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Physical Activity, Adiposity, and Diabetes Risk in Middle-Aged and Older Chinese Population

The Guangzhou Biobank Cohort Study

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OBJECTIVE — Physical activity may modify the association of adiposity with type 2 diabetes. We investigated the independent and joint association of adiposity and physical activity with fasting plasma glucose, impaired fasting glucose, and type 2 diabetes in a Chinese population.

RESEARCH DESIGN AND METHODS — Middle-aged and older Chinese (n = 28,946, ≥50 years, 72.4%women) from the Guangzhou Biobank Cohort Study were examined in 2003–2008. Multivariable regression was used in a cross-sectional analysis.

RESULTS — BMI, waist circumference, and waist-to-hip ratio (WHR) were positively associated with type 2 diabetes after multiple adjustment, most strongly for WHR with odds ratio (OR) of 3.99 (95% CI 3.60–4.42) for highest compared with lowest tertile. Lack of moderate-to-vigorous physical activity, but not walking, was associated with diabetes with an OR of 1.29 (1.17–1.41). The association of moderate-to-vigorous activity with fasting glucose varied with WHR tertiles (P = 0.01 for interaction). Within the high WHR tertile, participants who had a lack of moderate-to-vigorous activity had an OR of 3.87 (3.22–4.65) for diabetes, whereas those who were active had an OR of 2.94 (2.41–3.59).

CONCLUSIONS — In this population, WHR was a better measure of adiposity-related diabetes risk than BMI or waist circumference. Higher moderate-to-vigorous activity was associated with lower diabetes risk, especially in abdominally obese individuals.

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Type 2 diabetes is a worldwide cause of morbidity and mortality. Adiposity, especially abdominal adiposity, seems to be at the core of development of hyperglycemia and type 2 diabetes (1). Increased physical activity may mitigate some of the diabetogenic impact of adiposity (2–4). Individuals who are obese but fit could even have a lower risk of mortality than those who are normal weight but unfit (5,6). However, being physically active does not completely abolish the obesity-related risk for cardiovascular disease and associated mortality (7). Adiposity is still the main risk factor for the development of type 2 diabetes (2–4,8). Although increased physical activity has been shown to be associated with reduced type 2 diabetes risk independent of adiposity, the protective effects may differ by the level of adiposity. However, the group that could benefit most from physical activity for the prevention of diabetes is still unclear (2–4,8–10).

Understanding the relationship between adiposity and physical activity is important to stratify risk groups for the development of effective diabetes prevention strategies from public health and clinical perspectives. Most of the studies relate to Caucasians (2–4,8–10), whereas Asians, including Chinese and Indians, are possibly more vulnerable to insulin resistance (11). The number of Chinese adults with type 2 diabetes was estimated to be ∼28.1 million in 2000 and may double by 2030, with China being second only to India (12). The purpose of this study was to investigate the independent and joint association of adiposity and physical activity with fasting plasma glucose, impaired fasting glucose (IFG), and type 2 diabetes in 28,946 middle-aged and older Chinese participants in the Guangzhou Biobank Cohort Study.

RESEARCH DESIGN AND METHODS

The Guangzhou Biobank Cohort Study is an ongoing collaboration among the Guangzhou Number 12 Hospital, Guangzhou, China, the University of Hong Kong, Hong Kong, and University of Birmingham, Birmingham, U.K. The study has been described in detail previously (13). All participants were drawn from the Guangzhou Health and Happiness Association for Respectable Elders, a community social and welfare association unofficially aligned with the municipal government, for which membership is open to anyone aged ≥50 years for a monthly, nominal fee of 4 yuan (50 U.S. cents). The Guangzhou Health and Happiness Association for Respectable Elders has a citywide network with ∼95,000 members who are permanent residents, constituting ∼7% of Guangzhou residents (aged ≥50 years), of whom ∼33% were selected for this study and were included if they were capable of consenting, were ambulatory, and were

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not receiving treatment modalities that if omitted may result in immediate life-threatening risk, such as chemotherapy or radiotherapy for cancer or dialysis for renal failure.

