Sedentary Behavior, Physical Activity, and the Metabolic Syndrome among U.S. Adults

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Abstract

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Objective: We examined the associations among physical activity, sedentary behavior, and metabolic syndrome in a representative sample of U.S. adults.

Research Methods and Procedures: A total of 1626 men and women ≥20 years old from National Health and Nutrition Examination Survey 1999 to 2000 who attended the morning examination were evaluated. The metabolic syndrome was defined by using the definition from the National Cholesterol Education Program.

Results: In unadjusted analysis, participants who did not engage in any moderate or vigorous physical activity during leisure time had almost twice the odds of having metabolic syndrome [odds ratio (OR), 1.90; 95% confidence interval (CI), 1.22 to 2.97] as those who reportedly engaged in ≥150 min/wk of such activity. Adjustment for age, sex, race or ethnicity, educational status, smoking status, and alcohol use attenuated the OR (OR, 1.46; 95% CI, 0.87 to 2.45). Compared with participants who watched television or videos or used a computer <1 h/d outside of work, the adjusted ORs for having metabolic syndrome were 1.41 (95% CI 0.80 to 2.51) for 1 h/d, 1.37 (95% CI 0.85 to 2.20) for 2 h/d, 1.70 (95% CI 0.92 to 3.14) for 3 h/d, and 2.10 (95% CI 1.27 to 3.47) for ≥4 h/d. Additional adjustment for physical activity or sedentary behavior minimally affected the ORs.

Discussion: Sedentary behavior is an important potential determinant of the prevalence of the syndrome. Efforts to lessen the amount of time that U.S. adults spend watching television or videos or using a computer, especially if coupled to increases in physical activity, could result in substantial decreases in the prevalence of metabolic syndrome.

Key words: exertion, metabolic syndrome X, nutrition surveys, risk factors, television

Introduction

The metabolic syndrome has emerged as a major public health problem in the United States. Almost one-fourth of the adult population in the United States has this syndrome (1). The National Cholesterol Education Program considered abdominal obesity, hypertriglyceridemia, low high-density lipoprotein cholesterol, high blood pressure, and hyperglycemia in their definition (2). People with the metabolic syndrome are at increased risk for developing diabetes and cardiovascular disease (3–6). Because of the high prevalence and the morbidity and mortality associated with this syndrome, a thorough understanding of its risk factors is key to designing primary and secondary prevention programs.

Excess weight and lack of physical activity are two important determinants of the metabolic syndrome (5,7–19). Measuring a person's level of physical activity and measuring sedentary behaviors provides a more complete picture of that person's overall activity pattern. Therefore, an understanding of how sedentary behavior relates to health status may provide new avenues for clinical and public health approaches in disease prevention and control. Common sedentary behaviors include watching television or videos, playing video games, and using the computer. A survey conducted in 2002 found that U.S. adults watch television an average of 2.2 h/d and use a computer for 1.7 h/d during nonworking hours (20). The time spent in such activities has been increasing, raising concern for the current and future health of the U.S. population.

Although physical activity is inversely associated with the prevalence of the metabolic syndrome, the association

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between the amount of time spent in sedentary behaviors and the prevalence of the metabolic syndrome remains poorly understood. Therefore, we examined the associations among physical activity, physical inactivity (measured by watching television or videos or using a computer), and the prevalence of the metabolic syndrome in a national sample of U.S. adults.

Research Methods and Procedures

Data from the National Health and Nutrition Examination Survey 1999 to 2000 were used for this analysis (21). A representative sample of the noninstitutionalized civilian U.S. population was selected by using a stratified, multistage sampling design. Trained interviewers, using a computer-assisted personal interview system, interviewed participants at home. Participants were asked to attend the mobile examination center, where they were asked to complete additional questionnaires, undergo various examinations, and provide a blood sample.

