Physical Activity Level and Incident Type 2 Diabetes among Chinese Adults

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ABSTRACT

FAN, S., J. CHEN, J. HUANG, Y. LI, L. ZHAO, X. LIU, J. LI, J. CAO, L. YU, Y. DENG, N. CHEN, D. GUO, and D. GU. Physical Activity Level and Incident Type 2 Diabetes among Chinese Adults. *Med. Sci. Sports Exerc.*, Vol. 47, No. 4, pp. 751–756, 2015. **Purpose**: The objective is to examine the association between physical activity level (PAL) and incident type 2 diabetes among middle-age and older Chinese men and women in urban China. **Methods**: This prospective study included 6348 participants (age 35 to 74 yr) who were free of diabetes and cardiovascular disease at baseline. PAL was estimated on the basis of self-reported overall physical activity on a typical day. According to PAL, participants were classified into four groups: sedentary (PAL, 1.00–1.39), low active (PAL, 1.40–1.59), active (PAL, 1.60–1.89), and very active (PAL, >1.89). The association of PAL with incident diabetes was examined by Cox proportional hazards model. **Results**: During 7.9 yr of follow-up (50,293 person-years), 478 incident cases of type 2 diabetes were identified. After adjustment for age, sex, geographic region, educational level, smoking, alcohol use, and family history of diabetes, the HR (95% CI) values for type 2 diabetes across increasing categories of PAL were 1.00 (reference), 0.82 (0.62–1.09), 0.63 (0.47–0.83), and 0.47 (0.36–0.61), respectively (*P* for trend <0.0001). Additional adjustment for baseline body mass index or waist circumference attenuated the magnitude of risk reduction, but it remained significant. The inverse association between PAL and risk of incident diabetes was persistent in subgroup analyses according to age, sex, hypertension, smoking, body mass index, waist circumference, and fasting plasma glucose level. **Conclusions**: Higher PAL is associated with substantial reduction in risk of type 2 diabetes. Our findings suggest the importance of a physically active lifestyle in the prevention of diabetes. **Key Words:** PHYSICAL ACTIVITY, INCIDENCE, TYPE 2 DIABETES

In recent decades, the prevalence of diabetes has increased significantly in China (7,20,24,33). According to the most recent national survey conducted in 2010, the prevalence of diabetes was 11.6%. It was estimated that more than 113.9 million Chinese adults had diabetes, and another 493.4 million were prediabetic (33). This growing epidemic of diabetes is thought to be predominantly due to China's rapid shift from a plant-based traditional diet toward diabetogenic eating patterns combined with increasingly sedentary lifestyles (4).

There is strong evidence that physical activity is one of the most important modifiable factors in the prevention of type 2 diabetes. Intervention studies demonstrated that lifestyle changes including increased physical activity can prevent or postpone the onset of type 2 diabetes among individuals with impaired glucose tolerance (23,26,29). Also, a substantial number of prospective cohort studies have investigated the role of physical activity in the prevention of type 2 diabetes (5,6,9,14,17,22,27,31). Although the majority of these studies were consistent in reporting that physical activity was inversely associated with diabetes risk, the magnitude of the association seems different between studies. On the other hand, most of the previous studies were conducted in White populations of European descent and limited data are available from China. Therefore, with prospective data collected from 6348 Chinese men and women (age 35 to 74 yr) at baseline, we aimed to examine the association between physical activity level (PAL) and incident type 2 diabetes among adults in urban China.

METHODS

Study population. Participants for the present investigation were from two cohorts: China Multicenter Collaborative

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Study of Cardiovascular Epidemiology (ChinaMUCA) and China Cardiovascular Health Study. ChinaMUCA, which was conducted in 1998, included 15 clusters that were selected on the basis of the main characteristics of the population in terms of socioeconomic status, geographical locations, and dietary patterns. Approximately 1000 subjects with 50% women were sampled in each cluster. China Cardiovascular Health Study was a cross-sectional study of cardiovascular disease risk factors conducted in 2000–2001. A four-stage stratified sampling method was used to select a nationally representative sample of the general population. Details of the study designs and methods of ChinaMUCA (28) and China Cardiovascular Health Study (8) have been described elsewhere. At baseline, a total of 27,020 participants were included in the two studies.

