivariate model, we further adjusted for weekly volume of other PA domains, including LTPA, OA, DC, or AC. In the end, potential interactions of PA domains were evaluated by subgroup analysis. All statistical analyses were conducted using the Statistical Program for Social Sciences 13.0 software program (SPSS Inc. Chicago, IL).

RESULTS

As shown in Table 1, 3326 adult Chinese had an average age of 45.23 years, and 1671 (50.24%) were women. The overall prevalence of MS was 25.80% and was higher in men (30.82%) than in women (20.83%) (*P*=0.000). Adults with MS were more likely to consume alcohol (*P*=0.004) and smoke (*P*=0.003) than those without.

Of this population, 30.79%, 50.75%, and 18.46% performed sedentary-, light-, and moderate-intensity OA, respectively. About 22.30% of men performed moderate-intensity OA, which was significantly higher than the 14.66% found in women (*P*=0.000) (data not shown). Moreover, 55.17%, 80.13%, and 20.14% of adults commuted actively, performed DA, and performed LTPA, respectively. Approximately 95.50% of women performed DA, which was significantly higher than the 64.70% found in men (*P*=0.000). About 18.30% of women exercised during leisure time, which was lower than the 22.00% found in men (*P*=0.008) (data not shown). As shown in Table 2, a significantly lower proportion of adults among those with MS performed DA than those without (*P*=0.000), although such a difference did not consequentially reappear in men or women, separately.

Generally, in this population, the median volumes of OA, DA, AC, and LTPA were 6300.00 MET-min/week, 588.00 MET-min/week, 198.00 MET-min/week, and 0.00 MET-min/week, respectively. Women performed 1176.00 MET-min/week of DA during the previous year, which was significantly higher than the 336.00 MET-min/week performed by men (*P*=0.000).

As shown in Table 3, a median volume of DA performed by those with MS was significantly less than

Table 1. Characteristics of 3326 Chinese Adults Aged 35- 64 Years Old with the Metabolic Syndrome or Not