In total, 30,499 participants were recruited in three cross-sectional phases during 2003–2008 and received measurement of obesity indexes according to a standard protocol. A blood sample from each participant was used to assess fasting plasma glucose with a Shimadzu CL-80000 clinical chemical analyzer (Shimadzu, Kyoto, Japan). A detailed questionnaire was used to assess life-course socioeconomic position, personal disease history, and physical activity.

Assessment of adiposity and physical activity

General obesity was categorized into normal weight (BMI <23 kg/m^2), overweight (23 kg/m^2 ≤ BMI < 25 kg/m^2), and obese (BMI ≥ 25 kg/m^2), as suggested for southern Chinese populations (14). Waist circumference and waist-to-hip ratio (WHR) were categorized as sex-specific tertiles. The lower limit of the high waist circumference tertile for women (>81 cm) and men (>86 cm) was comparable to the International Diabetes Federation definition of central obesity for Asians (≥80 cm for women and ≥90 cm for men).

A short version of the International Physical Activity Questionnaire (IPAQ) (15) provided information on the amount of time spent per week in vigorous, moderate, and walking activities during work, as part of house and outdoor work, transportation, recreation, and exercise. The IPAQ-Chinese showed good test-retest reliability with all intraclass correlation coefficients >0.80 (P < 0.001) in a random sample of this population. Compared with objective pedometry data, the IPAQ-Chinese showed moderate-to-high validity for total physical activity and walking (16). Weekly metabolic equivalent task scores (measured as MET hours) were calculated, assuming 8.0, 4.0, and 2.5 MET h, respectively, for vigorous, moderate, and walking activities. Moderate-to-vigorous activity was categorized into "active" (≥24 MET h/week), "moderate" (0 < and <24 METs h/week), and "inactive" (no METs). Walking and total physical activity were divided into tertiles of MET hours per week in all participants.

Table 1—*Characteristics of 28,946 participants with normal glucose level, IFG, and type 2 diabetes*

	Normal glucose	IFG	Type 2 diabetes	P value*
n	22,247	3,064	3,635	
Women (%)	16,142 (72.5)	2,139 (69.8)	2,673 (73.5)	<0.001
Age (years)	61.5 ± 7.2	63.2 ± 6.6	63.7 ± 6.6	<0.001
BMI (kg/m^2)†	23.51 ± 0.04	24.63 ± 0.12	24.75 ± 0.11	<0.001
Waist circumference (cm)†	78.8 ± 0.1	81.7 ± 0.3	82.5 ± 0.3	<0.001
WHR†	0.860 ± 0.001	0.885 ± 0.002	0.898 ± 0.002	<0.001
Fasting plasma glucose (mmol/l)†	5.19 ± 0.01	6.40 ± 0.01	8.70 ± 0.10	<0.001
Central obesity (%)‡	6,738 (30.3)	1,427 (46.6)	1,855 (51.1)	<0.001
Overall obesity (BMI ≥25 kg/m^2)	6,692 (30.1)	1,360 (44.4)	1,590 (43.7)	<0.001
History of cardiovascular disease	976 (4.4)	169 (5.5)	269 (7.4)	<0.001
Education (%)				
Primary school	9,092 (40.9)	1,505 (49.1)	1,750 (48.1)	
Middle school	6,082 (27.3)	737 (24.1)	872 (24.0)	
Senior technical school/ college or university	7,073 (31.8)	822 (26.8)	1,013 (27.9)	<0.001
Occupation (%)				
Manual	10,665 (47.9)	1,650 (53.8)	1,873 (51.5)	
Nonmanual	6,675 (30.0)	930 (30.4)	1,084 (29.8)	
Others	4,907 (22.1)	484 (15.8)	678 (18.6)	<0.001
Personal income (%)				
<10,000 yuan	7,228 (32.5)	1,054 (34.4)	1,240 (34.1)	
10,000–15,000 yuan	9,776 (43.9)	1,250 (40.8)	1,556 (42.8)	
>15,000 yuan	4,188 (18.8)	589 (19.2)	671 (18.5)	
Do not know	1,055 (4.8)	171 (5.6)	168 (4.6)	0.013
Smoking (%)				
Never	17,993 (80.9)	2,442 (79.8)	2,956 (81.3)	
Former smoker	1,946 (8.8)	340 (11.1)	408 (11.2)	
Current	2,301 (10.3)	280 (9.1)	271 (7.5)	<0.001
Alcohol drinking (%)				
Never	12,918 (58.4)	1,670 (54.9)	2,255 (62.3)	
Former drinker	2,712 (12.3)	565 (18.6)	525 (14.5)	
Current	6,493 (29.3)	807 (26.5)	838 (23.2)	<0.001
Moderate to vigorous physical activity categories (%)				
Active (≥24 METs h/week)	6,020 (27.1)	839 (27.4)	851 (23.4)	
Moderate (0 < and <24 METs h/week)	5,710 (25.7)	851 (27.8)	927 (25.5)	
Inactive (no METs)	10,517 (47.2)	1,374 (44.8)	1,857 (51.1)	<0.001
Walking tertiles (%)				
Active (>44 METs h/week)	7,223 (32.5)	1,162 (37.9)	1,126 (31.0)	
Moderate (17.5 < and ≤44 METs h/week)	5,655 (25.4)	817 (26.7)	994 (27.3)	
Inactive (≤17.5 METs h/week)	9,369 (42.1)	1,085 (35.4)	1,515 (41.7)	<0.001
Total physical activity tertiles (%)				
Active (≥63 METs h/week)	7,408 (33.3)	1,179 (38.5)	1,095 (30.1)	
Moderate (31 < and <63 METs h/week)	7,578 (34.1)	1,061 (34.6)	1,339 (36.8)	
Inactive (≤31 METs h/week)	7,261 (32.6)	824 (26.9)	1,201 (33.0)	<0.001

