

Body mass index and health

Jason Gilmore

The relationship between weight and health is widely acknowledged. The association of excess weight with health problems such as heart disease, Type II diabetes, high blood pressure and stroke has been extensively documented.¹⁻⁶ But being too thin can also endanger health. Thus, other research has investigated the prevalence of underweight, usually among women, and its association with eating disorders.⁷ Few studies have compared the health of those who are underweight and those who are overweight with individuals of “acceptable” weight. However, data from the National Population Health Survey (NPHS), which are not available from other surveys, allow such a comparison.

The body mass index (BMI), which relates weight to height, is the most common method of determining if an individual’s weight is in a healthy range (see *Body mass index*). This analysis, based on the 1996/97 NPHS (see *Methods, Definitions and Limitations*), describes the socio-demographic characteristics and lifestyle behaviours of adult Canadians (aged 20 to 64) in the context of internationally accepted BMI groupings. It also explores the relationship between

Abstract

Objectives

This article describes the prevalence of the four international body mass index (BMI) categories—underweight (18.5 or less), acceptable weight (18.6 to 24.9), overweight (25 to 29.9) and obese (30 or more)—by selected socio-demographic and lifestyle characteristics. It also examines the association between BMI and selected health problems.

Data source

The data are from the household component of the 1996/97 National Population Health Survey, conducted by Statistics Canada. Results are based on a sample of 50,347 respondents aged 20 to 64.

Analytical techniques

Prevalence estimates of BMI categories were calculated. Multivariate analyses were used to examine associations between BMI and various health conditions by smoking status, while controlling for age and sex.

Main results

In 1996/97, about half of Canadian adults were in the acceptable weight range; 34% were overweight; 12%, obese; and 2%, underweight. Being overweight or obese was associated with asthma, arthritis, back problems, high blood pressure, diabetes and thyroid disorders, although this varied with smoking status. Underweight smokers had high odds of reporting cancer, bowel disorders, ulcers, and migraine.

Key words

body weight, obesity, thinness, risk factors, smoking

Author

Jason Gilmore (613-951-7118; gilmjas@statcan.ca) is with the Health Statistics Division at Statistics Canada, Ottawa K1A 0T6.

various health conditions and the three unacceptable BMI categories: underweight, overweight and obese. Because smoking is related to body weight and is also a risk factor for many medical problems,⁸ the effect of smoking status is assessed as well. While

most studies relating BMI to health have focussed on particular diseases, this article examines a broader set of health indicators: thirteen chronic conditions, along with activity restriction, repetitive strain injuries, depression, and self-rated health status.

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.^{9,10} It covers household residents in all provinces and territories, except people 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.

This analysis of Body Mass Index (BMI) uses cross-sectional data from cycle 2 of the NPHS, conducted in 1996/97. The data analyzed pertain to the household population in the 10 provinces.

The 1996/97 cross-sectional sample is made up of longitudinal respondents and respondents who were selected as part of supplemental samples, or buy-ins, in three provinces. The additional respondents for the buy-ins were chosen with the random digit dialing (RDD) technique and were included for cross-sectional purposes only.

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.

In households belonging to the cross-sectional buy-in component, one knowledgeable person provided the socio-demographic and health information about all household members for the General file. As well, one household member, not necessarily the same person, was randomly selected to provide in-depth health information about himself or herself for 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.

In 1996/97, there were 81,804 respondents to the questions on the Health file. The 1996/97 cross-sectional response rates for the

Health file were 93.1% for the longitudinal component and 75.8% for the RDD component, yielding an overall response rate of 79.0%.

The target population for this analysis is adults aged 20 to 64. Younger and older people, as well as pregnant women, were excluded because of their changing weight and/or height, which can distort BMI ratings. The cross-sectional file for the calculation of BMI had a sample of 50,347 respondents aged 20 to 64, representing an estimated 17.7 million people.

Analytical techniques

Prevalence estimates of underweight, acceptable weight, overweight and obesity by various characteristics were calculated. Cross-tabulations by educational attainment, household income, birthplace, alcohol consumption, smoking, and leisure-time physical activity were age-adjusted to the 1996/97 Canadian population, both sexes. All estimates were weighted to represent the population at the time of the survey. Tests of significance were done on unadjusted percentages. Critical values were adjusted to take multiple comparisons into account.

BMI ratings are related to a variety of health conditions. Logistic regressions were used to estimate the odds ratios for various conditions among people who were underweight, overweight or obese. Separate regressions were done for smokers, former smokers and never-smokers in each BMI category. Additional independent variables were the age and sex of the respondents. Acceptable weight by smoking status was the reference group for each of these analyses. A separate logistic regression was used to estimate the odds of various health conditions among people who were obese, compared with those who were overweight. Respondents with information missing for one or more variables were omitted from the analysis.

