Health effects of physical activity

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Abstract

Objectives
This article examines the potential protective effect of leisure-time physical activity on the incidence of heart disease and depression.

Data source
The data are from the household longitudinal component of the 1994/95 and 1996/97 cycles of the National Population Health Survey, conducted by Statistics Canada. Results are based on two sub-samples: 7,158 respondents aged 20 or older who were healthy and free of heart disease in 1994/95, and 7,593 respondents aged 12 or older who were healthy and free of depression in 1994/95.

Analytical techniques
Multiple logistic regression was used to estimate the effects of leisure-time physical activity on the incidence of heart disease and depression, while controlling for selected characteristics.

Main results
Individuals who were healthy and free of heart disease or depression in 1994/95 and who engaged in regular physical activity at a moderate level of energy expenditure had lower odds of reporting a diagnosis of heart disease or an episode of depression in 1996/97 than those who were less active.

Key words
cardiovascular disease, depression, energy expenditure

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The trend toward the automation of many physically demanding tasks has reduced the overall level of energy expenditure both at work and at home. In 1996/97, most Canadians aged 12 or older (95%) engaged in only light physical efforts in their daily activities.[1] While the reduction of everyday physical demands may have made life easier, it may also pose a challenge to the prevention of some chronic diseases and the maintenance of health.[2,3]

Widespread evidence indicates that regular physical activity has both physical and mental health benefits, including the prevention of heart disease and depression.[2-9] Heart disease is a leading cause of death, disability and illness, and one of the major costs of health care in Canada.[10] Depression is a common psychiatric disorder, and another major cause of hospitalization and disability.[3,8,11]

Early studies often emphasized vigorous and continuous exercise as key to improvements in health. However, more recent studies have suggested that moderate physical activity can also provide clinically significant health benefits.[2,3,12-17] Longitudinal data from the first two cycles of the National

Population Health Survey (1994/95 and 1996/97) present a unique opportunity to examine the potentially protective effect of leisure-time physical activity on heart disease and depression among representative samples of the general population (see *Methods*, *Definitions* and *Limitations*).

Level and frequency of activity

According to cross-sectional data from the 1994/95 NPHS, over half (58%) of Canadians aged 12 or older were physically inactive during their leisure time; that is, their activities required a *low* level of energy expenditure (see *Defining physical activity*). Another 22% reported activities that required *medium* energy expenditure. Just 20% had activities that involved a *high* level of energy expenditure. Little change was seen in 1996/97 (data not shown).

The situation was similar among the Canadians who were selected for this follow-up study. Among those who were aged 20 or older and free of heart

Methods

Data source

This article is based on Statistics Canada's National Population Health Survey (NPHS). The NPHS, which began in 1994/95, collects information about the health of the Canadian population every two years.[18,19] It covers household and institutional residents in all provinces and territories, except persons living on Indian reserves, on Canadian Forces bases, and in some remote areas. The NPHS has both a longitudinal and a cross-sectional component. Respondents who are part of the longitudinal component will be followed for up to 20 years.

Individual data are organized into two files: General and Health. Socio-demographic and some health information was obtained for each member of participating households. These data are found in the General file. Additional in-depth health information was collected for one randomly selected household member. The in-depth health information, as well as the information on the General file pertaining to that individual, is found in the Health file.

Among individuals in the longitudinal component, the person providing in-depth health information about himself or herself for the Health file was the randomly selected person for that household in cycle 1 (1994/95) and was usually the person who provided information on all household members for the General file in cycle 2.

The 1994/95 provincial, non-institutional sample consisted of 27,263 households, of which 88.7% agreed to participate in the survey. After the application of a screening rule to keep the sample representative,[18] 20,725 households remained. In 18,342 of these households, the randomly selected person was aged 12 or older. Their response rate to the in-depth health questions was 96.1%, or 17,626 respondents. Of these 17,626 randomly selected respondents, 14,786 were eligible members of the NPHS longitudinal panel. In addition, 468 persons for whom only general information was collected in 1994/95 and 2,022 of the 2,383 randomly selected respondents under age 12 were also eligible. Thus, 17,276 respondents were eligible for re-interview in 1996/97. The remaining respondents were sponsored by provincial governments that elected to enlarge the sample size in their province for cycle 1 only. These respondents were not followed up.

For the longitudinal panel, a response rate of 93.6% was achieved in 1996/97. Of these 16,168 respondents, full information was available for 15,670; that is, general and in-depth health information for both cycles of the survey.

