Definition and Prevalence of Sedentarism in an Urban Population

Martine S. Bernstein, MD, Alfredo Morabia, MD, PhD, and Dorith Sloutskis, MPH

ABSTRACT

Objectives. The present study sought to formulate a precise definition of sedentarism and to identify activities performed by active people that could serve as effective preventive goals.

Methods. A population-based sample of 919 residents of Geneva, Switzerland, aged 35 to 74 years, completed a 24-hour recall. Sedentary people were defined as those expending less than 10% of their daily energy in the performance of moderate- and high-intensity activities (at least 4 times the basal metabolism rate).

Results. The rates of sedentarism were 79.5% in men and 87.2% in women. Among sedentary and active men, average daily energy expenditures were 2600 kcal (95% confidence interval [CI]=2552, 2648) and 3226 kcal (95% CI=3110, 3346), respectively; the corresponding averages for women were 2092 kcal (95% CI=2064, 2120) and 2356 kcal (95% CI=2274, 2440). The main moderate- and high-intensity activities among active people were sports (tennis, gymnastics, skiing), walking, climbing stairs, gardening, and (for men only) occupational activities.

Conclusions. The definition of sedentarism outlined in this article can be reproduced in other populations, allows comparisons across studies, and provides preventive guidelines in that the activities most frequently performed by active people are the ones most likely to be adopted by their sedentary peers. (*Am J Public Health.* 1999;89:862–867)

Sedentarism is an independent risk factor for coronary heart disease,[1–3] osteoporosis,[4–7] and cancer.[8] However, it still lacks a consensual definition. Also unclear are the activities that differentiate active from sedentary people. In previous reports, sedentarism has been defined according to total energy expenditure[9,10] or according to energy expended in walking, climbing stairs, and engaging in sports[11]; in performing leisure-time activities[2,12]; and in performing vigorous activities.[13] Occupational activities have usually not been evaluated, despite their importance.[14] To improve the possibility of comparisons across studies, we must establish a definition of sedentarism that will allow universal use.[15]

A report of the US surgeon general[16] suggests that such a definition may be based on total energy expenditure: an increase in daily energy expenditure of approximately 150 kcal is associated with substantial health benefits, and the activity does not need to be vigorous to produce benefits.[16] We used this conclusion as a basis for defining active persons as those expending at least 150 kcal per day in moderate-intensity activities; individuals expending less than this amount were defined as sedentary.

However, the amount of kilocalories expended depends on an individual's basal metabolism rate and on the duration and intensity of the activity. For example, approximately 150 kcal will be expended during 40 minutes of brisk walking for an average adult woman but only 30 minutes for an average adult man. The surgeon general's report defines moderate-intensity activities as those expending 3 to 5 metabolic equivalents,[16] which is approximately 3 to 5 times the basal metabolism rate. For example, walking normally and engaging in household work expend 3 times the basal metabolism rate, while walking briskly and playing table tennis expend 4 times the basal metabolism rate.[17,18] In the present study, we defined moderate activities as those expending 4 times or more the basal metabolism rate.

It is currently recommended that every adult accumulate 30 minutes or more of moderate-intensity physical activity on most—and preferably all—days of the week.[19] However, the moderate activities that would involve the greatest adherence among people older than 35 years still need to be determined.[19–21]

The present study had 2 goals. The first was to formulate, independent of the method used to calculate daily energy expenditure, a precise definition of sedentarism that would be applicable to individuals of all ages and basal metabolism rates and to both sexes. The second goal was to identify moderate- and high-intensity activities performed by active people that could be suggested in preventive guidelines. The rationale is that activities most frequently performed by active people can reasonably be adopted by a large fraction of their sedentary peers.

Methods

Population Recruitment

Geneva, Switzerland, has a population of about 400 000 distributed over 242 km^2 of land. Survey participants were randomly selected throughout 1994 to represent the 89 000 male and 98 000 female noninstitutionalized residents aged 35 to 74 years. An official guide including the first and last

The authors are with the Clinical Epidemiology Division, University Canton Hospital, Geneva, Switzerland.