We used the definition of the metabolic syndrome proposed in the Third Report of the National Cholesterol Education Program Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (2). According to this definition, participants had the metabolic syndrome if they had three or more of the following five criteria: waist circumference $>$ 102 cm in men and $>$88 cm in women, concentration of triglycerides $\geq$150 mg/dL (1.695 mM), concentration of high-density lipoprotein cholesterol $<$ 40 mg/dL (1.036 mM) in men and $<$50 mg/dL (1.295 mM) in women, systolic blood pressure $\geq$ 130 mm Hg or diastolic blood pressure $\geq$ 85 mm Hg, or fasting glucose $\geq$ 110 mg/dL ($\geq$6.1 mM). In addition, we considered participants who reported that they were currently using antihypertensive medications as having high blood pressure and those who were using antidiabetic medications (insulin or oral agents) as having diabetes.

Waist circumference was measured at the high point of the iliac crest at minimal respiration to the nearest 0.1 cm at the end of normal expiration. Serum triglyceride concentration was measured enzymatically and high-density lipoprotein cholesterol concentration, after the precipitation of other lipoproteins with a heparin-manganese chloride mixture, was measured on a Hitachi 717 Analyzer (Boehringer Mannheim Diagnostics, Indianapolis, IN). Up to four blood pressure measurements were obtained from each participant. To establish high blood pressure status, we used the average of the last two measurements of blood pressure for participants who had three or four measurements, the last measurement for participants with only two measurements, and the only measurement for participants who had one measurement. Plasma glucose concentration was measured using an enzymatic reaction at the University of Missouri (Cobas Mira Chemistry System, Roche Diagnostic Systems, Inc., Montclair, NJ).

Participants were asked to report the frequency and the duration that they spent participating in 43 leisure-time physical activities of moderate or vigorous intensity (22). Physical activities of light intensity were not reported. Participants could also report information for up to three additional activities of moderate or vigorous intensity. Furthermore, we included time spent doing moderate tasks around the home or yard. For each activity, we calculated the weekly number of minutes spent in that activity. Total minutes per week spent performing the activities were calculated by summing the weekly minutes for each activity. We divided the total weekly minutes into three categories: 0, $<$150, and $\geq$150 min/wk of moderate or vigorous physical activity.

The amount of time spent watching television or videos, or using a computer was determined from the question, "Now I will ask you about TV watching or computer use. Over the past 30 days, on a typical day how much time altogether did you spend on a typical day sitting and watching TV or videos or using a computer outside of work? Would you say . . . " Answer choices were $<$1 hour, 1 hour, 2 hours, 3 hours, 4 hours, 5 hours or more, or does not watch TV or videos or use a computer outside of work. We grouped these answers into three categories for some analyses ($\leq$1, 2 to 3, and $\geq$4 hours) and into five categories for other analyses ($<$1, 1, 2, 3, and $\geq$4 hours).

Covariates included age, sex, race or ethnicity (white, African American, Mexican American, other), education ($<$high school, high school diploma or general equivalency diploma, $>$high school), smoking status (current, former, never), and alcohol use ($<$1, 1 to 4, 5 to 7, $>$7 drinks per month). Smoking status was determined from two questions: "Have you smoked at least 100 cigarettes in your entire life?" and "Do you now smoke cigarettes?". Participants who had not smoked 100 cigarettes were defined as never having smoked. Those who provided affirmative responses to both questions were considered to be current smokers. Participants who had smoked 100 cigarettes but did not report smoking at the time of the survey were considered as former smokers. Alcohol use was determined from three questions that asked participants about the frequency of consumption of beer or light beer; wine, wine coolers, sangria, or champagne; and hard liquor during the past 30 days. The frequency of consumption of alcoholic beverages was then calculated by summing the answers of the three questions.