Item	Male		Female		Total	
	Yes (*n*=510)	No (*n*=1145)	Yes (*n*=348)	No (*n*=1323)	Yes (*n*=858)	No (*n*=2468)
Age (year)	47.2 (46.6-47.8)	46.5 (46.1-46.9)*	45.6 (45.0-46.2)	43.3 (43.0- 43.6)	46.6 (46.1-47.0)	44.8 (44.5- 45.0)**
Education						
primary or middle school (%)	61.37 (56.97-65.59)	62.18 (59.29-64.99)	62.07 (56.72-67.15)	60.85 (58.15-63.48)	61.66 (58.30- 64.91)	61.47 (59.51- 63.39)
High school (%)	25.29 (21.62-29.34)	24.45 (22.01-27.07)	23.56 (19.27-28.44)	22.90 (20.68-25.28)	24.59 (21.77- 27.64)	23.62 (21.97- 25.36)
College (%)	13.33 (10.56-16.66)	13.36 (11.47-15.50)	14.37 (10.95-18.60)	16.25 (14.32-18.37)	13.75 (11.55- 16.28)	14.91 (13.54- 16.39)
House income per capita						
<10,000 RMB (%)	16.27 (13.23-19.83)	15.90 (13.86-18.18)	22.70 (18.48-27.54)	19.27 (17.20- 21.52)	18.88 (16.35- 21.70)	17.71 (16.23-19.29)
10,000-19,000 RMB (%)	31.57 (27.59-35.83)	37.47 (34.67-40.36)	38.51 (33.41-43.87)	40.36 (37.71- 43.07)	34.38 (31.22- 37.68)	39.02 (37.09-40.98)
20,000-800,000 RMB (%)	52.16 (47.73-56.56)	46.64 (43.72-49.58)	38.79 (33.68-44.15)	40.36 (37.71- 43.07)	46.74 (43.37- 50.14)	43.27 (41.31-45.25)
Current smokers (%)	49.61 (45.19-54.03)	46.11 (43.20-49.05)	17.53 (13.77-22.03)	18.22 (16.20-20.43)	36.60 (33.39-39.94)	31.16 (29.34-33.04)**
Current alcohol (%)	44.31 (39.96-48.75)	41.22 (38.36-44.14)	20.98 (16.90-25.72)	19.58 (17.49-21.84)	34.85 (31.68- 38.16)	29.62 (27.83- 31.47)**
Height (cm)	169.5 (169.0-170.1)	168.2 (167.8-168.6)**	158.4 (157.8-159.0)	157.9 (157.6-158.2)**	165.0 (164.5-165.6)	162.7 (162.4-163.0)**
Weight (kg)	79.0 (78.2-79.8)	68.7 (68.1-69.3)**	67.8 (66.9-68.7)	58.7 (58.3-59.2)**	74.5 (73.7-75.2)	63.4 (62.9-63.8)**
Body mass index (kg/m^2)	27.5 (27.2-27.8)	24.3 (24.1-24.5)**	27.0 (26.7-27.3)	23.5 (23.4-23.7)**	27.3 (27.1-27.5)	23.9 (23.8-24.0)**
Waist circumference (cm)	95.1 (94.5-95.7)	85.7 (84.2-87.1)**	90.2 (85.6-94.8)	78.0 (77.5-78.4)**	93.1 (91.2-95.0)	81.5 (80.8-82.3)**
Systolic blood pressure (mmHg)	134.6 (133.3-135.8)	123.0 (122.1-123.8)**	131.6 (129.9-133.3)	116.9 (116.2-117.6)**	133.4 (132.4-134.4)	119.7 (119.1-120.3)**
Diastolic blood pressure (mmHg)	89.2 (88.4-90.0)	82.2 (81.6-82.8)**	86.0 (85.0-87.1)	77.0 (76.5-77.4)**	87.9 (87.3-88.6)	79.4 (79.0-79.8)**
Total cholesterol (mmol/L)	5.21 (5.01-5.42)	4.91 (4.86-4.97)**	4.94 (4.84-5.04)	4.76 (4.71-4.81)**	5.10 (4.97-5.23)	4.83 (4.79-4.87)**
HDL-cholesterol (mmol/L)	1.09 (1.06-1.11)	1.31 (1.29-1.32)**	1.18 (1.16-1.21)	1.47 (1.45-1.49)**	1.13 (1.11-1.14)	1.39 (1.38-1.41)**
Triglyceride (mmol/L)	3.26 (3.03-3.49)	1.52 (1.46-1.58)**	2.19 (2.05-2.34)	1.09 (1.05-1.13)**	2.83 (2.67-2.98)	1.29 (1.25-1.32)**
Fasting glucose (mmol/L)	5.91 (5.73-6.08)	5.08 (5.02-5.15)**	5.48 (5.32-5.64)	4.98 (4.94-5.02)**	5.73 (5.61-5.86)	5.03 (4.99-5.06)**
Sedentary behaviors (hr/day)	3.38 (3.21-3.55)	3.21 (3.09-3.32)	2.95 (2.73-3.16)	2.82 (2.72-2.92)	3.20 (3.07-3.34)	3.00 (2.92-3.08)

Note. *, $P<0.05$; **, $P<0.01$.

Table 2. Percentage of Participating Physical Activity Among Chinese 3326 Adults Aged 35-64 Years Old by Metabolic Syndrome Status

Item	Male		Female		Total	
	Yes (*n*=510)	No (*n*=1145)	Yes (*n*=348)	No (*n*=1323)	Yes (*n*=858)	No (*n*=2468)
Occupational intensity						
Sedentary (%)	32.16 (28.16- 36.43)	27.51 (24.96- 30.21)	29.02 (24.37- 34.15)	33.56 (31.03- 36.19)	30.89 (27.83- 34.12)	30.75 (28.94- 32.62)**
Light (%)	49.22 (44.81- 53.65)	48.56 (45.63- 51.50)	52.87 (47.48- 58.20)	52.68 (49.95- 55.40)	50.70 (47.30- 54.09)	50.77 (48.78- 52.76)
Moderate (%)	18.63 (15.40- 22.34)	23.93 (21.51- 26.53)	18.10 (14.28- 22.64)	13.76 (11.97- 15.76)	18.41 (15.90- 21.20)	18.48 (16.98- 20.08)
Active commuting (%)	56.86 (52.43- 61.19)	54.50 (51.56- 57.41)	58.33 (52.94- 63.53)	54.27 (51.54- 56.98)	57.46 (54.07- (60.79)	54.38 (52.39- 56.36)
Leisure-time exercise (%)	19.61 (52.43- 61.19)	23.06 (20.67- 25.63)	21.55 (17.42- 26.32)	17.46 (15.47- 19.64)	20.40 (17.78- 23.29)	20.06 (18.51- 21.71)
Domestic activity (%)	62.35 (57.97- 66.54)	65.68 (62.84- 68.42)	95.98 (93.19- 97.70)	95.31 (93.99- 96.36)	75.99 (72.96- 78.78)	81.56 (79.96- 83.06)**