Requests for reprints should be sent to Martine S. Bernstein, MD, Clinical Epidemiology Division, University Canton Hospital, Rue Micheli-du-Crest 25, 1211 Geneva 14, Switzerland.

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names, sex, age, nationality, and address of all residents is published each year. A list of 3 random numbers generated via computer was used to select a page, a column, and a line in this guide. About 0.5% of the target population was sampled per age group.

Selected men and women received an information letter. Subsequently, interviewers attempted to contact them by telephone. Up to 7 phone calls were made at different times of the day and of the week, including weekends; one seventh of the interviews were conducted each day of the week. Those who could not be reached after 7 attempts were replaced. A systematic check of the following year's edition of the population list showed that more than 90% of "unreachable" subjects no longer resided in Geneva. Subjects who were reached but refused to participate were not replaced. The process of recruiting a potential subject lasted from 2 weeks to 2 months.

Data Collection

Among the 1552 persons selected, 76% (559 men, 617 women) were actually contacted. Among the 35- to 44-year, 45- to 54-year, 55- to 64-year, and 65- to 74-year age groups, respectively, average response rates were 85%, 75%, 75%, and 65% for women and 88%, 86%, 73%, and 66% for men. The study sample distribution was similar to the general population in regard to age and sex (data not shown).

The detailed methods used in the study have been described previously.[22] Briefly, all subjects were interviewed via telephone by 2 public health technicians specially trained for more than a month in the use of a standardized approach to help individuals remember, minute by minute, what they had done since they awoke on the previous day. Time spent sleeping was calculated according to number of waking hours. All activities and their duration were recorded. Participants were also asked whether the day in question was typical in terms of activities performed. Finally, participants responded to items regarding their occupational status, age, weight, and height. Overall, the interview lasted 20 minutes.

Energy Requirements for Physical Activity

We wanted to measure daily energy expenditure as precisely as possible. Comparisons of previous reports[17,18] showed that metabolic equivalent and basal metabolism rate multiples are almost identical but are used differently to calculate daily energy expenditure. One metabolic equivalent is the energy expended per minute while sitting quietly, and this value is equivalent to 3.5 mL of oxygen uptake per kilogram of body weight per minute for an average male adult weighing 70 kg. The basal metabolism rate is a function of sex, age, weight, and height. Metabolic equivalents are expressed for a steady state; basal metabolism rate multiples take into account rest periods embedded in the time during which the activity is being performed (e.g., for chopping wood, intensity is averaged over time actually spent engaging in the activity, including positioning, winding up, chopping, catching one's breath, and rearranging the wood pile).

Equations for calculating basal metabolism rates were derived from the World Health Organization 1986 consensus report,[17] which also provides a detailed list of basal metabolism rate multiples. For example, 20 minutes of slow walking (2.7 basal metabolism rate multiple) by a 40-year-old woman who weighs 54 kg, is 1.62 m tall, and has a basal metabolism rate of 0.899 kcal/minute would expend 48.5 kcal ($20 \times 2.7 \times 0.899$).

All physical activities (n=224) were coded by the interviewers using the energy expenditure table included in the World Health Organization consensus report.[17] Cross checking of coded questionnaires by the interviewers revealed an error rate of less than 1%.

Calculation of Daily Energy Expenditure

For all participants, basal metabolism rate (kilocalories per minute) was computed as a function of sex, age, weight (in kilograms), and height (in centimeters).[17] Energy expenditure for each of the 189 physical activities mentioned during the interviews was obtained as follows: duration per day (minutes) $\times$ basal metabolism rate multiple $\times$ basal metabolism rate.

For each individual, daily energy expenditure was the sum of all activity-specific energy expenditures over the 24-hour period; energy expenditure for the total sample was the sum of all individuals' daily expenditures. Activities' relative contributions to the daily energy expenditure of each individual were also computed.

Statistical Analysis

Four age groups were specified: 35 to 44, 45 to 54, 55 to 64, and 65 to 74 years. Body mass index was computed as reported weight in kilograms divided by reported height in meters squared. Participants were categorized as employed or unemployed (including those who had retired).