The sample weights were used in all the analyses. A weighted bootstrap resampling procedure was used to calculate coefficients of variations for totals and rates.^{11,12} This technique also served to test the significance of differences between rates and to estimate standard errors used in the calculation of the confidence intervals for the odds ratios. Results at the 0.05 level were considered significant.

One in eight obese

In 1996/97, the weight of almost half (48%) of Canadians aged 20 to 64 was in a range appropriate to their height (Table 1). Another 34% were overweight, and 12%, approximately 2.1 million, were obese. Research indicates that calculations based on self-reported height and weight underestimate obesity by about 10%;² therefore, 2.3 million may be a more accurate estimate of the number of obese adults.

According to data compiled by the Organisation for Economic Co-operation and Development, Canada's obesity rate was higher than levels reported

Body mass index

Body mass index (BMI) is calculated by dividing weight in kilograms by height in metres squared. For example, to calculate the BMI of someone 5 feet 8 inches tall weighing 160 pounds, it is first necessary to convert their height into metres (68 inches X 2.54 = 172.7 centimetres or 1.727 metres) and their weight into kilograms (160 pounds X 0.454 = 72.6 kilograms). The BMI of this individual is 24.4, a result of dividing weight (72.6 kilograms) by height in metres squared (1.727 X 1.727 = 2.98).

The BMI categories used for this article are: 18.5 or less (underweight), 18.6 to 24.9 (acceptable weight), 25.0 to 29.9 (overweight), and 30.0 or more (obese). These groupings are endorsed by the World Health Organization^{13,14} and the National Institutes of Health¹ of the United States. This classification differs from the Canadian standard: less than 20.0 (underweight), 20.0 to 24.9 (acceptable weight), 25 to 27.0 (some excess weight), and more than 27.0 (overweight).¹⁵ The international standard is used here so that results for Canada can be compared with those of other countries. BMI is calculated for people aged 20 to 64 (excluding pregnant women).

In 1996/97, the average height of Canadian women aged 20 to 64 was 1.63 metres (5 feet 4 inches), and their average weight was 65.8 kilograms (145 pounds). The average man was 1.78 metres tall (5 feet 10 inches) and weighed 83.2 kilograms (183 pounds).¹ Thus, using the formula, the average woman's BMI was 24.8 (acceptable range), and the average man's, 26.3 (overweight).

While height varied little among age groups, weight tended to rise with age. For women, average weight increased from 62.2 kilograms (137 pounds) at ages 20 to 24 to 68.9 kilograms (152 pounds) at ages 55 to 64. For men, average weight was lowest at ages 20 to 24 (79.5 kilograms or 175 pounds), and highest at ages 45 to 54 (84.6 kilograms or 187 pounds).

Table 1

Percentage distribution of body mass index categories, population aged 20 to 64, by selected characteristics, Canada excluding territories, 1996/97

	Population	Under- weight	Acceptable weight	Over- weight	Obese	Not stated
	'000	%				
Total 20-64	17,702	2	48	34	12	3
Age and sex						
Men	8,955	1	40	44	13	1
Women	8,748	4	56	24	11	5
20-24	1,837	5	65	22	6	2
Men	948	2 [†]	60	31	6	1 [†]
Women	889	9	69	13	5 [†]	3
25-34	4,319	3	53	31	10	3
Men	2,209	1 [†]	45	42	11	1 [†]
Women	2,110	6	60	20	10	4
35-44	5,213	2	49	34	12	3
Men	2,645	--	39	46	14	1
Women	2,568	3	60	22	10	5
45-54	3,768	1	40	40	15	3
Men	1,922	1 [†]	31	50	17	2 [†]
Women	1,846	2 [†]	49	30	14	5
55-64	2,565	1	38	42	16	3
Men	1,231	1 [†]	32	49	15	2 [†]
Women	1,334	2 [†]	43	34	17	5
Education[§]						
Less than high school	3,179	2	42	37	16	3
High school	3,109	3	47	34	12	4
Some post-secondary	4,459	3	47	35	12	3
Postsecondary graduation	6,849	2	52	33	10	3
Missing	105	--	39	34	9 [†]	13 [†]
Household income[§]						
Lowest	733	4 [†]	52	29	14	2 [†]
Lower-middle	1,387	4 [†]	46	31	16	2 [†]
Middle	4,092	3	47	34	14	2
Upper-middle	6,232	2	48	36	12	2
Highest	2,554	2	50	37	9	2
Missing	2,704	3	47	32	10	8
Province						
Newfoundland	336	--	42	39	17	--
Prince Edward Island	79	2 [†]	38	41	16	--
Nova Scotia	557	--	42	37	18	--
New Brunswick	446	--	38	40	20	--
Québec	4,465	3	51	33	11	2
Ontario	6,736	3	48	33	12	4
Manitoba	627	2 [†]	43	36	15	4
Saskatchewan	527	--	39	40	18	--
Alberta	1,633	2	47	36	12	3
British Columbia	2,295	2 [†]	52	35	10	1 [†]
Birthplace[§]						
Canada	14,165	2	47	35	13	3
United States,						
Europe, Australia	1,837	2	49	35	11	3
Asia	1,079	7	62	22	5 [†]	3 [†]
Elsewhere	579	2 [†]	46	39	9	4 [†]
Missing	41	--	--	--	--	--