Data are means ± SD or SE (continuous variables) or n (%) (categorical variables). *P values for continuous variables were tested by multivariate linear model; P values for categorical variables were tested by the χ^2 test. †Adjusted for age and sex. ‡Central obesity is defined as waist circumference ≥80 cm for women and ≥90 cm for men.

Ascertainment of outcomes

Glucose status was categorized as normal fasting plasma glucose (<6.1mmol/l), IFG (fasting glucose ≥6.1and <7.0 mmol/l and no glucose-lowering medication use or no history of diabetes), and

Table 2—*Adjusted ORs for the independent association of BMI categories, waist circumference, and WHR tertiles with IFG and type 2 diabetes*

	IFG			Type 2 diabetes		
	n	Model 1*	Model 2	*n*	Model 1*	Model 2
BMI category†						
Normal	982	1.00	1.00	1,077	1.00	1.00
Overweight	722	1.35 (1.21–1.49)	1.08 (0.97–1.22)	968	1.66 (1.51–1.83)	1.12 (1.01–1.25)
Obese	1,360	2.05 (1.88–2.25)	1.44 (1.27–1.64)	1,590	2.19 (2.01–2.39)	1.11 (0.99–1.25)
P_{trend}		<0.001	<0.001		<0.001	0.11
Waist circumference tertile‡						
Low	728	1.00	1.00	736	1.00	1.00
Medium	991	1.57 (1.42–1.74)	1.41 (1.26–1.58)	1,140	1.86 (1.69–2.06)	1.76 (1.57–1.97)
High	1,343	2.26 (2.05–2.49)	1.72 (1.50–1.97)	1,755	3.10 (2.82–3.40)	2.84 (2.50–3.24)
P_{trend}		<0.001	<0.001		<0.001	<0.001
WHR tertile‡						
Low	703	1.00	1.00	555	1.00	1.00
Medium	1,051	1.56 (1.41–1.73)	1.39 (1.25–1.54)	1,175	2.24 (2.02–2.50)	2.05 (1.84–2.29)
High	1,306	2.13 (1.93–2.35)	1.70 (1.52–1.89)	1,900	3.99 (3.60–4.42)	3.40 (3.05–3.80)
P_{trend}		<0.001	<0.001		<0.001	<0.001

Data are ORs (95% CI). *Model 1: adjusted for study phase, age, sex, smoking and alcohol use, history of cardiovascular disease, occupation, education, income, and total physical activity. †Model 2: based on model 1, further adjusted for waist circumference. ‡Model 2: based on model 1, further adjusted for BMI.

type 2 diabetes (fasting glucose ≥7.0 mmol/l or treatment with glucose-lowering medications) (17). Because a categorical variable leads to loss of information, fasting glucose was also used as a continuous variable.