Because the distribution of individuals' daily energy expenditures was skewed to the right, a natural log transformation was performed to achieve normality. Means of transformed values were transformed back to original scale values (geometric means). SAS general linear models were used in comparing individuals' daily energy expenditures, and the resulting values were adjusted for age.

Results

Sample Characteristics

Distributions of daily energy expenditures are displayed in Table 1. In men, the geometric means were 2925 kcal in the 35- to 44-year age group and 2374 kcal in the 65- to 74-year age group ($P=.0001$). Age differences were less important among women (2177 kcal in the 35- to 44-year group vs 1956 kcal in the 65- to 74-year group) but were still statistically significant. After adjusting for age, we found that employed men and women expended as much energy as unemployed men and women. Energy expenditure was identical for all days of the week in both sexes (data not shown).

Definition of Sedentarism

The 150-kcal amount reported in the US surgeon general's report[16] as the increase in daily expenditure required for substantial health benefits represented 7.5% and 6%, respectively, of the average daily energy expenditure among the men and women in our adult population. With the idea that our definition of sedentarism will be used in future research in association with health benefits, we wanted to be sure to include all sedentary people in the sedentary group rather than the active group. We therefore classified sedentary people as those expending less than 10% of their daily energy expenditure in activities using 4 or more basal metabolism rate multiples.

Figures 1 and 2 show, for each sex, the cumulative percentage of daily energy expenditure in activities expending 3 or more (bottom curve), 4 or more (middle curve), and 5 or more (top curve) basal metabolism rate multiples.

Activities expending 3 or more basal metabolism rate multiples (e.g., walking normally, engaging in household work) were performed by 90% of men and women. In contrast, 35% of the men and 40% of the women did not perform any activities expending 4 or more basal metabolism rate multiples (e.g., brisk walking and table tennis expend 4 multiples, and leaf raking and lawn

mowing expend 4.5 multiples). A majority of people (70% of men and 80% of women) did not perform any activities expending 5 or more basal metabolism rate multiples (ballroom dancing and bicycling at a rate of 15 km/hour expend about 5 multiples, and most sports expend 6 multiples or more).

According to the proposed definition, the rates of sedentarism were 79.5% (338/425) in men and 87.3% (431/494) in women (Table 2). Daily energy expenditure was statistically smaller in sedentary men (2600 kcal, 95% confidence interval [CI]= 2552, 2648) than in active men (3226 kcal, 95% CI=3110, 3346). The difference was also statistically significant in women: 2092 kilocalories (95% CI=2064, 2120) in sedentary women vs 2356 kcal (95% CI=2274, 2440) in active women. On average, sedentary people were about 3 years older than active people.

Table 3 presents the contribution of activities performed by active people to the overall energy expended in moderate- or high-intensity activities (4 or more basal metabolism rate multiples). The respective contributions among men and women were 40.7% and 51.7% for sports and 12.3% and 41.9% for nonoccupational walking and climbing stairs.

Some activities were important for men only (soccer, handball), while others were important for women only (dancing, aerobics, swimming). Leisure-time pursuits were almost exclusively gardening activities; among men and women, respectively, they contributed to 11.0% and 6.3% of the energy expended in activities involving 4 or more basal metabolism rate multiples. Moderate activity at work was an important source of energy expenditure in men (36.0%) but not in women (0.1%).

TABLE 1—Individual Daily Energy Expenditure (EE), by Sex, According to Sample Characteristics: Geneva, Switzerland, 1994

	Individual Daily EE (kcal/d)					
	Men (n = 425)			Women (n = 494)		
Characteristic	No.	Mean[a]	95% Confidence Interval	No.	Mean[a]	95% Confidence Interval
Age, y						
35–44	135	2925	2825, 3027	153	2177	2125, 2229
45–54	131	2804	2708, 2703	157	2175	2125, 2227
55–64	92	2573	2473, 2677	115	2091	2035, 2148
65–74	67	2374	2228, 2530	69	1956	1884, 2031
P[b]		.0001			.0001	
Employed						
Yes	343	2743	2685, 2802	307	2143	2107, 2180
No	82	2613	2485, 2747	187	2092	2046, 2139
P[b]		.1			.1	
Body mass index, kg/m^2						
<25	223	2583	2516, 2651	350	2040	2009, 2072
≥25	202	2874	2796, 2954	144	2342	2285, 2400
P[b]		.0001			.0001	

[a]Geometric mean adjusted for other factors shown.
[b]For analysis of variance F test on log-transformed values.