This analysis of leisure-time physical activity and health is based on longitudinal data from the household component of the first (1994/95) and second (1996/97) cycles of the NPHS for the 10 provinces.

To study the incidence of heart disease and depression, the analysis was restricted to 7,158 respondents aged 20 or older who were healthy (that is, they reported their health to be excellent or very good) and free of heart disease in 1994/95 and 7,593 respondents aged 12 or older who were healthy and free of depression in 1994/95. Because of the very low incidence of heart disease among those younger than 20 in 1994/95, this group was excluded from the analysis of heart disease. Those who reported their general health status as poor, fair, or good in 1994/95 were excluded from both analyses to minimize the potential selection bias toward low-level activity as a result of undetected or undiagnosed disease. This approach may reduce selection bias as a possible explanation of the association between physical activity and health. The examination of depression, however, may include individuals with chronic or recurrent depression.[20]

Analytical techniques

The analysis was based on a weighted sample to represent the total household population in the 10 provinces. Multiple logistic regression was used to study the effect of physical activity while controlling for a number of possible confounding factors. The standard errors of regression coefficients were calculated using the bootstrap technique,[21-23] which fully accounts for the design effects of the NPHS.

disease in 1994/95, 57% engaged in leisure-time physical activity with *low* energy expenditure, as did 54% of the population aged 12 or older who were free of depression (Appendix Table A).

About 6 in 10 of the healthy Canadians examined in this article participated in *regular* physical activity. The remaining 40% engaged in physical activity only irregularly.

For this analysis, the reported level and frequency of leisure-time physical activities were combined into four categories: active (high/regular), moderate (medium/regular), light (low/regular) and sedentary (irregular regardless of energy expenditure). In 1994/95, 18% of the population aged 20 or older were active; 22%, moderate; and 15%, light. The largest single group, however, accounting for 40%, were sedentary (Appendix Table B). Reflecting the higher levels of energy expenditure at younger ages, among the population aged 12 or older, the active

percentage was slightly greater (22%), although the sedentary percentage was the same (40%).

Incidence of heart disease

The age-adjusted two-year incidence of heart disease declined with increasing physical activity, from 2.3% for individuals who were sedentary in their leisure time to less than 1% for those who were moderate or active (Chart 1, Appendix Table B). The incidence of heart disease also varied by age, education, household income, activity limitation, smoking status, high blood pressure, and body mass index.[10,26,27] Yet even after adjusting for these risk factors, the odds of two-year incidence of heart disease were higher for those in the less active groups (Table 1). The adjusted odds of having heart disease were significantly high for those in the light and sedentary groups (3.7 and 5.0, respectively), compared with the moderate group. The odds were

Defining physical activity

In the National Population Health Survey (NPHS), the *level* (or amount) of physical activity was defined based on total accumulated energy expenditure, or EE, during leisure time. Information about energy expenditure at work was not available. The EE values were calculated using the frequency and duration of all of the respondents' leisure-time activities in the previous three months as well as the MET values of these activities. MET values, which are the metabolic energy demand of each activity, were independently established.[24,25]

$$EE = \sum(N_i * D_i * METS_i / 365)$$

where

N_i = number of occasions of activity i in a year

D_i = average duration in hours of activity i

$METS_i$ = a constant value for metabolic energy cost of activity i.

For each individual, daily EE was the sum of energy expenditures of all activities in leisure time.[25] It was expressed as total kilocalories expended per kilogram of body weight per day: kcal/kg/day or KKD. An EE of 1.5 to 2.9 KKD was considered *medium* energy expenditure. An EE of 3 or more KKD was *high*; an EE of less than 1.5 KKD, *low*.[24]

The *frequency* (or regularity) of physical activity was based on the number of times in the previous three months that respondents had participated in a physical activity that lasted more than 15 minutes: *regular* (12 or more times per month) or irregular (11 or fewer times per month).

To examine the effects of *level* and *frequency* of physical activity on health, four physical activity categories were defined:

- *Active*—high (3 or more KKD) energy expenditure during regular physical activity.
- *Moderate*—medium (1.5 to 2.9 KKD) energy expenditure during regular physical activity.
- *Light*—low (less than 1.5 KKD) energy expenditure during regular physical activity.
- *Sedentary*—irregular physical activity regardless of energy expenditure.

This analysis focuses on the health differences between individuals who regularly engaged in physical activities with high or medium energy expenditure (active and moderate) and those who were less active (light and sedentary).