Baseline examination. Baseline data were collected in examination centers at local health stations or community clinics in the participants' residential area. A standardized questionnaire was administered to participants by trained staff to obtain information on sociodemographic characteristics, personal and family medical history, and lifestyle risk factors including cigarette smoking, alcohol use, and physical activity habits (8). Smoking status was classified as current smoker, ex-smoker, or nonsmoker by asking the subject whether he or she had ever smoked at least 400 cigarettes or 500 g tobacco leaves during his/her lifetime and whether he or she still smoked at the time of the baseline interview. Alcohol use was defined as drinking alcohol at least once a week during the last year. Educational level was classified according to self-reported school years (0–6, 7–9, and ≥10 yr). Hypertension was defined as systolic blood pressure/diastolic blood pressure values ≥140/90 mm Hg and/or use of antihypertensive medication within the past 2 wk. Family history of diabetes was considered positive if a parent or sibling had been diagnosed with type 2 diabetes.

Participants were then invited to take a physical examination after the interview. Body weight and height were measured to the nearest 0.5 kg and 0.5 cm, respectively, with the participant wearing lightweight clothing and no shoes. Body mass index (BMI) was calculated as weight in kilograms divided by height in meter squared. Waist circumference (WC) was measured at 1 cm above the navel at minimal respiration. For each participant, three blood pressure measurements were obtained according to a standardized procedure recommended by the American Heart Association (25). All study investigators and staff members have been trained and certified.

Blood samples were taken after at least a 10-h fast, immediately centrifuged, and then transferred under cold chain condition to the central laboratory in the department of Evidence Based Medicine at Fuwai Hospital of the Chinese Academy of Medical Sciences (Beijing, China). Plasma glucose was measured by a modified hexokinase enzymatic method (Hitachi automatic clinical analyzer, model 7060; Hitachi, Tokyo, Japan).Concentrations of total cholesterol, HDL cholesterol, and triglyceride were assessed enzymatically with commercially available reagents (2).

Follow-up examination. Participants of the two cohorts were invited to participate in the follow-up study in 2007–2008. The protocol, questionnaire, and measurement of blood glucose and lipids used in the follow-up examination were the same as the baseline. If death occurred, a detailed medical history was obtained from a family member or health care provider. Participants' previous medical records were also obtained, if available.

In total, 21,556 individuals were followed up, with an overall response rate of 79.8%. Because the physical activity status of rural participants varied a lot between busy and slack farming seasons, the accuracy and precision of our 1-yr physical activity questionnaire for rural participants were not as reliable as their urban counterparts. Therefore, we focused on 8891 participants who came from urban areas in the current investigation. Of these, participants who had a history of myocardial infarction/stroke (n = 176) or who had diabetes (n = 544) at baseline were excluded for the present study. Participants with incomplete or invalid data on baseline diabetes status (n = 127) or physical activity (n = 328) were also excluded. For this report, after excluding those (n = 1368) without complete follow-up data for diabetes ascertainment, 6348 participants (2966 men and 3382 women) were included. The baseline characteristics of participants included in this analysis were similar to those lost to follow-up. Among participants who underwent follow-up examination and those who were lost to follow-up, the percentages of women were 51.8% and 51.5%, respectively; the mean baseline ages were 49.2 and 50.0 yr; the percentages of subjects who had high education (≥13 yr) were 19.8% and 18.0%; those who smoked were 34.0% and 35.2%; those who consumed alcohol were 22.6% and 22.3%; the mean BMI were 24.2 and 24.1 $kg \cdot m^{-2}$; and the mean PAL were 1.73 and 1.67, respectively. The Institutional Review Boards at Fuwai Hospital, Chinese Academy of Medical Sciences and Peking Union Medical College approved this study. All study participants gave written informed consents.

Measurement of PAL. The main exposure of interest in the present study was PAL. In our questionnaire, participants were asked to indicate the number of hours per day that they spent in vigorous activity (shoveling, heavy farming, jogging, bicycling on hills, etc.), moderate activity (carpentry, yard work, folk dancing, bicycling on level ground, etc.), light activity (office work, fishing, cooking, standing with little motion, etc.), sedentary activity (desk work, eating, reading, watching television, etc.), and periods of reclining/sleeping on a typical day during the previous 12 months. The physical activity experience for participants who reported spending more than 26 h or less than 22 h per day in the five physical activity categories were treated as invalid data. Using the compendium proposed by Ainsworth et al. (1), an average MET score was derived for each type of activity: vigorous activity (8.0), moderate activity (4.0), light activity (2.0), sedentary activity (1.0), and reclining/sleeping (1.0). We used the model developed by the Institute of Medicine to calculate PAL (13). The formula is as follows:

$$\text{Males}: \Delta\text{PAL} = \sum(\text{MET}_n - 1) \times 1.34 \times h_n/24$$

$$\text{Females}: \Delta\text{PAL} = \sum(\text{MET}_n - 1) \times 1.42 \times h_n/24$$

$$\text{PAL} = 1.00 + \Delta\text{PAL}$$

MET_n stands for the MET score of one activity; h_n stands for self-reported hours spent on this kind of activity.