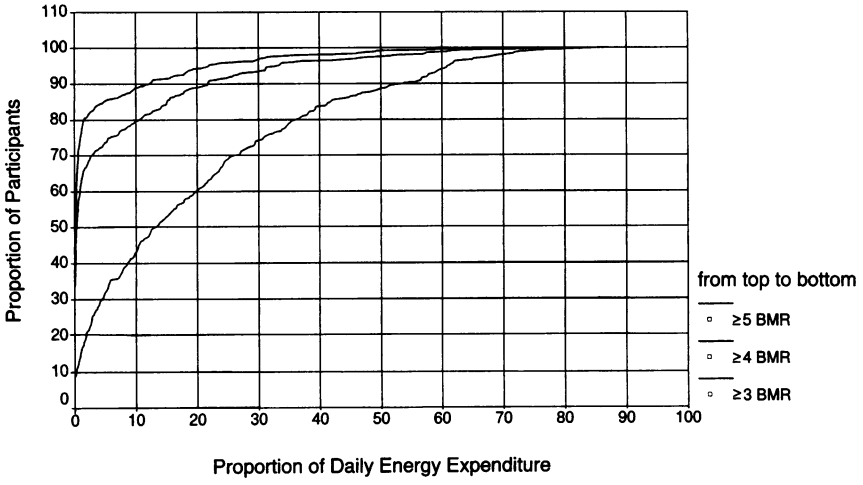

FIGURE 1—Proportion of daily energy expended by men in activities involving various basal metabolism rates (BMR): Geneva, Switzerland, 1994.

Discussion

We proposed that sedentary people be classified as those expending less than 10% of their daily energy in performing moderate- or high-intensity activities (i.e., activities expending 4 or more basal metabolism rate multiples). According to this definition, the sedentarism rates in our general urban population were 79.5% for men and 87.3% for women. Among active men and women, sports and walking were the main moderate- and high-intensity activities.

Sedentarism has previously been defined according to quartiles or tertiles of participants' total or leisure time energy expenditure.[1,2,9,23] But distributions vary between populations, making comparisons across populations impossible. A more comparable approach has been proposed by Paffenbarger et al.,[11] who defined sedentary individuals as those expending fewer than 2000 kcal per week in performing nonoccupational activities rating 3.5 times the basal metabolism rate or more. Some[23,24] have suggested that only high-intensity activities are associated with longevity.[13] Other studies have shown, however, that not only vigorous but also moderate-intensity activities are protective, with a dose–response association.[1,9,15,19,25,26] According to the US surgeon general, both total energy expenditure and energy expended in moderate and vigorous activities should be taken into account. We therefore based our definition of sedentarism on the proportion of daily energy expended in performing moderate and vigorous activities.

Definitions of the amount of energy spent in moderate-intensity activities vary (e.g., 3–5,[27] 3.6–7.1,[16] 4.5–5.5,[18,28] and more than 4.4 basal metabolism rate multiples[11]). Activities expending 3 basal metabolism rate multiples, such as walking slowly or normally, are performed by almost everyone, as shown in our population (Figures 1 and 2). It was decided in the present study that moderate-intensity activities would be those in

