Modest Levels of Physical Activity Are Associated With a Lower Incidence of Diabetes in a Population With a High Rate of Obesity

The Strong Heart Family Study

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OBJECTIVE—To examine the association of objectively measured participation in low levels of physical activity with incident type 2 diabetes.

RESEARCH DESIGN AND METHODS—The study population included participants free of diabetes and cardiovascular disease at baseline (n = 1,826) who participated in a follow-up examination. Generalized estimating equations were used to examine the association of steps per day with incident diabetes.

RESULTS—During 5 years of follow-up, 243 incident cases of diabetes were identified. When compared with participants in the lowest quartile of steps per day (<3,500 steps), participants in the upper three quartiles of steps per day had lower odds for diabetes, consistent with a threshold effect. Contrasting the three upper quartiles with the lowest quartile, the odds ratio of diabetes was 0.71 (95% CI 0.51–0.98).

CONCLUSIONS—Modest levels of physical activity are associated with a lower risk of incident diabetes, compared with lower levels of activity.

Guidelines recommend accumulating 10,000 steps per day as part of a healthy lifestyle (1,2). However, it is not known whether participating in more modest levels of activity is associated with a lower risk of diabetes in a high-risk, relatively inactive population. The purpose of this study was to assess the relationship of pedometer-determined steps per day with incident diabetes among American Indians (AIs) who participated in the Strong Heart Family Study (SHFS), a population with a high prevalence of obesity, low physical activity levels, and a high burden of diabetes.

RESEARCH DESIGN AND METHODS—The SHFS is a population-based longitudinal study of cardiovascular disease in 13 AI communities in Arizona, North Dakota, South Dakota, and Oklahoma. Details of the study design have been described previously (3).

We excluded SHFS participants who had diabetes at the baseline examination in 2001–2003 and those without a follow-up examination in 2007–2009. Additionally, we excluded those with a history of myocardial infarction, stroke, or heart failure and those who were pregnant, because these conditions may influence activity and diabetes risk. Participants missing baseline glucose measures, family information, <18 or ≥75 years of age, or who had less than 3 days of pedometer data were also excluded. In total, 1,826 individuals comprised the study population.

Accusplit AE120 pedometers (Livermore, CA) were used to measure the number of steps taken per day (4). These pedometers have known reliability and validity (5–7). Participants wore the pedometer on the hip during waking hours for 7 consecutive days, except while bathing or swimming (8). Incident diabetes was defined based on 2003 American Diabetes Association criteria.

The primary measure of physical activity used was the average steps per day during the time the pedometer was worn. Generalized estimating equations (GEE) with an independence working correlation structure and robust standard errors were used to examine the association of pedometer-determined steps per day with the risk of diabetes. Statistical analyses were conducted using STATA version 9.0 (Stata, College Station, TX).

We computed the odds ratio (OR) and 95% CI for developing diabetes using GEE. Odds ratios (95% CI) were calculated using participants in the lowest quartile of steps per day as the referent group, after adjusting for confounding factors.

RESULTS—The study population included 1,149 (62.9%) women, and the median age at baseline examination was 37.6 years (range 18.7–74.9). The median BMI was 32.0 kg/m^2 (16.6–68.7). There were 178 (9.7%) participants with prediabetes at baseline.

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Table 1—*OR (95% CI) of type 2 diabetes according to steps per day*

	Quartiles (steps per day)				
Incident diabetes	<3,500	3,500–5,399	5,400–7,799	7,800+	3,500+‡
No. of cases	84	57	52	50	159
Total at risk	479	465	448	434	1,347
Age, site, sex adjustment	1.00	0.74 (0.51–1.08)	0.73 (0.48–1.12)	0.74 (0.50–1.11)	0.74 (0.53–1.00)
Multivariate*	1.00	0.76 (0.53–1.11)	0.74 (0.49–1.13)	0.77 (0.51–1.16)	0.76 (0.55–0.99)
Additional adjustment for diet†	1.00	0.76 (0.52–1.12)	0.65 (0.43–0.98)	0.70 (0.46–1.06)	0.71 (0.51–0.98)
Additional adjustment for BMI	1.00	0.95 (0.65–1.39)	0.83 (0.53–1.28)	1.04 (0.69–1.59)	0.93 (0.67–1.29)