Ascertainment of type 2 diabetes. Type 2 diabetes was defined as having a fasting plasma glucose ≥7.0 $\text{mmol}\cdot\text{L}^{-1}$, having prior diagnosis of diabetes mellitus, or indicating self-reported use of insulin or oral hypoglycemic agents (3). This definition was used for both excluding subjects with diabetes at baseline and determining incident type 2 diabetes during the follow-up. Fatal cases during follow-up were ascertained by death certificates. If diabetes was one of the underlying causes of death (ICD-10 codes E10-E14), although it has not been diagnosed before, cases were also treated as diabetes events.

Statistical analysis. According to PAL, participants were classified into four categories: sedentary (PAL, 1.00–1.39), low active (PAL, 1.40–1.59), active (PAL, 1.60–1.89), and very active (PAL >1.89) (16). Baseline characteristics were compared, and statistics for trend tests were calculated. For categorical variables, the Mantel–Haenszel chi-square test was used; for continuous variables, a linear trend test was used, with the median value in each group used as a continuous variable in linear regression. Follow-up time was calculated from baseline to the date of diagnosis of type 2 diabetes, death, or the follow-up interview, whichever came first. Cox proportional hazards models were used to examine the association between PAL and the development of type 2 diabetes. To test for linear trend, the median PAL in each group was treated as a continuous variable in Cox regression models. To ensure the robustness of our results, we conducted sensitivity analyses by removing all incident cases of diabetes diagnosed within the first 12 months after the baseline. To examine whether the effects of PAL on diabetes were modified by potential risk factors, we conducted subgroup analyses according to categories of age, sex, hypertension, family history of diabetes, smoking, BMI, WC, and fasting plasma glucose. All tests were two sided and $P < 0.05$ was considered statistically significant. Statistical analyses were performed using SAS, version 9.2 (SAS Institute, Inc., Cary, NC).

RESULTS

Table 1 shows the baseline characteristics of the study population according to categories of PAL. Overall, participants with higher PAL were younger and more likely to live in southern China, to have a lower educational level, and to have family history of diabetes. They were also more likely to be men, smokers, and alcohol drinkers. With respect to metabolic parameters, participants with higher PAL exhibited lower levels of BMI, WC, systolic blood pressure, diastolic blood pressure, triglyceride, and total cholesterol, whereas higher levels of HDL cholesterol.

A total of 478 cases of type 2 diabetes were identified during 7.9 yr (50,293 person-years) of follow-up, corresponding to an incidence rate of 9.50 per 1000 person-years. In Cox proportional hazards models, higher PAL was significantly associated with decreased risk of diabetes (shown in Table 2). After adjusting for age, sex, geographic region, educational level, smoking, alcohol use, and family history of diabetes (Model 2), the HR values (95% CI) across increasing categories of PAL were 1.00 (reference), 0.82 (0.62–1.09), 0.63 (0.47–0.83), and 0.47 (0.36–0.61), respectively (P for trend <0.0001). Additional adjustment for BMI (model 3) or WC (model 4) attenuated the magnitude of risk reduction, but it remained significant. A sensitivity analysis in which we excluded cases of diabetes that occurred

EPIDEMIOLOGY

TABLE 1. Baseline characteristics of the study participants according to categories of PAL.