Chart 1
Age-adjusted two-year incidence of heart disease by leisure-time physical activity, household population aged 20 or older, Canada excluding territories, 1994/95 to 1996/97
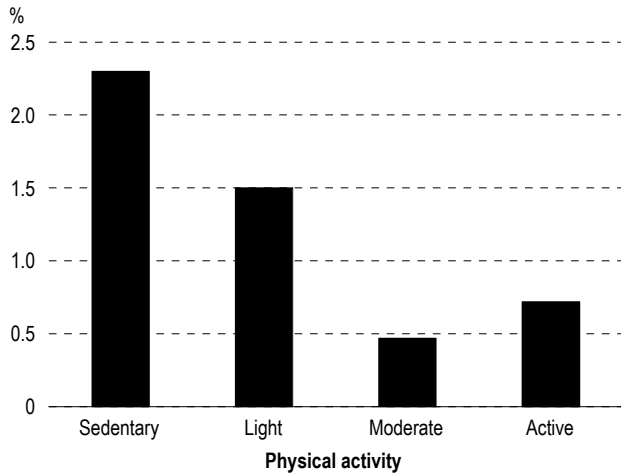
Data source: *1994/95 and 1996/97 National Population Health Survey, longitudinal sample, Health file*

Chart 2
Age-adjusted two-year incidence of depression by leisure-time physical activity, household population aged 12 or older, Canada excluding territories, 1994/95 to 1996/97
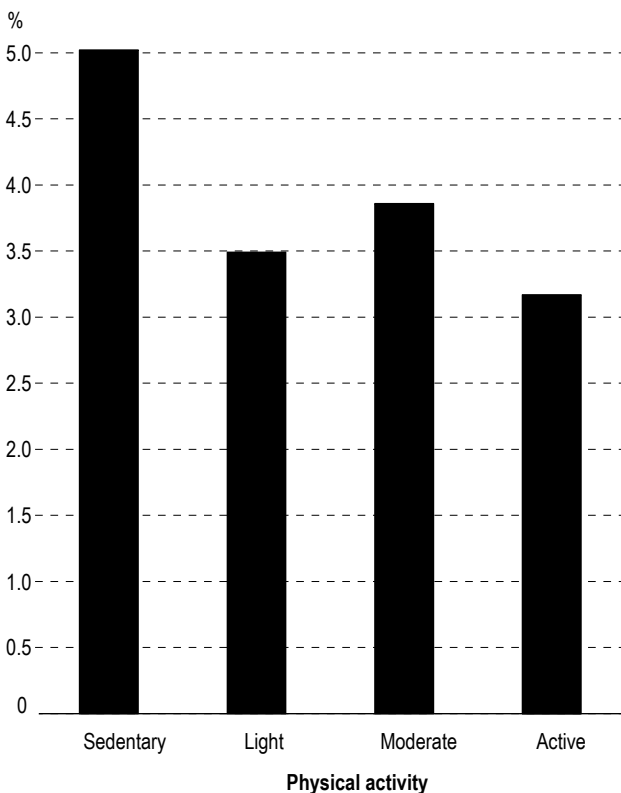
Data source: *1994/95 and 1996/97 National Population Health Survey, longitudinal sample, Health file*

also slightly higher for those in the active group than the moderate group, but the difference was not statistically significant. This implies that regular—and at least moderate—physical activity can be beneficial to heart health. The results also suggest that engaging in physical activity on a more regular basis, even at moderate levels of energy expenditure, may provide some protection against heart disease. Besides the amount of physical activity, being 65 or older was associated with higher odds for heart disease compared with being 20 to 44.

Table 1
Adjusted odds ratios for two-year incidence of heart disease, household population aged 20 or older who were healthy and free of heart disease in 1994/95, by selected characteristics, Canada excluding territories, 1994/95 to 1996/97

Characteristics in 1994/95	Odds ratio	95% confidence interval
Leisure-time physical activity		
Active	1.3	0.41, 3.89
Moderate†	1.0	...
Light	3.7*	1.26,10.67
Sedentary	5.0*	1.84,13.59
Age group		
20-44†	1.0	...
45-64	2.1	0.72, 6.11
65+	12.6*	5.08,31.44
Sex		
Male†	1.0	...
Female	0.7	0.35, 1.42
Educational attainment		
Less than secondary graduation†	1.0	...
Secondary graduation or more	0.8	0.37, 1.75
Household income		
Low†	1.0	...
Middle	1.4	0.52, 3.71
High	3.2	0.72,14.51
Activity limitation		
Yes	3.1	0.96, 9.91
No†	1.0	...
Smoking status		
Daily	2.1	0.88, 5.10
Occasional/Former	0.9	0.40, 2.01
Never†	1.0	...
High blood pressure		
Yes	0.5	0.13, 1.77
No†	1.0	...
Body mass index (BMI)		
Overweight (BMI >27)	1.7	0.67, 4.48
Not overweight (BMI ≤ 27)†	1.0	...