Note. **, *P*<0.01. Sedentary occupational activity: mostly sedentary reading or writing during working day; Light-intensity occupational activity: mostly working with arms or legs with little effort during working day; Moderate-intensity occupational activity: mostly lifting/carrying objects with moderate or hard effort

Table 3. Volume of Physical Activity Domains Among 3326 Chinese Adults Aged 35-64 years Old by Metabolic Syndrome Status

Item	Male		Female		Total	
	Yes (*n*=510)	No (*n*=1145)	Yes (*n*=348)	No (*n*=1323)	Yes (*n*=858)	No (*n*=2468)
Occupational activity, Met-min/week	5520 (3600-7728)	6300 (4410-8280)**	6624 (4320-8820)	6300 (3780-8694)	5796 (3813.8-8640)	6300 (4320-8640)
Domestic activity, Met-min/week	196 (0-609.00)	336 (0-1008)*	1176 (588.00-2352.00)	1176 (588.00-2352.00)	588 (56-1176)	679 (196-1344)**
Active commuting, Met-min/week	272 (0-933)	160 (0-840)	288.5 (0-1137)	165 (0-840)*	280 (0-990)	160 (0-840)*
Leisure-time exercise, Met-min/week	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)

Note. Median (25th percentile of the volume of activity, 75th percentile of the volume of activity), *, *P*<0.05; **, *P*<0.01.

that performed by those without (*P*=0.000), and the difference existed in men rather than in women. Those with MS had significantly higher volumes of AC than those without (*P*=0.014), especially in women. Only in men, a lower level of OA volume was significant among those with MS than among those without (*P*=0.009). No significant difference on the volume of LTPA or OA was found between those with and without MS.

In all the binary logistic regression models, no meaningful ORs were detected for the association of OA or LTPA volume with MS. Table 4 presents the ORs of having MS according to quartiles of DA volumes. In unadjusted analysis, adults who engaged in ≥1176.00 METs-min/week DA had 41.6% less chance of having MS than those did not engage in any DA (OR, 0.584; 95% CI, 0.480-0.710), and this association remained significant even after adjusting for other domains of PA and all the confounders.

As shown for AC in Table 5, in the unadjusted model and those after adjusting for age and sex, no difference was detected for the odds for having MS until smoking status, alcohol use, BMI, and house income per capita were controlled. Adults doing AC for ≥33 MET-min/week but <528 MET-min/week had 25.0% less chance of having MS than those who did not (OR, 0.750; 95% CI, 0.582-0.966). Those engaged in ≥528 MET-min/week did not show a significant relation with the odds of having MS. Furthermore, no significant interaction between AC and DA was detected in general analysis (*P*=0.193).

Table 4. ORs of Having the Metabolic Syndrome According to Quartiles of Domestic Activity Volume

Item	Quartiles of Domestic Activity Volume			
	1 (0-140 MET-min/week)	2 (168-560 MET-min/week)	3 (588.0-1092 MET-min/week)	4 (1176.0-11760 MET-min/week)
Median volume of domestic activity, MET-min/week	0.000	336	588.0	1764.0
Unadjusted	1.000	0.783 (0.615-0.997)	0.757 (0.594-0.966)	0.584 (0.480-0.710)
Age and gender adjusted	1.000	0.842 (0.658-1.103)	0.855 (0.662-1.103)	0.694 (0.553-0.870)
Multiple adjusted*	1.000	0.845 (0.642-1.111)	0.894 (0.675-1.183)	0.675 (0.525-0.869)
Multiple adjusted†	1.000	0.846 (0.643-1.112)	0.894 (0.675-1.184)	0.678 (0.527-0.873)

Note. Odds ratio (95% confidence interval of the odds ratio). *, Adjusted for age,gender, smoking status (current or not), alcohol consumption (current or not), BMI, house income per capita.†, Adjusted for all the above plus the volume of leisure time activity, occupational activity, and active commuting.