Because concentrations of plasma glucose and serum triglycerides were measured using reference analytic methods only for participants who attended the morning examination, we limited the analyses to men and nonpregnant women $\geq$ 20 years old who attended the morning examination and who had fasted $\geq$8 hours. To age-adjust statistics, we directly adjusted to the U.S. population $\geq$ 20 years old in the year 2000. Difference in proportions and means

Table 1. Baseline characteristics among U.S. adults 20 years old by metabolic syndrome status, National Health and Nutrition Examination Survey 1999 to 2000

	Metabolic syndrome								
	Total			Men			Women		
	Yes	No	*p*	Yes	No	*p*	Yes	No	*p*
n	524	1102		230	582		294	520	
Age (years)	52.2 (1.0)	43.0 (0.8)	<0.001	51.6 (1.4)	42.1 (0.9)	<0.001	52.7 (1.2)	43.9 (1.0)	<0.001
Men (%)	44.9 (3.3)	51.2 (1.2)	0.141						
White (%)	72.1 (4.9)	74.8 (2.3)	0.507	74.1 (5.2)	74.3 (2.5)	0.957	70.3 (5.4)	75.5 (2.3)	0.248
High school graduate (%)	77.4 (2.9)	77.4 (1.8)	0.986	75.1 (4.1)	76.2 (2.2)	0.809	78.5 (3.0)	78.7 (2.4)	0.968
Current smoker (%)	26.9 (3.3)	23.1 (2.1)	0.214	23.3 (4.1)	27.9 (2.8)	0.344	29.9 (5.2)	17.6 (2.2)	0.014
Number of drinks in 30 days	6.8 (0.9)	9.2 (0.9)	0.031	9.3 (1.6)	12.2 (1.3)	0.148	4.8 (0.9)	6.3 (0.7)	0.145
Physical activity (min/wk)			0.041			0.595			0.027
0	43.9 (4.2)	34.4 (2.2)		35.7 (5.2)	31.4 (2.7)		51.5 (6.6)	36.8 (2.8)	
<150	40.7 (3.4)	44.6 (2.0)		48.0 (5.7)	47.6 (3.0)		34.9 (5.1)	42.0 (2.8)	
≥150	15.4 (3.1)	21.0 (2.1)		16.3 (4.2)	20.9 (2.3)		13.6 (3.5)	21.2 (2.6)	
Viewing television, videos, or computer outside of work (h/d)			0.013			0.139			0.117
≤1	20.5 (2.2)	29.0 (1.8)		19.6 (4.1)	27.4 (2.4)		22.1 (3.5)	30.5 (2.7)	
2 to 3	51.2 (3.3)	51.0 (2.1)		53.1 (5.9)	51.3 (3.1)		49.6 (3.9)	51.3 (2.6)	
≥4	28.3 (3.5)	20.1 (1.6)		27.3 (5.2)	21.3 (2.1)		28.3 (4.1)	18.2 (1.8)	

Values are means or percentages (SE). All results are adjusted for age (except mean age).

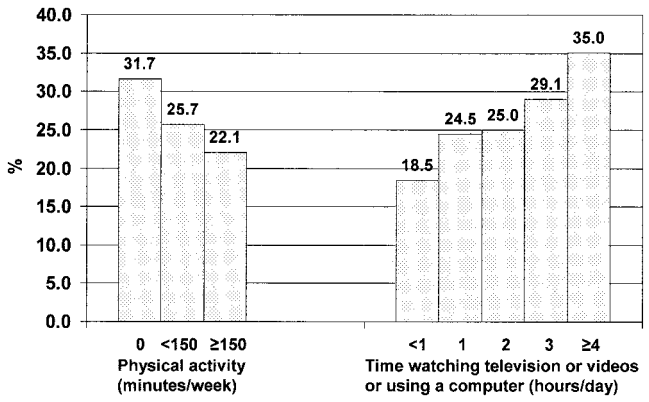

Figure 1: The age-adjusted prevalence of the metabolic syndrome by levels of physical activity and time spent watching television or videos or using a computer outside of work among 1626 U.S. adults ≥ 20 years old, National Health and Nutrition Examination Survey 1999 to 2000.

were calculated using a χ^2 test or a Student's *t* test. We used logistic regression analysis to examine the unadjusted, age-adjusted, and multiple-adjusted associations between the measures of physical activity or sedentary behavior and the metabolic syndrome. We used SUDAAN (Software for the Statistical Analysis of Correlated Data) for analyses to account for the complex sampling design. Prevalence estimates were calculated by using the sampling weights so that the estimates were representative of the civilian, noninstitutionalized U.S. population.