*Adjusted for age (years), site, sex, education (years), cigarette smoking (never, ever, current), alcohol use (never, ever, current), and family history of diabetes (%). †Adjusting for all variables in multivariate, as well as total calories (kilocalories per day), total fat (% calories), fiber from grains (grams per 1,000 kcal), sweetened beverage intake (servings per day), fruit/vegetable intake (servings per day). ‡Because we found no evidence of a dose-response trend, the three upper quartiles were collapsed to maximize power.

Mean steps per day decreased with age, and men had higher step counts than women. The median steps per day for participants aged <55 years were 6,696 for men and 4,770 for women. Among participants aged ≥55 years, median steps per day were 5,513 men and 3,452 for women. Moreover, in this population without major morbidity, physical inactivity was common in all age groups. Approximately 26% of participants aged <30 accumulated <3,500 steps/day, 25% of participants aged 30–49 years accumulated fewer than 3,500 steps/day, and 35% of participants aged 50+ accumulated <3,500 steps/day.

During follow-up, diabetes developed in 243 participants. Compared with individuals in the lowest quartile of steps per day, the odds ratio for diabetes among those in the steps per day category "3,500-5,399 steps/day" was 0.76 (95% CI 0.53–1.11), after adjustment for confounders. Likewise, the odds ratios comparing "5,400-7,799 steps/day" and "7,800+ steps/day" with those who accumulated "<3,500 steps/day" were 0.74 (0.49–1.13) and 0.77 (0.51–1.16), respectively. These data are most consistent with a threshold effect within the first quartile of steps per day. Contrasting the three upper quartiles with the lowest quartile, the odds ratio for diabetes after adjustment for confounders was 0.71 (0.51–0.98). Adjustment for BMI attenuated the odds ratios (Table 1).

CONCLUSIONS—The results from this analysis in an obese and relatively inactive population indicate that modest amounts of objectively measured steps per day are associated with a lower odds of developing diabetes. The odds ratios for the association of physical activity with diabetes were similar among the upper three steps-per-day quartiles. Participants who took at least 3,500 steps/day had a 29% lower odds of developing diabetes compared with more sedentary participants.

We assessed previously the relationship of self-reported participation in moderate-to-high intensity leisure-time or occupational activities on the incidence of diabetes among middle-aged or older AIs. In the earlier report, when compared with less active participants, those who reported any moderate-to-high intensity leisure-time or occupational activity had a 33% lower odds of incident diabetes (9), and there was no evidence that more activity was better than less activity. Thus, both studies support a benefit associated with participation in modest levels of physical activity on risk of diabetes in an inactive population.

Several studies suggest that individuals who accumulate 10,000 steps per day have a decreased risk of obesity and better glucose tolerance compared with individuals who accumulate fewer steps (1,10–13). However, health benefits do not appear to be limited to only the most active individuals; certain health benefits may be achieved by adding as little as 2,500 steps per day to baseline activity (1,11,13,14). Our analyses complement such findings and indicate that even modest amounts of activity are associated with lower odds of developing diabetes.

Observed odds ratios were attenuated after additional adjustment for baseline BMI. This attenuation may be because of confounding by the independent effects of obesity on physical activity and diabetes risk or because of the role of obesity as a mediator. Unfortunately, we cannot differentiate between potential confounding and mediation by BMI in this analysis. Additionally, because diabetes in this cohort is not rare (13% of cohort developed diabetes during follow-up), reported odds ratios may not accurately estimate hazard ratios.