	Self-reported PAL				
	1.00–1.39 (n = 1723)	**1.40–1.59 (n = 1244)**	**1.60–1.89 (n = 1168)**	**>1.89 (n = 2213)**	***P* for Trend**
Age (yr)	52.7 ± 10.0	48.0 ± 9.0	48.2 ± 8.2	45.1 ± 6.6	<0.0001
Women (%)	59.8	45.8	58.0	49.9	<0.0001
Northern residents (%)	48.2	52.4	42.8	40.4	<0.0001
Educational level (%)					
0–6 yr	26.5	14.1	12.6	8.5	
7–12 yr	59.1	58.5	63.3	74.5	<0.0001
≥13 yr	14.4	27.4	24.1	17.0	
Smoking status (%)					
Never a smoker	70.9	64.2	69.9	65.4	
Ex-smoker	7.6	5.7	6.1	4.7	<0.0001
Current smoker	21.5	30.1	24.1	29.8	
Current alcohol drinker (%)	17.6	24.2	21.0	24.0	<0.0001
Family history of diabetes (%)	8.0	8.8	10.6	11.7	<0.0001
BMI ($\text{kg}\cdot\text{m}^{-2}$)	24.5 ± 3.8	24.1 ± 3.3	23.9 ± 3.3	23.6 ± 3.2	<0.0001
Waist circumstance (cm)	81.8 ± 10.0	80.8 ± 9.8	79.8 ± 9.5	78.3 ± 8.9	<0.0001
Systolic blood pressure (mm Hg)	125.5 ± 20.9	120.2 ± 17.3	120.0 ± 18.7	117.3 ± 16.8	<0.0001
Diastolic blood pressure (mm Hg)	78.9 ± 11.5	78.2 ± 10.8	77.6 ± 11.4	76.6 ± 11.0	<0.0001
Triglycerides ($\text{mmol}\cdot\text{L}^{-1}$)	1.34(0.99–1.87)	1.33(0.96–1.90)	1.29(0.94–1.86)	1.19(0.86–1.68)	0.0002
Total cholesterol ($\text{mmol}\cdot\text{L}^{-1}$)	5.02 ± 0.98	4.97 ± 0.95	4.91 ± 0.91	4.77 ± 0.97	<0.0001
HDL cholesterol ($\text{mmol}\cdot\text{L}^{-1}$)	1.27 ± 0.31	1.28 ± 0.32	1.33 ± 0.33	1.34 ± 0.33	<0.0001

Data are expressed as means ± SD, percentages, or medians (interquartile ranges).

TABLE 2. HR of type 2 diabetes according to categories of PAL.

Variable	Self-reported PAL 1.00–1.39	1.40–1.59	1.60–1.89	>1.89	*P* for Trend
Cases of diabetes	142	78	93	165	
Person-years of follow-up	12,399.8	9122.2	9442.7	19,328.4	
Crude incidence per 1000 person-years	11.45	8.55	9.85	8.54	
HR (95% CI)					
Model 1[a]	1.00 (reference)	0.79 (0.60–1.05)	0.61 (0.46–0.81)	0.47 (0.36–0.61)	<0.0001
Model 2[b]	1.00 (reference)	0.82 (0.62–1.09)	0.63 (0.47–0.83)	0.47 (0.36–0.61)	<0.0001
Model 3[c]	1.00 (reference)	0.92 (0.69–1.22)	0.70 (0.52–0.93)	0.55 (0.42–0.73)	<0.0001
Model 4[d]	1.00 (reference)	0.92 (0.69–1.22)	0.67 (0.50–0.89)	0.59 (0.45–0.77)	<0.0001

[a]Model 1: adjusted for age and sex.
[b]Model 2: adjusted for age, sex, geographic region (north or south), educational level (0–6, 7–9, or ≥10 yr), cigarette smoking (never, ever, or current), alcohol consumption (yes or no), and family history of diabetes (yes or no).
[c]Model 3: further adjusted for BMI on the basis of model 2.
[d]Model 4: further adjusted for waist circumstance on the basis of model 2.

during the first 12 months of follow-up (n = 32) produced results similar to those of the main analysis. The multivariate-adjusted (Model 2) HR values (95% CI) across increasing categories of PAL were 1.00 (reference), 0.86 (0.64–1.15), 0.63 (0.47–0.84), and 0.47 (0.35–0.62) (P for trend <0.0001).

As shown in Table 3, the inverse association between PAL and diabetes risk was persistent in subgroup analyses according to age (<50 vs ≥50 yr), sex (men vs women), hypertension (no vs yes), smoking (never vs ever), BMI (<25 vs ≥25 kg·m^{-2}), WC (<90 cm in men/<80 cm in women vs ≥90 cm in men/≥80 cm in women), and fasting plasma glucose (<5.6 vs ≥5.6 mmol·L^{-1}), but not among participants with family history of diabetes.