Results

Our analytic sample included 1626 participants. Of these participants, 11.0% watched television or videos or used a computer 0 h/d, 16.6% did so for <1 h/d, 29.3% for 2 h/d, 21.1% for 3 h/d, and 21.9% for ≥4 h/d. Furthermore, 36.4% reported not engaging in any moderate or vigorous physical activity, 44.0% engaged in <150 min/wk, and 19.6% engaged in ≥150 min/wk.

Participants with the metabolic syndrome were older and had a lower alcohol intake than participants who did not have the metabolic syndrome (Table 1). The two groups had similar percentages of participants who were men or white, had graduated from high school, or were current smokers. Participants with the metabolic syndrome were more likely to spend less time engaged in moderate or vigorous physical activity and to spend more hours watching television or videos or using a computer. Among men, only mean age differed significantly between those with and without the metabolic syndrome. Among women, in addition to an age difference, the percentage of participants who were current smokers or did not participate in physical activity during leisure time was higher among those with the metabolic syndrome than among those without this syndrome.

The age-adjusted prevalence of the metabolic syndrome decreased with increasing amount of time engaged in moderate or vigorous physical activity and increased as the amount of time spent watching television or videos or using a computer increased (Figure 1). In unadjusted analysis, adults who did not engage in any moderate or vigorous physical activity had almost twice the odds of having the metabolic syndrome as those who engaged in ≥150 min/wk of such activity (Table 2). Adjustment for age and other covariates led to some attenuation of the association. The odds associated with having the metabolic syndrome increased steadily as the number of hours spent watching television or videos or using a computer outside of work increased. Little attenuation of the odds ratio (OR)[1] occurred as covariates were added to the models. In the fully adjusted model that contained both physical activity and watching television or videos or using a computer, the ORs were very similar to those of the models shown in Table 2, suggesting that the two sets of activities provided independent information about the metabolic syndrome. The independent effect of physical activity and watching television or videos or using a computer is shown in Figure 2. Although the prevalence of the metabolic syndrome decreased as levels of physical activity increased among participants who watched television or videos or who used a computer for ≤1 and 2 to 3 h/d, such a pattern was not apparent among those who engaged in this sedentary behavior for ≥4 h/d. However, we did not detect significant interaction between physical activity and sedentary behavior (p = 0.348).

Generally, the associations between the metabolic syndrome and physical activity or watching television or videos or using a computer were stronger among women than men (Table 2). However, none of the tests for interaction between sex and either physical activity or sedentary behavior for any of the models was statistically significant.

Discussion

Our analyses show that the prevalence of the metabolic syndrome was higher among those who spend an increased amount of time engaged in sedentary activities such as watching television or videos or using a computer. If high levels of sedentary behavior are causally related to the metabolic syndrome, the high prevalences of both sedentary behavior and the metabolic syndrome in the United States suggest an enormous potential for prevention of the syndrome. If people reduced their time spent watching television or videos or using a computer to <1 h/d and consequently reduced the prevalence of the metabolic syndrome to that of people engaged in <1 hour of such activities, the

[1] Nonstandard abbreviation: OR, odds ratio.

Table 2. Associations from logistic regression analysis between metabolic syndrome and physical activity, viewing television or videos, or using computers, National Health and Nutrition Examination Survey 1999 to 2000