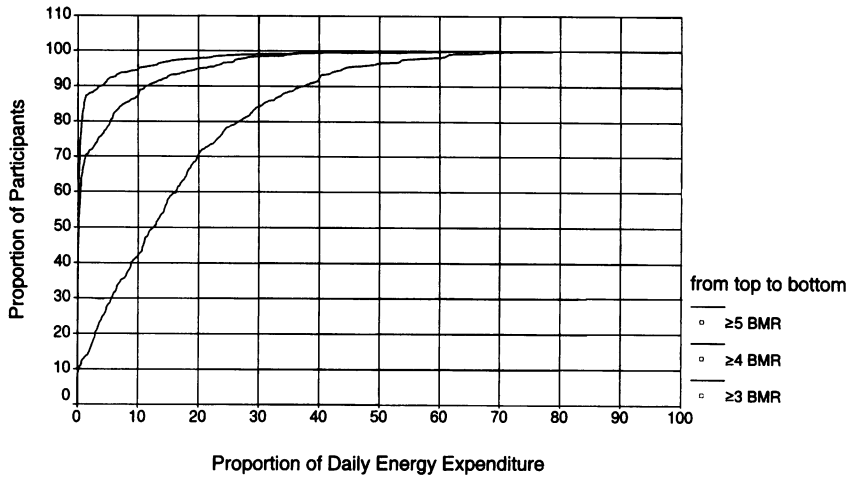

FIGURE 2—Proportion of daily energy expended by women in activities involving various basal metabolism rates (BMR): Geneva, Switzerland, 1994.

which at least 4 basal metabolism rate multiples were expended (e.g., brisk walking and most gardening activities).

Mounting evidence indicates that the health benefits of physical activity are linked principally to total amount of energy expended.[1,9,10,19] The amount of energy required for cholesterol and blood pressure reduction[12,24,29] or for decreases in mortality rates has been found to vary between 60 and 290 additional kcal per day in performing leisure-time physical activities.[11,13] Walking more than 4 hours per week (which expends an average of about 140 kcal per day) has also been found to reduce the risk of cardiovascular disease hospitalizations and death in older adults.[30] The *Healthy People 2000* recommendations include increasing to at least 30% the percentage of people who engage regularly (preferably daily) in light to moderate physical activity for at least 30 minutes per day.[31] For an adult weighing 80 kg, 30 minutes of moderate-intensity activity (e.g., brisk walking) will expend about 150 kcal.

Expending the additional 150 kcal suggested by the surgeon general's report[16] depends on the basal metabolism rate of the individual and the duration and intensity of the activity. For example, a 40-year-old woman who weighs 60 kg, is 1.65 m tall, and has a basal metabolism rate of 0.899 kcal/minute will expend 150 kcal in 40 minutes of brisk walking (4 basal metabolism rate multiples) or 24 minutes of jogging (7 basal metabolism rate multiples). For a man of the same age who weighs 80 kg and is 1.75 m tall, 30 minutes of brisk walking will be sufficient. Our goal was to create a definition that would be applicable to everyone (i.e., individuals of all ages, basal metabolism rates, and weights and those of both sexes).

In our adult population, 150 kcal represented 7.5% of the average daily energy expenditure among women (2100 kcal) and 6% of the expenditure among men (2700 kcal). To be conservative, we chose a higher cutoff of 10%.

Although the rationale for our definition was based on scientific results, the cutoff for moderate-intensity activity could be changed to 3 or 5 basal metabolism rate multiples, and the cutoff for percentage of total energy expenditure (10%) could be decreased (to 6% to 9%). These cutoffs need to be confirmed by additional studies using the proposed definition and showing the health benefits of physical activity in active vs sedentary people.

Among the reasons why people fail to exercise, convenience and motivation are important, but there is also a prevalent misperception that only vigorous, continuous exercise will provide health benefits.[19–21]

TABLE 2—Characteristics of Sedentary and Active Persons, by Sex: Geneva, Switzerland, 1994