DISCUSSION

In this population-based cohort of Chinese adults, PAL was inversely associated with the risk of developing type 2 diabetes. This inverse association was consistent in participants at high baseline risk of diabetes and those at low risk.

Although previous prospective studies conducted in Western countries have consistently reported an inverse association between physical activity and type 2 diabetes (5,9,11,12,17,18,31), most of these studies have focused on structured leisure-time activity. However, among Chinese adults, the participation in leisure-time physical activity was rather low in the early 2000 (19), whereas non-leisure-time activities, including activities related to housework, commuting, or occupation, were the predominant sources of daily energy expenditure. Moreover, the protective effects of physical activity may be related to total energy expenditure rather than only the vigorous fitness-enhancing activities (32). Therefore, to investigate the effects of physical activity on diabetes risk in our study, we selected PAL, which is a comprehensive evaluation of physical activities across all domains of daily life, as an exposure indicator.

In the present study, we observed an inverse association between PAL and reduction in diabetes risk. However, the Shanghai Women's Health Study (SWHS) (30), which followed 70,658 middle-age and older Chinese women for

TABLE 3. HR of type 2 diabetes according to categories of PAL among various subgroups of the study participants.

	n	Self-reported PAL, HR (95% CI)[a] 1.00–1.39	1.40–1.59	1.60–1.89	>1.89	*P* for Trend
Sex						
Men	2966	1.00 (reference)	0.96 (0.63–1.44)	0.44 (0.28–0.69)	0.44 (0.30–0.65)	<0.0001
Women	3382	1.00 (reference)	0.73 (0.49–1.09)	0.80 (0.56–1.14)	0.47 (0.32–0.69)	0.0001
Age (yr)						
<50	3908	1.00 (reference)	0.86 (0.55–1.33)	0.46 (0.28–0.73)	0.43 (0.29–0.63)	<0.0001
≥50	2440	1.00 (reference)	0.70 (0.48–1.01)	0.69 (0.49–0.97)	0.47 (0.33–0.68)	<0.0001
Hypertension						
Yes	1488	1.00 (reference)	0.77 (0.50–1.20)	0.43 (0.27–0.67)	0.40 (0.26–0.62)	<0.0001
No	4860	1.00 (reference)	0.95 (0.65–1.38)	0.80 (0.56–1.15)	0.56 (0.40–0.79)	0.0002
Family history of diabetes						
Yes	630	1.00 (reference)	1.66 (0.74–3.75)	1.18 (0.54–2.55)	0.80 (0.38–1.69)	0.1682
No	5718	1.00 (reference)	0.76 (0.56–1.03)	0.59 (0.44–0.81)	0.44 (0.33–0.60)	<0.0001
Smoking						
Ever	2065	1.00 (reference)	1.34 (0.85–2.12)	0.52 (0.31–0.88)	0.50 (0.31–0.79)	0.0005
Never	4283	1.00 (reference)	0.63 (0.43–0.91)	0.67 (0.48–0.94)	0.44 (0.32–0.62)	<0.0001
BMI (kg·m^{-2})						
<25	4074	1.00 (reference)	0.57 (0.33–0.97)	0.53 (0.33–0.86)	0.50 (0.32–0.77)	0.0068
≥25	2274	1.00 (reference)	1.00 (0.72–1.40)	0.70 (0.49–0.98)	0.51 (0.36–0.72)	<0.0001
Waist circumstance (cm)						
<90 in men/<80 in women	4367	1.00 (reference)	0.64 (0.40–1.02)	0.45 (0.28–0.72)	0.45 (0.30–0.68)	0.0006
≥90 in men/≥80 in women	1981	1.00 (reference)	1.03 (0.73–1.47)	0.75 (0.53–1.07)	0.56 (0.39–0.81)	0.0009
Fasting plasma glucose (mmol·L^{-1})						
<5.6	5030	1.00 (reference)	1.01 (0.65–1.57)	0.73 (0.47–1.13)	0.56 (0.37–0.84)	0.0413
≥5.6	1318	1.00 (reference)	0.71 (0.49–1.03)	0.67 (0.46–0.98)	0.65 (0.45–0.94)	0.0015

[a]HR values were estimated after adjustment for age (continuous), sex, geographic region (north or south), educational level (0–6, 7–9, or ≥10 yr), cigarette smoking (never, ever, or current), alcohol consumption (yes or no), and family history of diabetes (yes or no), except stratifying factors.