	OR (95% confidence interval)			
	Unadjusted	**Age adjusted**	**Multiple adjustment***	**Multiple adjustment†**
Total (N = 1626)				
Physical activity (min/wk)				
0	1.90 (1.22 to 2.97)	1.63 (1.01 to 2.65)	1.46 (0.87 to 2.45)	1.45 (0.86 to 2.44)
<150	1.22 (0.80 to 1.84)	1.24 (0.79 to 1.92)	1.18 (0.75 to 1.87)	1.21 (0.76 to 1.91)
≥150 (reference)	1.00	1.00	1.00	1.00
p (Wald χ^2)	<0.001	0.046	0.200	0.281
Viewing television, videos, or computer outside of work (h/d)				
<1 (reference)	1.00	1.00	1.00	1.00
1	1.33 (0.76 to 2.32)	1.40 (0.79 to 2.47)	1.41 (0.80 to 2.51)	1.41 (0.79 to 2.52)
2	1.42 (0.89 to 2.27)	1.37 (0.88 to 2.15)	1.37 (0.85 to 2.20)	1.38 (0.85 to 2.23)
3	1.74 (0.95 to 3.16)	1.68 (0.92 to 3.07)	1.70 (0.92 to 3.14)	1.74 (0.94 to 3.23)
≥4	2.26 (1.38 to 3.68)	2.14 (1.30 to 3.53)	2.10 (1.27 to 3.47)	2.07 (1.23 to 3.46)
p (Wald χ^2)	0.012	0.042	0.051	0.067
Men (N = 812)				
Physical activity (min/wk)				
0	1.41 (0.77 to 2.60)	1.26 (0.67 to 2.37)	1.18 (0.59 to 2.36)	1.25 (0.63 to 2.47)
<150	1.22 (0.66 to 2.24)	1.25 (0.66 to 2.36)	1.25 (0.65 to 2.41)	1.34 (0.69 to 2.60)
≥150 (reference)	1.00	1.00	1.00	1.00
p (Wald χ^2)	0.507	0.736	0.791	0.677
Viewing television, videos, or computer outside of work (h/d)				
<1 (reference)	1.00	1.00	1.00	1.00
1	1.43 (0.58 to 3.49)	1.42 (0.56 to 3.61)	1.28 (0.45 to 3.64)	1.29 (0.44 to 3.78)
2	1.43 (0.65 to 3.17)	1.34 (0.61 to 2.96)	1.19 (0.49 to 2.90)	1.21 (0.49 to 2.99)
3	2.09 (0.87 to 5.03)	2.16 (0.91 to 5.13)	2.05 (0.77 to 5.44)	2.13 (0.79 to 5.79)
≥4	1.88 (0.87 to 4.05)	1.82 (0.82 to 4.03)	1.61 (0.69 to 3.73)	1.63 (0.69 to 3.83)
p (Wald χ^2)	0.324	0.260	0.349	0.329
Women (N = 814)				
Physical activity (min/wk)				
0	2.35 (1.19 to 4.63)	1.98 (1.00 to 3.96)	1.68 (0.82 to 3.45)	1.64 (0.79 to 3.40)
<150	1.22 (0.64 to 2.32)	1.22 (0.63 to 2.37)	1.15 (0.59 to 2.25)	1.17 (0.59 to 2.34)
≥150 (reference)	1.00	1.00	1.00	1.00
p (Wald χ^2)	0.001	0.027	0.174	0.259
Viewing television, videos, or computer outside of work (h/d)				
<1 (reference)	1.00	1.00	1.00	1.00
1	1.25 (0.56 to 2.76)	1.36 (0.60 to 3.12)	1.66 (0.72 to 3.79)	1.64 (0.70 to 3.86)
2	1.43 (0.77 to 2.67)	1.42 (0.75 to 2.71)	1.61 (0.84 to 3.06)	1.59 (0.81 to 3.13)
3	1.47 (0.67 to 3.22)	1.35 (0.60 to 3.02)	1.47 (0.67 to 3.24)	1.50 (0.66 to 3.41)
≥4	2.71 (1.24 to 5.91)	2.53 (1.14 to 5.61)	2.82 (1.27 to 6.28)	2.76 (1.19 to 6.41)
p (Wald χ^2)	0.036	0.093	0.075	0.120

* Adjusted for age, sex, race or ethnicity, educational status, smoking status, and alcohol use.

† Adjusted for all the above plus physical activity or viewing television or videos or using a computer outside of work.