Table 5. ORs of Having the Metabolic Syndrome According to Quartiles of Active Commuting Volume

Item	Quartiles of Active Commuting Volume			
	1 (0-30 MET-min/week)	2 (33-516 MET-min/week)	3 (528-1236 MET-min/week)	4 (≥1253-41706 MET-min/week)
Median volume of active commuting, MET-min/week	0	280.0	798.0	2079.0
Unadjusted	1.00	0.903 (0.722-1.130)	1.251 (1.013-1.545)	1.262 (1.023-1.557)
Age and gender adjusted	1.00	0.850 (0.677-1.067)	1.120 (0.901-1.392)	1.115 (0.896-1.386)
Multiple adjusted*	1.00	0.750 (0.582-0.966)	0.813 (0.635-1.041)	0.829 (0.648-1.059)
Multiple adjusted†	1.00	0.754 (0.585-0.973)	0.827 (0.645-1.061)	0.850 (0.661-1.092)

Note. Odds ratio (95% confidence interval of the odds ratio). *, Adjusted for age, gender, smoking status (current or not), alcohol consumption (current or not), BMI, house income per capita. †,Adjusted for all the above plus the volume of leisure time activity, occupational activity, and domestic activity.

DISCUSSION

In this 35-64-year-old Chinese population from Beijing and Zhejiang province, a significantly higher prevalence of MS was observed among those with less time spent in housework or actively commuting, independently, and no joint association was detected between these two PA domains and MS.

These finding are comparable with several prospective studies about the association of PA domains with MS and related chronic diseases. A large-scale cohort study[16] involving 14,290 adults aged 35-64 years in Finland found that moderate and high occupational, commuting, or leisure time physical activity independently and significantly reduced risk of Type 2 diabetes from 1982 to 1992. However, compared with our analysis, the percentage of 30% of people with 'active' OA was much higher, and the similar proportion of those 'almost completely inactive' was much lower. Carnethon et al.[17] also reported that regular leisure time and work-related PA were protective against MS, based on data involving 4192 young adults (aged 18-30 years, 49% African-American people) followed up from 1985 to 2001 within the Coronary Artery Risk Development in Young Adults (CARDIA) study. The reason for the difference with our study was identical with that of Hu et al.'s report[16]. However, two analyses[8,18] based on the National Health and Nutrition Examination Survey (NHANES) for 1999-2004 and 2003-2006 reported that OA/DA was not significantly associated with MS, while AC and LTPA were determined to be protective against MS by Churilla et al.[8]. Based on another large prospective sample[19] comprising 13,221 adults aged 35 years and more from the Scottish Health Study Survey from 1985 to 2003, intense DA was even unrelated with CVD, while total PA was protective after DA was excluded. In this sample, about three-fourths, one-half, and three-fifths of people did not perform sports, walking, or intense DA, respectively, which was somewhat similar to the findings of our study. Furthermore, our study did not find any association of LTPA with MS, which was identical to a population-based (aged 18-74 years) cross-sectional survey[20] conducted in 2007-2008 in Nantong City in Jiangsu province in China, where there was a very similar prevalence of 9.7% of LTPA.

Rapid economic and social change have led to increased use of time- and labor-saving technologies, potentially reducing energy expenditure in the home and occupational sectors[21]. Over the last 50 years in the US, daily occupation-related energy expenditure has decreased by more than 100 calories[22]. The rapid social and economic changes over recent decades in China are well documented[23-24] and have caused logical declines in overall PA and some domains[25]. Between 1991 and 2011 in China, OA declined about 30% in men and 58% in women[26]. In our analysis, only 2.82% of adults lifted or carried heavy objects with much effort during most of the time every work day, and the reason for the lack of relationship with the prevalence of MS in this sample may be similar to that in US in 2003-2006[18].

In China, DA is always an important part of total PA. Our analysis was identical with that from the Chinese National Nutrition and Health Status Survey (CNNHS) in 2002[27], in which 80% of adults (59% in men and 98% in women) aged 18-59 years performed DA, and this proportion was much higher than that from the above reports. Notwithstanding, it was obvious that about twice as many hours were spent in 2002[27] compared with those in this population. The activity volume of DA in women in our analysis was much lower than that in 2011 from Ng et al.'s report[26], which may be because of the higher economic development in Beijing and Zhejiang province than in other areas in China. In addition, most DA in China was housework (including cooking, cleaning, washing clothing, and caring for children or elders)[27] rather than 'heavy housework and/or heavy gardening/do-it-yourself activities'[19]. The presence or absence of protection by DA against CVD or all-cause mortality requires more research in China in the future.