Data source: *1994/95 and 1996/97 National Population Health Survey, longitudinal sample, Health file*
† Reference category, for which odds ratio is always 1.0
* $p < 0.05$
... Not applicable

Incidence of depression

The age-adjusted two-year incidence of depression differed mainly between the three groups who engaged in regular physical activity regardless of level (about 3%) and the group who did not participate regularly (5%) (Chart 2). Because the incidence of depression varied by age, education, household income and activity limitation status (Appendix Table B),[6,11,28,29] it was necessary to control for these risk factors when considering the effects of physical activity on depression.

After these factors were controlled, those who were sedentary during leisure time had higher odds of experiencing a depressive episode than did their counterparts who engaged in moderate activity (Table 2). The differences in the incidence of

Table 2
Adjusted odds ratios for two-year incidence of depression, household population aged 12 or older who were healthy and free of depression in 1994/95, by selected characteristics, Canada excluding territories, 1994/95 to 1996/97

Characteristics in 1994/95	Odds ratio	95% confidence interval
Leisure-time physical activity		
Active	1.0	0.60, 1.56
Moderate[†]	1.0	...
Light	1.1	0.60, 1.77
Sedentary	1.6*	1.03, 2.48
Age group		
12-19[†]	1.0	...
20-44	0.6*	0.35, 0.87
45-64	0.4*	0.24, 0.61
65+	0.5*	0.29, 0.91
Sex		
Male[†]	1.0	...
Female	1.3	0.95, 1.82
Education		
Less than secondary graduation[†]	1.0	...
Secondary graduation or above	0.8	0.56, 1.18
Household income		
Low[†]	1.0	...
Middle	0.7	0.46, 1.15
High	1.1	0.61, 2.04
Activity limitation		
Yes	2.3*	1.35, 4.04
No[†]	1.0	...

Data source: *1994/95 and 1996/97 National Population Health Survey, longitudinal sample, Health file*
† Reference category, for which odds ratio is always 1.0
* $p < 0.05$
... Not applicable

depression between active and moderate were not statistically significant, however. This suggests that even moderate physical activity performed regularly may be instrumental in preventing or managing depression. As well as physical activity, age and activity limitation were related to depression. Those who were young (12 to 19) or who had an activity limitation had higher odds of having had a depressive episode in the past year.

Moderate activity beneficial

Accumulating evidence indicates that physical activity may have multiple beneficial physiological and metabolic effects on heart health. These include "advantageous effects on atherosclerosis, plasma lipid/lipoprotein profiles, blood pressure, availability of oxygenated blood for heart muscle needs (ischemia), blood clotting (thrombosis), and heart rhythm disturbances (arrhythmia)."[3] Physical activity may also have positive effects on heart disease risk factors, such as obesity, distribution of body fat, and incidence of non-insulin-dependent diabetes, and on the prevalence of smoking.[3,9,12,14]

The effects of physical activity on depression may also be diverse. It has been suggested that "exercise-induced changes in brain neuroreceptor concentrations of monoamines (norepinephrine, dopamine, or serotonin) or endogenous opiates (endorphins and enkephalins) may help to favorably alter mood."[3] In addition, physical activity may provide psychological benefits, such as "having the opportunity for social interaction and support, experiencing increased feelings of self-mastery and self-efficacy, and experiencing relief from daily stressors."[3]

Although active and moderate participation in physical activity may have protective effects against heart disease or depression in general, vigorous physical activity may carry some risks, such as musculoskeletal injuries or sudden acute cardiac events. Those who engage in moderate physical activity, however, may be at lower risk of injury compared with those who engage in vigorous activity. While it is recommended that persons with heart conditions and seniors with multiple cardiovascular risk factors should have a medical

consultation before beginning vigorous activity,[3,30,31] moderate participation appears to safely produce health benefits.