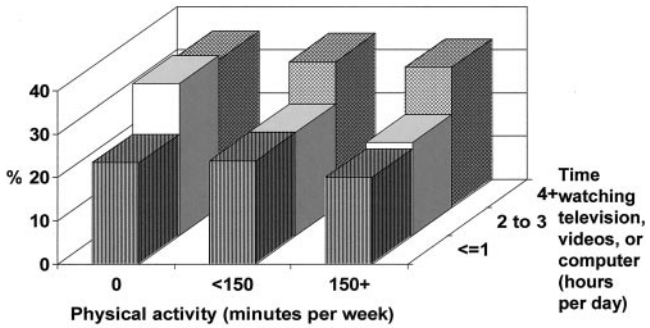

Figure 2: The age-adjusted prevalence of the metabolic syndrome by cross-classified by levels of physical activity and time spent watching television or videos or using a computer outside of work among 1626 U.S. adults ≥ 20 years old, National Health and Nutrition Examination Survey 1999 to 2000.

prevalence of the metabolic syndrome among U.S. adults could potentially be reduced by ~30% to 35%.

Previous studies showed that the metabolic syndrome was inversely associated with participation in physical activity (5,13,15,16,18,19). Our results were consistent with those from other studies, although the association between physical activity and the metabolic syndrome in our study did not attain statistical significance. To date, little was known about the association between sedentary behaviors and the metabolic syndrome. In a study of young adults, the number of hours of inactivity and of watching television or playing video or computer games was positively associated with the prevalence of having three or more risk factors that have been considered to be part of the metabolic syndrome (13).

The adverse effect of excess television viewing on obesity and other risk factors for cardiovascular disease is thought to be attributable, in part, to reduced energy expenditure and, in part, to increased energy intake stimulated by television commercials. Energy expenditure affects all five components of the metabolic syndrome: it is inversely associated with body weight, blood pressure, and concentrations of triglycerides and glucose and is directly associated with the concentration of high-density lipoprotein cholesterol. Thus, people who spend considerable time pursuing sedentary activities are likely to have an unfavorable energy balance with untoward effects on the five components of the metabolic syndrome. The unfavorable energy balance of sedentary people who watch considerable amounts of television may be even further disturbed if they are stimulated to increase their energy intake as well.

The results of our analyses may have several implications for people with or who are at risk for developing the metabolic syndrome and for researchers and health care professionals. Our results support findings from other studies that suggest that engaging in adequate physical activity may help to lower the risk of developing this syndrome. Second, to help lower the prevalence of this syndrome, people should limit the amount of time that they spend in sedentary activities such as watching television or videos or using a computer. Interestingly, our results suggest that measuring participation in physical activity and measuring sedentary behavior provide independent measures of the activity spectrum of individuals and may provide independent information about the risk of future disease. Further, at higher levels of inactivity, the inverse association between physical activity and the metabolic syndrome was attenuated. Third, future studies may wish to include both physical activity questionnaires and questions about sedentary behaviors. Fourth, because a simple question may provide information about the future risk of developing the metabolic syndrome, health care professionals should ask their patients about the amount of time that they spend in sedentary activities and counsel those who spend too much time in such activities about moderating their behavior.

Several limitations of our study deserve comment. The sample size was inadequate to examine associations in greater detail. Furthermore, because this was a cross-sectional study, the directionality of the associations cannot be definitively established. Nevertheless, it seems quite plausible that inadequate physical activity and too much sedentariness contribute to the metabolic syndrome. The reliability or validity of the physical activity questionnaire and the question about watching television or videos or using a computer have not been tested. Questionnaires did undergo extensive cognitive testing, however. Only a single question was asked about participants' time spent sitting and watching television or videos or using a computer outside of work. Thus, we were unable to distinguish the separate effects of the two behaviors.

Excess weight, too much inactivity, and too little physical activity are major modifiable risk factors for the metabolic syndrome. Intervention studies have shown that reducing the amount of time that children watch television results in weight loss (23,24). Future studies that seek to study the beneficial effects of reducing the amount of time that people spend watching television or videos or using a computer are needed to examine the effects on the prevalence of the metabolic syndrome. Weight loss studies have incorporated reduced time watching television as one of their elements (23–28). In addition, studies are needed to test directly the effects of increasing physical activity on the prevalence of the metabolic syndrome.

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