The results of this study demonstrate that physical activity of 3,500 or greater steps per day is associated with a lower risk of incident diabetes, compared with lower levels of activity; above 3,500 steps/day, more was not better than less activity. This study identifies physical inactivity as an important factor related to diabetes and suggests the need for physical activity education and outreach programs that target inactive individuals, particularly AIs who have epidemic rates of obesity, physical inactivity, and type 2 diabetes.

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This work comprises the contribution of nine authors. A.M.F. was responsible for developing the research question of interest and performing the literature review and data analysis for the project, as well as writing the manuscript. B.V.H. and D.S.S. were the senior investigators on the project. They supervised all activities and aided in all aspects of the project, including development of the research question and writing the manuscript. G.E.D. and S.A.A.B. participated in all analyses and writing of the manuscript. B.M. was the biostatistician on the project and supervised the statistical methods of the manuscript as well as reviewed all drafts of the manuscript. A.M.K. and K.L.S. were involved in the implementation of the pedometers used in the study and reviewed and edited all drafts of the manuscript. D.C. reviewed and edited all drafts of the manuscript and helped write the results and discussion sections of the manuscript. A.M.F. is the guarantor of this work and, as such, had full access to all the data in the study and takes

responsibility for the integrity of the data and the accuracy of the data analysis.

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References

1. Tudor-Locke C, Bassett DR Jr. How many steps/day are enough? Preliminary pedometer indices for public health. Sports Med 2004; 34:1–8
2. Tudor-Locke C, et al. How Many Steps/day are Enough? For Adults. Int J Behav Nutr Phys Act 2011;8:79
3. North KE, Howard BV, Welty TK, et al. Genetic and environmental contributions to cardiovascular disease risk in American Indians: the strong heart family study. Am J Epidemiol 2003;157:303–314
4. Marsh AP, Vance RM, Frederick TL, Hesselmann SA, Rejeski WJ. Objective assessment of activity in older adults at risk for mobility disability. Med Sci Sports Exerc 2007;39:1020–1026
5. Schneider PL, Crouter SE, Lukajic O, Bassett DR Jr. Accuracy and reliability of 10 pedometers for measuring steps over a 400-m walk. Med Sci Sports Exerc 2003; 35:1779–1784
6. Bassett DR Jr, Ainsworth BE, Leggett SR, et al. Accuracy of five electronic pedometers for measuring distance walked. Med Sci Sports Exerc 1996;28:1071–1077
7. Tudor-Locke C, Ainsworth BE, Thompson RW, Matthews CE. Comparison of pedometer and accelerometer measures of free-living physical activity. Med Sci Sports Exerc 2002;34:2045–2051
8. Storti KL, Arena VC, Barmada MM, et al. Physical activity levels in American-Indian adults: the Strong Heart Family Study. Am J Prev Med 2009;37:481–487
9. Fretts AM, Howard BV, Kriska AM, et al. Physical activity and incident diabetes in American Indians: the Strong Heart Study. Am J Epidemiol 2009;170:632–639
10. Swartz A, Strath S, Bassett D, et al. Increasing daily walking improves glucose tolerance in overweight women. Prev Med 2003:37;356–362
11. Sugiura H, Sugiura H, Kajima K, Mirbod SM, Iwata H, Matsuoka T. Effects of long-term moderate exercise and increase in number of daily steps on serum lipids in women: radomized controlled trial. BMC Womens Health 2002;2: 3–10
12. Tudor-Locke C, Ainsworth BE, Whitt MC, Thompson RW, Addy CL, Jones DA. The relationship between pedometer-determined ambulatory activity and body composition variables. Int J Obes Relat Metab Disord 2001;25:1571–1578
13. Moreau KL, Degarmo R, Langley J, et al. Increasing daily walking lowers blood pressure in postmenopausal women. Med Sci Sports Exerc 2001;33:1825–1831
14. Tudor-Locke CE, Myers AM, Bell RC, Harris SB, Wilson Rodger N. Preliminary outcome evaluation of the First Step Program: a daily physical activity intervention for individuals with type 2 diabetes. Patient Educ Couns 2002;47: 23–28