Concluding remarks

This prospective analysis of the incidence of heart disease and depression over the two-year period between the first two cycles (1994/95 and 1996/97) of the National Population Health Survey clarifies the direction of the associations between physical activity and health. It suggests that physical activity has protective effects on heart health and mental health that are independent of many other risk factors. The associations are consistent with previous

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Definitions

National Population Health Survey (NPHS) respondents were asked if they had any "long-term conditions that have lasted or are expected to last 6 months or more and that have been diagnosed by a health professional." The interviewer then read a list of conditions. *Heart disease* was included in this list. (If respondents asked what was meant by "heart disease," they were told that it includes angina, heart failure, and rheumatic heart disease.) *High blood pressure*, also relevant to this analysis, was among the conditions listed.

Using the methodology of Kessler et al.,[32] the NPHS identifies a major depressive episode (MDE) with a subset of questions from the Composite International Diagnostic Interview. These questions cover a cluster of symptoms for depressive disorder, which are listed in the *Diagnostic and Statistical Manual of Mental Disorders (DSM III-R).*[33] Responses to these questions were scored on a scale and transformed into a probability estimate of a diagnosis of MDE. If this estimate was 0.9 (that is, 90% certainty of a positive diagnosis), then the respondent was considered to have experienced *depression* in the previous 12 months.[11]

Educational attainment was collapsed into two categories: less than secondary graduation, and secondary graduation or more.

Household income groups were defined by taking into account both household income and the number of people in the household. Three groups were established:

Income group	Number of household members	Household income
Low	1 or 2	Less than $14,999
	3 or 4	Less than $19,999
	5 or more	Less than $29,999
Middle	1 or 2	$15,000 to $59,999
	3 or 4	$20,000 to $79,999
	5 or more	$30,000 to $79,999
High	1 or 2	$60,000 and over
	3 or 4	$80,000 and over
	5 or more	$80,000 and over

A positive response to the question, "Because of a long-term physical or mental condition or a health problem, are you limited in the amount of physical activity you can do at home? at school? at work? in other activities, such as transportation to or from work or leisure time activities?" or "Do you have any long-term disabilities or handicaps?" indicated an *activity limitation*.

Smoking status was determined by asking the following questions: (1) "At the present time do you smoke cigarettes daily, occasionally or not at all?" and (2) "Have you ever smoked cigarettes at all?". Those who chose "daily" in response to Question 1 were classed as *daily* smokers; those replying, "occasionally," as *occasional* smokers. *Former* smokers are those who chose "not at all" in answer to Question 1 and "yes" for Question 2. Respondents who answered "no" to Question 2 were given *never* smoking status.

Body mass index (BMI), which was calculated by dividing weight in kilograms by height in metres squared, was grouped into two categories: overweight (a BMI of more than 27) and not overweight (a BMI of 27 or less).[34] Some caution is warranted in using BMI in populations containing individuals older than 64. The BMI may be less reliable because of loss of height as persons age.[35,36]

Limitations

National Population Health Survey (NPHS) data are subject to the problems inherent in self-reporting. There was no independent source to confirm whether people who reported having been diagnosed with heart disease or other health problems were actually afflicted.

Ideally, a study of the incidence of heart disease should control for other potential confounding risk factors, such as diet and cholesterol, but this information was not collected by the NPHS.[3,4,37-39] A study of the incidence of heart disease should also control for diabetes.[3,6,25,28] However, the sample size for respondents with diabetes who described their health as excellent or very good in 1994/95 was too small to produce reliable estimates of the incidence of heart disease among them by 1996/97.

As well, the analysis of depression should exclude people who had suffered recurrent or chronic depression before the first NPHS cycle,[20] but such information is not available.

A longer period would be preferable to examine the temporal relationship between change in physical activity and the incidence of heart disease or depression.[5,6] This will be possible only when new cycles of longitudinal data become available.

A measure of total energy expenditure rather than only that pertaining to leisure time would be more useful, as some individuals may expend considerable amounts of energy in their non-leisure time (at work or doing household chores, for example).[40] A direct assessment of physical fitness would also have higher accuracy and reliability in measuring physical activity than self-reported information. It has been suggested that potential measurement errors would tend to reduce the strength of the association between physical activity and health.[3,40]

studies, and they show a temporal sequence; that is, physical activity status preceded the onset of heart disease or depression.[3,9,12,14] Nonetheless, causality has not been established. Both heart disease and depression have complex origins and usually develop over a long period. A two-year follow-up study may remain subject to some undetected selection bias. And because a respondent's past level and duration of physical activity are unknown, the effect of physical activity on health can also be subject to error.