Statistical analysis

Multivariate multinomial logistical regression was used to estimate the odds ratios (ORs) of IFG and diabetes by adiposity and physical activity, both independently and jointly. We compared the Akaike information criterion value among models with different measures of adiposity used as continuous variables to assess the best predictor of diabetes. Multivariate censored-normal regression was used to censor the use of glucose-lowering medications and to assess the linear association of fasting glucose with WHR and physical activity independently and jointly. Whether the association of physical activity with fasting glucose or diabetes varied with adiposity was assessed from the significant interaction term by multiplying these two variables and was compared from the heterogeneity of models with and without interaction term. All *P* values were two-sided and obtained with STATA (version 9.2, StataCorp, College Station, TX).

RESULTS— Of 30,499 recruited participants, 28,946 participants remained after exclusion of missing data. Physical activity was associated with IFG, type 2 diabetes, and fasting glucose similarly in women and men, so women and men were combined. Table 1 shows that 22,247 (76.9% of the total) participants had normal fasting glucose, 3,064 (10.6%) had IFG, and 3,635 (12.5%) had type 2 diabetes. Participants with diabetes were less active than those with normal glucose with respect to moderate-to-vigorous activity.

Table 2 shows that, after adjustment for study phase, age, sex, education, occupation, income, smoking, alcohol use, history of cardiovascular disease, and total physical activity, a larger BMI, waist circumference, or WHR was associated with a higher OR of IFG and diabetes. WHR showed the strongest association with diabetes. The model using WHR fitted better than a model including waist circumference or BMI in the association with IFG and diabetes, with the smallest Akaike information criterion value ($P < 0.001$). WHR was strongly associated with fasting glucose ($P < 0.001$).

Table 3 shows that lower moderate-to-vigorous physical activity was independently associated with a higher OR of diabetes but not walking. There was no significant association of physical activity with IFG. To test the possibility of participants who might change their physical activity patterns in response to ill-health leading to reverse causation, we performed additional analyses. Of the total 3,635 participants with diabetes, 60.2% had known diabetes but did not appear different in walking or moderate-to-vigorous activity than those who had newly diagnosed diabetes (data not presented).

Table 4 shows the joint association of adiposity and moderate-to-vigorous activity with IFG and diabetes. Both higher WHR and lower activity were associated with diabetes (*P* for interaction = 0.45 between WHR and activity), and the association of WHR with diabetes was stronger than that of physical activity. Within the low WHR tertile, moderate-to-vigorous activity was not associated with diabetes ($P = 0.23$). Within the high WHR tertile, the active group had OR of 2.94 (95% CI 2.41–3.59), whereas the inactive group had an OR of 3.87 (3.22–4.65). Physical activity was not associated with IFG across different WHR tertiles. Repeating the analyses with a cut point of 5.6 mmol/l instead of 6.1 mmol/l did not change the findings.

Figure 1 shows that the association of higher moderate-to-vigorous activity with lower fasting glucose varied with WHR tertiles (*P* for interaction = 0.01) but not with BMI (*P* for interaction = 0.65) or waist circumference (*P* for interaction = 0.30). In addition, the association of longer walking with lower fasting glucose was only found in the high WHR tertile ($P = 0.02$). The modification effect of walking over WHR tertiles was smaller (*P* for interaction = 0.05), compared with moderate-to-vigorous activity (data not presented).