4.6 yr, observed no significant association between total METs (combination of leisure-time physical activity METs and daily living physical activity METs) and diabetes risk. This discrepancy might be resulted from the fact that participants of our study were selected from 14 provinces across mainland China with different stratums of socioeconomic status, geographical locations, and dietary patterns, whereas SWHS only included women from seven urban communities in Shanghai. The high homogeneity of SWHS participants might contribute to the nonsignificance in regression analyses for the association. In addition, the self-report–based diagnosis of diabetes during follow-up in SWHS might misclassify quite a number of patients who would have been diagnosed as diabetic by plasma glucose test as nondiabetic given the low awareness (23.66%) among Chinese diabetes patients in the early 2000 (10). This may consequently lead to underestimation of the true effects of physical activity. On the other hand, different follow-up durations in the two studies (4.6 vs 7.9 yr) might also contribute to the discrepancy.

Previous epidemiological studies that examined whether the protective effect of physical activity against type 2 diabetes is greater among individuals at increased baseline risk than their lower-risk counterparts have yielded inconsistent results (5,9,11,15,17,18). For example, leisure-time physical activity reduced the risk of diabetes to a greater extent among overweight individuals than the lean ones in the Physicians' Health Study (17) but not in the Iowa Women's Health Study (5). The protective effect of physical activity was most apparent for those who were overweight, were hypertensive, or had a family history of diabetes in the University of Pennsylvania male alumni (9) and the Kuopio cohorts (15), but not in the Nurse's Health Study (18). The Health Professionals Follow-up Study (11) also found that the magnitude of the physical activity–diabetes association did not significantly vary according to BMI and family history of diabetes. In our study, the inverse association between daily energy expenditure and diabetes risk was persistent in subgroup analyses according to age, sex, hypertension, smoking, BMI, WC, and fasting plasma glucose. However, daily energy expenditure had no significant effect on the risk of developing type 2 diabetes in participants with a family history of diabetes. In our study, identification of diabetic family history of participants was possibly underestimated by questionnaire interview because the awareness was low among Chinese diabetes patients at baseline survey and the completed medical records were not available from their parents. Positive family history of some participants might be classified as negative; thus, the classification for family history of type 2 diabetes might be less reliable. The misclassification might lead to a smaller number of participants with positive family history and a consequent low statistical power.

The strengths of the present study are primarily its prospective design, its extensive period of follow-up, and the representativeness of the cohort based on a sample selected from 14 provinces across mainland China. Furthermore, diabetes diagnosis in our study was based on measurement of fasting glucose plus physician-diagnosed diabetes at both baseline and follow-up examinations. This could identify most type 2 diabetes events and reduce the risks of reverse causality. Another advantage is the availability of detailed data on lifestyle and multiple cardiovascular risk factors at baseline, which allowed for an adequate adjustment for potential confounders.

Our study has some limitations that need to be considered. Firstly, nearly 20% of the participants were lost to follow-up, which may bias our findings. However, this impact was limited because the baseline characteristics of subjects included in this analysis were similar to those who were lost to follow-up. Secondly, the assessment of PAL in our study was not based on a direct measure of energy expenditure but was derived from a nonvalidated physical activity questionnaire. However, an accurate measurement of daily energy expenditure by doubly labeled water method or motion sensors is still challenging in large population studies because they are expensive and cumbersome. Thirdly, we only assessed daily energy expenditure at baseline, and any changes between baseline and follow-up may have caused misclassification. Thus, a more detailed evaluation of physical activity, with regular updates, might have disclosed a stronger benefit of physical activity on type 2 diabetes.

In conclusion, our prospective findings show that higher PAL is associated with substantial reduction in risk of type 2 diabetes. In recent decades, China has been undergoing rapid economic development and urbanization. With the increasing availability and popularity of personal computers, televisions, vehicles, and other automation machines, Chinese people become more and more sedentary in domestic, community, and workplace environments. According to Chinese National Health and Nutrition Surveys, average weekly PAL among Chinese adults declined by 32% between 1991 and 2006 (21). Given the fact that urbanization will be further accelerated in China, our results underscore the urgent need to develop national strategies of promoting an active lifestyle to combat the diabetes epidemic.

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We declare no conflict of interest. The results of the present study do not constitute endorsement by the American College of Sports Medicine.

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