AC has been well recommended for PA improvement to protect against CVD[28-30]. Both walking and cycling were still the most popular traffic tools in China, while the little contribution to total PA was very similar with Ng et al.'s report[26]. Approximately 60% and 26% of adults aged 18-60 years reported to select walking and cycling, respectively, as ways to commute from home to work in 2002 in China[27], which was very similar to the results of our analysis and higher than that of the Scottish Health Study Survey[19]. In addition, the stably consistent level of 1-2 MET hours per week spent in travel PA[26] may ensure the necessity of future improvement in traffic or neighborhood environment in China.

Most evidence about the influence of PA on MS focuses on the benefit of LTPA[8,31], while the generally

unfavorable prevalence of LTPA is a public concern in the world[1]. However, in China, there was a very low prevalence of LTPA for many years. Ng et al.'s report[26] showed that active leisure remained less than 7 MET hours per week on an average among men and less than 3 MET hours per week on an average among women, between 1991 and 2011 in China. Recent national data showed only about one-tenth of adults engaged in regular LTPA for at least 10 min in 3 d per week in 2010[32], and the prevalence in urban areas increased from 15.1% in 2002[33] to 19.9% in 2010[32]. The prevalence and the hours of LTPA in our analysis were consistent with the above Chinese analysis, and the slight contribution to protection against MS was inevitably undetected.

In addition, although leisure time sedentary behavior (LTSB) has been well recognized as an independent risk factor for MS[8,34-35], the lack of relation in this study conflicted with current evidence. This may be because the hours of LTSB were generally high in this sample, which could attenuate the association. Therefore, ways to improve leisure time activity in this population should be considered in future potential interventions.

The prevalence of current smoking and alcohol consumption in this analysis was similar to the recent national data[36]. The difference between those with and without MS was not significant, which conflicted with current evidence[37-39]. One possible reason is that the generally similar prevalence of current drinking and smoking status among separate sexes may minimize the association, and the other is the lack of total pack-years of cigarettes smoked or alcohol grams in this preliminary analysis. For the high prevalence of smoking or alcohol drinking in this sample, a more detailed study related to the risk for MS should be conducted in future.

The total prevalence of MS in the regions evaluated in this study was similar with that in Nantong City[20], which was higher than that in China in 2000[40] and 2002[27]. For the widely recognized fact of the increasing trend in this disorder, it should be important to understand the related risk factors and priority for inventions in China.

Several limitations deserve comment. First, the sample was not representative of Chinese adults, and the size was inadequate to examine associations in detail. Second, the directionality of the association could not be definitively established in this cross-sectional analysis. Finally, the reliability or validity of this modified GPAQ had not been tested. The GPAQ has been recommended for PA evaluation globally and is used widely in China[36], but the information on domestic and OA could not be collected separately. The profile of PA domains in Chinese should be different from that in some Western countries. In this survey, because OA intensity declines continuously in such a developing country, and because it was our intension to learn the profile of physical characteristics of occupational activities in this Chinese population, we asked about posture during OA after information on DA was asked separately. Our findings probably prompt design of a suitable questionnaire for monitoring PA in Chinese in the future.

In summary, this study highlighted the independently negative association of traffic activity and house activity with the prevalence of MS in this middle-aged Chinese population with a generally low level of most PA domains. For the evident and sharp trend of reduction in occupational and DA in China, more attention should be given to the improvement of moderate and vigorous PA.

COMPETING INTERESTS

The authors declare that they have no competing interests.

AUTHORS' CONTRIBUTIONS

CHENG Xiao Rong modified the GPAQ, carried out the analyses, drafted the manuscript, critically reviewed the manuscript, and approved the final manuscript as submitted. ZHAO Wen Hua conceptualized and designed the study, critically reviewed the manuscript, and approved the final manuscript as submitted. DING Guang Qian, DONG Zhong, ZHANG Xin Wen, LI Jian Hong, and MI Sheng Quan, contributed to the study design and supervised and coordinated data collection. All authors have approved the final version.

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