CONCLUSIONS— In this cross-sectional survey, WHR was a better measure of adiposity-related type 2 diabetes

Table 3—*Adjusted OR for the independent association of walking tertiles, moderate-to-vigorous physical activity categories, and total physical activity tertiles with IFG and type 2 diabetes*

	IFG				Type 2 diabetes			
	n	Model 1*	Model 2	Model 3	*n*	Model 1*	Model 2	Model 3
Walking tertile†,‡								
Active	1,162	1.00	1.00	1.00	1,126	1.00	1.00	1.00
Moderate	817	0.91 (0.82–1.01)	0.92 (0.83–1.01)	0.92 (0.83–1.02)	994	1.07 (0.97 − 1.17)	1.06 (0.96–1.17)	1.08 (0.98–1.19)
Inactive	1,085	0.92 (0.83–1.01)	0.93 (0.84–1.02)	0.93 (0.84–1.03)	1,515	1.06 (0.96 − 1.16)	1.07 (0.97–1.17)	1.10 (1.00–1.21)
P_{trend}		0.09	0.12	0.17		0.27	0.19	0.05
Moderate-to-vigorous physical activity§,‖								
Active	839	1.00	1.00	1.00	851	1.00	1.00	1.00
Moderate	851	1.03 (0.93–1.14)	1.03 (0.92–1.14)	1.02 (0.92–1.14)	927	1.09 (0.99–1.21)	1.08 (0.98–1.20)	1.07 (0.97–1.19)
Inactive	1,374	1.03 (0.94–1.14)	1.01 (0.93–1.12)	1.02 (0.93–1.12)	1,857	1.29 (1.17–1.41)	1.25 (1.14–1.37)	1.25 (1.14–1.37)
P_{trend}		0.51	0.71	0.82		<0.001	<0.001	<0.001
Total physical activity¶,#								
Active	1,179	1.00	1.00	1.00	1,095	1.00	1.00	1.00
Moderate	1,061	0.92 (0.84–1.01)	0.92 (0.84–1.00)	0.92 (0.84–1.01)	1,339	1.15 (1.05–1.26)	1.15 (1.05–1.26)	1.16 (1.06–1.27)
Inactive	824	0.93 (0.84–1.03)	0.92 (0.83–1.02)	0.93 (0.84–1.03)	1,201	1.17 (1.06–1.29)	1.16 (1.05–1.28)	1.18 (1.07–1.31)
P_{trend}		0.13	0.10	0.14		0.001	0.003	0.001

Data are ORs (95% CI). *Model 1: adjusted for study phase, age, sex, smoking and alcohol use, history of cardiovascular disease, occupation, education, income and BMI. †Model 2: based on model 1, further adjusted for waist circumference and moderate-to-vigorous physical activity. ‡Model 3: based on model 1, further adjusted for WHR and moderate-to-vigorous physical activity. §Model 2: based on model 1, further adjusted for waist circumference and walking. ‖Model 3: based on model 1, further adjusted for WHR and walking. ¶Model 2: based on model 1, further adjusted for waist circumference. #Model 3: based on model 1, further adjusted for WHR.

Table 4—*Adjusted OR for the joint association of waist circumference or WHR tertiles and moderate-to-vigorous physical activity categories with IFG and type 2 diabetes*

	IFG				Type 2 diabetes			
	Active	Moderate	Inactive	P_{trend}	Active	Moderate	Inactive	P_{trend}
Waist circumference tertile								
Low	1.00	1.19 (0.96–1.45)	0.98 (0.82–1.19)	0.89	1.00	0.97 (0.79–1.20)	1.21 (1.01–1.46)	0.05
Medium	1.48 (1.21–1.80)	1.36 (1.11–1.67)	1.52 (1.28–1.84)	0.49	1.69 (1.38–2.06)	1.85 (1.51–2.26)	2.09 (1.74–2.50)	0.005
High	1.75 (1.42–2.17)	1.79 (1.45–2.21)	1.81 (1.50–2.20)	0.96	2.63 (2.14–3.24)	2.98 (2.43–3.65)	3.40 (2.82–4.11)	<0.001
WHR tertile								
Low	1.00	1.07 (0.88–1.32)	0.98 (0.81–1.18)	0.99	1.00	0.90 (0.71–1.14)	1.10 (0.89–1.35)	0.23
Medium	1.42 (1.17–1.71)	1.44 (1.96–1.74)	1.37 (1.14–1.63)	0.54	1.81 (1.47–2.22)	2.07 (1.69–2.53)	2.27 (1.89–2.74)	0.003
High	1.63 (1.34–1.98)	1.65 (1.36–1.99)	1.80 (1.51–2.14)	0.30	2.94 (2.41–3.59)	3.25 (2.67–3.96)	3.87 (3.22–4.65)	<0.001

Data are ORs (95% CI). Adjusted for study phase, age, sex, smoking and alcohol use, history of cardiovascular disease, occupation, education, income, BMI, and walking.