Even so, the results indicate that regular and at least moderate physical activity is associated with reduced odds of heart disease and depression. They also underscore the importance of encouraging more people to make moderate physical activity a part of their lives.[2,14,17]

Despite many years of health promotion, about 4 in 10 Canadian adults are sedentary during their leisure time. Some research suggests that among such persons, the previous emphasis on vigorous exercise may have been seen as unrealistic.[2,3,12,32] Consequently, many inactive persons may have been discouraged from pursuing physical activity. The results of this analysis, however, can be added to those showing that moderate, but regular, physical activity confers health benefits. ●

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Appendix

Table A
Level and frequency of leisure-time physical activity in 1994/95, Canada excluding territories

Level of activity	Total population		Frequency of activity			
			Regular (12 or more times per month)		Irregular (less than 12 times per month)	
	'000	%	'000	%	'000	%
Household population aged 20 or older†	**11,841**	**100.0**	**6,877**	**100.0**	**4,963**	**100.0**
High	2,255	19.0	2,255	32.8	0	0.0
Medium	2,803	23.7	2,753	40.0	50	1.0
Low	6,782	57.3	1,869	27.2	4,913	99.0
Household population aged 12 or older‡	**13,574**	**100.0**	**8,210**	**100.0**	**5,364**	**100.0**
High	3,031	22.3	3,030	36.9	1	0.0
Medium	3,230	23.8	3,131	38.1	99	1.8
Low	7,314	53.9	2,049	25.0	5,265	98.1

Data source: *1994/95 and 1996/97 National Population Health Survey, longitudinal sample, Health file*
Note: *Detail may not add to totals because of rounding.*
† Individuals who reported their health as excellent or very good and who were free of heart disease in 1994/95
‡ Individuals who reported their health as excellent or very good and who were free of depression in 1994/95

Table B
Unadjusted two-year incidence of heart disease or depression, household population healthy and free of heart disease or depression in 1994/95, by selected characteristics, Canada excluding territories, 1994/95 to 1996/97

Characteristics in 1994/95	Heart disease (age 20 or older)			Depression (age 12 or older)		
	Total		Two-year incidence %	Total		Two-year incidence %
	Sample size	Population '000		Sample size	Population '000	
Total	7,158	12,456	1.4	7,593	13,578	4.1
Leisure-time physical activity†						
Active	1,309	2,255	0.7	1,622	3,030	3.6
Moderate	1,616	2,753	0.5	1,778	3,131	3.8
Light	1,131	1,869	1.6	1,189	2,049	3.4
Sedentary	2,822	4,963	2.2	3,002	5,364	4.8
Missing	280	616	1.2	2	4	0.0
Age group						
12-19	...	...	...	887	2,061	6.9
20-44	4,386	8,011	0.6	4,021	7,321	3.8
45-64	1,876	3,286	1.8	1,773	3,056	2.8
65+	896	1,159	5.9	912	1,139	4.1
Sex						
Male	3,298	6,314	1.7	3,505	6,858	3.5
Female	3,860	6,142	1.1	4,088	6,720	4.7
Educational attainment						
Less than secondary graduation	1,456	2,173	2.7	2,069	3,662	5.5
Secondary graduation or above	5,693	10,266	1.2	5,515	9,900	3.6
Missing	9	18	0.0	9	16	0.0
Household income						
Low	1,134	1,550	1.3	1,254	1,787	5.2
Middle	4,680	7,953	1.3	4,933	8,589	3.5
High	1,071	2,357	2.2	1,110	2,542	4.9
Missing	273	596	0.8	296	660	4.6
Activity limitation						
Yes	749	1,241	3.7	785	1,292	7.9
No	6,408	11,214	1.2	6,806	12,281	3.7
Missing	1	1	0.0	2	5	0.0
Smoking status						
Daily	1,744	2,846	2.0	...	...	...
Occasional/Former	2,565	4,386	1.3	...	...	...
Never	2,847	5,218	1.2	...	...	...
Missing	2	8	0.0	...	...	...
High blood pressure						
Yes	447	611	2.1	...	...	...
No	6,711	11,846	1.4	...	...	...
Body mass index (BMI)						
Overweight (BMI > 27)	1,949	3,207	2.2	...	...	...
Not overweight (BMI ≤ 27)	5,036	8,965	1.1	...	...	...
Missing	173	284	2.0	...	...	...

Data source: *1994/95 and 1996/97 National Population Health Survey, longitudinal sample, Health file*
Note: *Detail may not add to totals because of rounding.*
† Because these figures are not age-adjusted, two-year incidence rates differ slightly from those in Charts 1 and 2.
¨ Not applicable