Characteristic	Men		Women	
	Sedentary (n = 338)	Active (n = 87)	Sedentary (n = 431)	Active (n = 63)
Age, y, mean (95% confidence interval)	52.6 (51.7, 53.6)	49.8 (47.9, 51.6)	52.1 (51.3, 53.0)	49.7 (47.3, 52.0)
P^a	.007		.05	
Individual daily energy expenditure, kcal/d, geometric mean (95% confidence interval)	2600 (2552, 2648)	3226 (3110, 3346)	2092 (2064, 2120)	2356 (2274, 2440)
P^a	.0001		.0001	
Body mass index, kg/m^2, mean (95% confidence interval)	25.2 (24.9, 25.5)	25.4 (24.7, 26.0)	23.7 (23.3, 24.2)	23.3 (22.2, 24.4)
P^a	.65		.24	
Employed, %				
Yes	80.2	82.8	61.5	66.7
No	19.8	17.2	38.5	33.3
P^b	.59		.43	
Smoking status, %				
Never smoked	25.9	27.3	50.5	58.1
Ex-smoker	37.5	37.7	24.4	22.6
Current smoker	36.6	35.1	25.1	19.4
P^b	.96		.50	

[a]For analysis of variance F test.
[b]For χ^2 test of homogeneity of proportions of sedentary vs nonsedentary persons.

TABLE 3—Contribution of Reported Activities to Overall Energy Expended in Activities Involving 4 or More Basal Metabolic Rate Multiples Among Active People, by Sex: Geneva, Switzerland, 1994

Activity	Contribution	
	Active Men (n = 87), No.[a] (%)	Active Women (n = 63), No.[a] (%)
Sports	57 (40.7)	37 (51.7)
Tennis	9 (7.5)	3 (9.1)
Gymnastics and weight lifting	15 (4.9)	11 (10.4)
Skiing (winter/water skiing)	2 (3.8)	1 (6.4)
Bicycling	7 (2.7)	5 (6.3)
Running	4 (2.4)	1 (0.3)
Swimming	5 (1.8)	6 (5.9)
Aerobic dancing	3 (2.2)	7 (10.2)
Soccer	4 (7.4)	0 (0)
Handball	2 (3.0)	0 (0)
Walking/climbing stairs	66 (12.3)	75 (41.9)
Leisure time[b]	27 (11.0)	5 (6.3)
Work	20 (36)	2 (0.1)
Construction work	7 (19.8)	0 (0)
Brisk walking—stairs	9 (11.0)	2 (0.1)

[a]Number of people in activity group.
[b]Gardening or farming activities.

Therefore, it is important to communicate that exercise can be moderate and can be easy to integrate into everyday life. Moderate activities may differ according to the characteristics of a population (habits, facilities, surroundings, weather) and, within the population, according to sex and age. Therefore, the activities most frequently selected by the active members of the target population will more likely be adopted by sedentary peers. In the present survey, we ranked moderate- and high-intensity activities contributing 10% or more of daily energy expenditure. The most important were bicycling for both genders; walking, gymnastics, and swimming for women; and gardening and weight lifting for men. These results indicate the activities that are preferred by active citizens and that should be emphasized in campaigns promoting physical activity.

Validity and Limitations

The high response rate for the 24-hour recalls offers some security regarding the representativeness of our sample. As expected, daily energy expenditure decreased with age and was generally lower in women than in men. The interviews were conducted evenly over the days of the week throughout the year, making seasonal bias in description of activities unlikely. Daily energy expenditures in men and women were identical throughout the week.

No test–retest reliability analyses were performed, but the physical activity 24-hour recall was validated in 41 volunteers.[22] Briefly, daily energy expenditures were compared with those measured by a modification of the minute-by-minute heart rate method described by Spurr et al.[32] Mean daily energy expenditures calculated via 24-hour recall were not statistically different from those calculated via heart monitoring. The Pearson correlation coefficient between the 2 measurements was quite satisfactory (0.76).

The 24-hour recall method probably underestimates the variety of activities for any single individual, but the complete scope of activities performed in the population is likely to be captured by this method.

Conclusion

The definition of sedentarism proposed here is quantitative, with an explicit cutoff. It can be easily reproduced and applied to everyone independently of age and sex. Given the large numbers of sedentary individuals, it is essential that physical activity levels be increased, especially in urban populations. Identifying moderate activities performed by active people can provide preventive goals for their sedentary peers. □

Contributors

M. Bernstein and A. Morabia conceived and designed the study and wrote the paper. D. Sloutskis analyzed the data. All 3 authors interpreted the data and approved the final version of the paper.

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