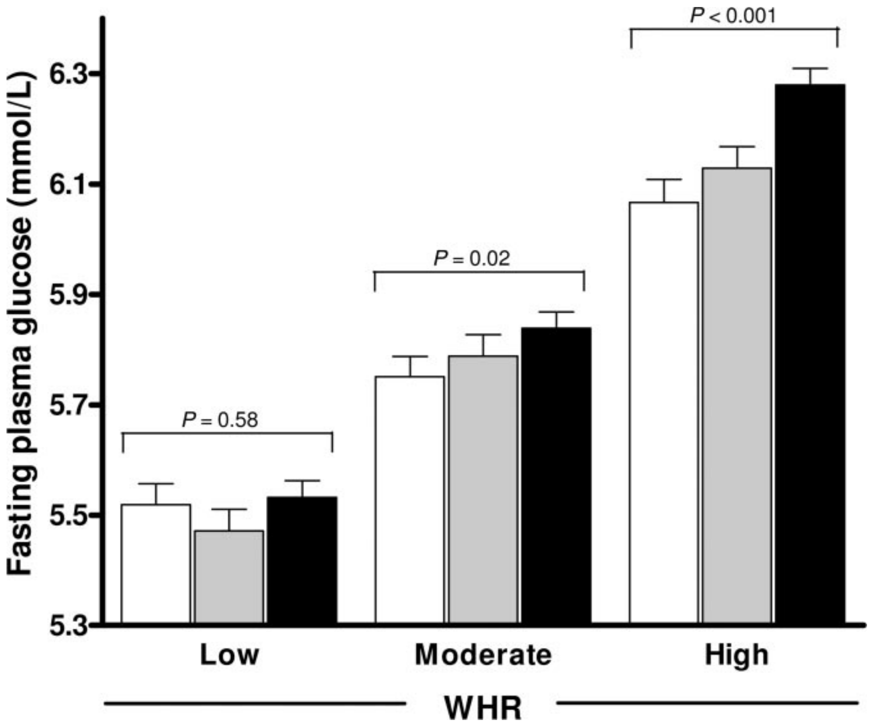

Figure 1—*Fasting plasma glucose (millimoles per liter) stratified by WHR tertiles and moderate-to-vigorous physical activity categories (□, active; ■, moderate; ■, inactive), adjusted for study phase, age, sex, BMI, smoking and drinking habits, history of cardiovascular disease, occupation, education, income and walking, and censored by the use of glucose-lowering medications (*P = *0.01 for interaction).*

risk than BMI or waist circumference. Moderate-to-vigorous physical activity but not walking duration was independently associated with type 2 diabetes. The strength of the association with WHR was greater than that with physical activity in the joint analysis. However, in the high WHR tertile, lack of moderate-to-vigorous physical activity was associated with ~0.21mmol/l higher fasting glucose and ~1.3-fold higher OR of diabetes, compared with those who had high moderate-to-vigorous activity (≥24 MET h/week). This association was not noticeable in the low WHR tertile group.

The present data are consistent with previous findings that central obesity, as indicated by waist circumference or WHR, is more strongly associated with type 2 diabetes than BMI (1). There are two main explanations for this observation in middle-aged and older Chinese people. First, people generally lose height with aging, so their BMI may be overestimated. Second, sarcopenia and increased body fat are associated with aging. For the same level of BMI, older adults generally have on average more fat and less muscle mass than young adults (18). Moreover, WHR showed a stronger association with diabetes than waist circumference in this population. Higher WHR can be the result of a larger waist or a smaller hip. We have previously shown that larger hips are negatively associated with diabetes in a similar southern Chinese population, but this is only significant in women after adjustment for BMI (19).

Physical activity is well known to independently decrease type 2 diabetes risk. In this study, only moderate-to-vigorous activity was negatively associated with diabetes. Even though walking, as a relatively low-intensity activity, may have a beneficial effect with daily performance over a long period, it was not associated with IFG or diabetes. Walking was, however, associated with lower fasting glucose in the high WHR tertile. Walking was the most prevalent activity in this population, probably because of its easy accessibility and minimal availability of personal mechanized transportation. We cannot exclude the possibility that random error in self-reported walking may underestimate the beneficial effect. Furthermore, participants might change their walking patterns in response to ill-health, which needs to be elucidated in a longitudinal study. Another explanation is that walking is only beneficial above a certain level of intensity. In the Nurses' Health Study, only women with a brisk walking pace (>4.8 km/h) had a significantly lower diabetes risk (2). However, we did not collect information on walking pace.

Results of previous cohort studies examining the interrelationship of adiposity and physical inactivity with diabetes are still controversial (20). Some researchers found that higher physical activity was associated with reduced diabetes risk, particularly in obese people (2–4). On the contrary, physical activity might be more beneficial for normal-weight than for obese individuals or equally beneficial (8–10). No studies reported a significant interaction between obesity and physical activity. However, those studies may not have had the power to detect such an interaction, especially when physical activity was crudely quantified or had a relatively small effect compared with obesity. A recent study showed that higher cardiorespiratory fitness was associated with a lower incidence of type 2 diabetes in overweight but not in lean individuals (21). Although cardiorespiratory fitness as an objective maker for habitual physical activity was not assessed in the present study, moderate-to-vigorous activity could partly contribute to fitness level. Our findings support the interaction of physical activity and adiposity with fasting glucose and suggest that physical activity has the potential to be more protective against elevated glucose concentrations in abdominally obese individuals, although this hypothesis needs further confirmation in intervention studies.

Physical activity may have independently beneficial effects through many biological mechanisms, e.g., by reducing inflammation stress, increasing skeletal muscle mass, and improving muscle fatty acid oxidative capacity, insulin sensitivity, and glucose disposal rate (22). Its chronic effects may not be completely independent of changes in body composition. After control for the acute effect of exercise, the beneficial effects on glucose metabolism are not noticeable in obese individuals, if no certain changes in body composition are achieved, e.g., reduction in weight and visceral fat (23). Exercise-induced weight loss does not appear to result in greater improvements than dietary-induced weight loss (24). This finding indicates that in the long-term exercise may mainly interact with a reduction in body fat, especially abdominal fat, to reduce diabetes risk, rather than having an independent effect.

Our study had several strengths. We had a large sample size (~30,000 participants) and used three measures (BMI, waist circumference, and WHR) to estimate adiposity. To our knowledge, this is the first study to look at the joint associations of adiposity and physical activity with diabetes risk in the Chinese population, and one of the few to do so in a middle-aged and older population. Limitations of this study include the cross-sectional design, which makes the examination of causal relationships impossible, and recall error describing physical activity patterns over the previous 7 days. Second, our subjects may not have been completely representative of the older population of Guangzhou. However, every adult aged ≥50 years has equal and easy accessibility to this community association, and we did not expect that those who were willing to attend had interrelationships of adiposity, physical activity, and diabetes different from those who did not attend. This population had levels of diabetes comparable to nationally representative samples of urban Chinese within sex groups and age-groups (25). Although women were overrepresented, no differences in the associations analyzed were found in men and women. Third, a low level of physical activity could be the consequence of diabetes complications. However, participants with known diabetes were not more or less active than those with newly diagnosed diabetes with regard to walking and moderate-to-vigorous activity. Therefore, our observations were not likely to be the result of reverse causation.

In summary, the present data suggested that adiposity and moderate-to-vigorous physical activity were independently associated with type 2 diabetes. WHR as a measure of adiposity-related diabetes risk performed better than BMI or waist circumference alone in this population. Although abdominal adiposity was the key risk factor, higher moderate-to-vigorous physical activity was associated with lower diabetes risk, especially in abdominally obese individuals. Future prospective studies to investigate the underlying mechanisms of chronic physical activity to diabetes risk over different categories of abdominal adiposity are needed. Our data suggest that the potential of regular physical activity should be further explored as an important and low-cost primary prevention factor for type 2 diabetes in middle-aged and older Chinese people.

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