Data source: 1996/97 National Population Health Survey, cross-sectional sample, Health file

Note: Because of rounding, detail may not add to totals.

[†] Coefficient of variation between 16.6% and 25.0%

[‡] Coefficient of variation between 25.1% and 33.3%

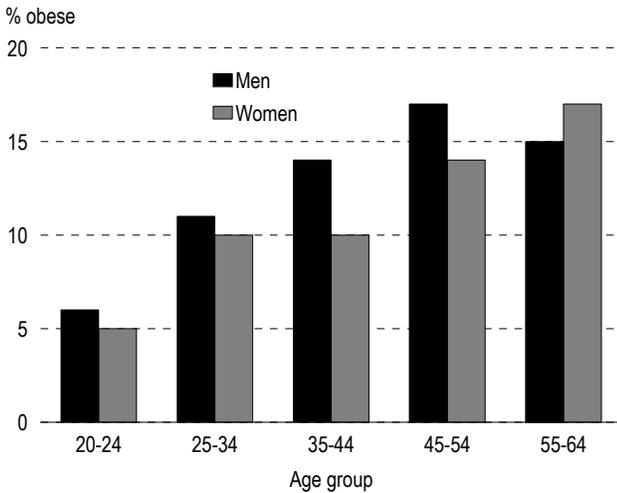
[§] Age-adjusted to the 1996/97 Canadian population, both sexes.

-- Amount too small to provide reliable estimate

for the Netherlands (7%), France (8%) and Australia (9%).¹⁶ However, the rate in Canada was well below that in England (16%)¹³ and the United States (23%).

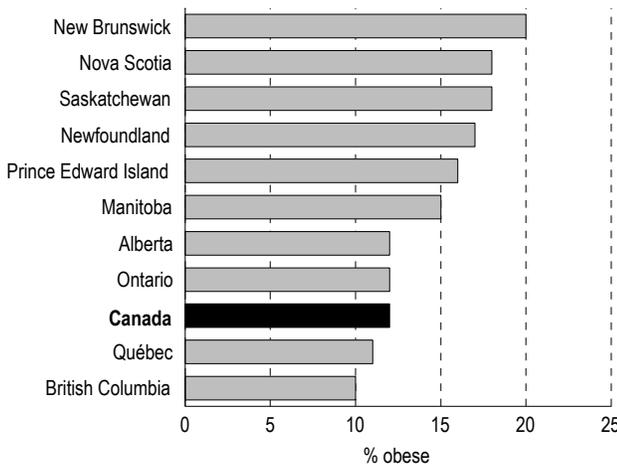
Underweight was relatively uncommon. Only 2% of Canadian adults, about 400,000, were classified as underweight.

Chart 1
Prevalence of obesity,[†] population aged 20 to 64, by age group and sex, Canada excluding territories, 1996/97



Data source: 1996/97 National Population Health Survey, cross-sectional sample, Health file
† Body mass index 30+

Chart 2
Prevalence of obesity,[†] population aged 20 to 64, by province, 1996/97



Data source: 1996/97 National Population Health Survey, cross-sectional sample, Health file
† Body mass index 30+

BMI differs by sex and age

Women were significantly more likely than men to have an acceptable weight or to be underweight, while the prevalence of overweight and obesity was significantly higher among men. These patterns echo numerous earlier studies,^{3,14,17,18} although men's greater muscle and bone mass accounts for some of the difference.

BMI rose with age. Younger people (both men and women aged 20 to 24) had the lowest rates of overweight and obesity and the highest rates of being at an acceptable weight (Table 1 and Chart 1).

Education, income and province

At each successive level of education, the percentage of people with an acceptable BMI tended to increase, while the proportion classified as overweight or obese tended to decline. This is consistent with the literature,^{1,2} and may be partly attributable to more educated people being better informed about healthy dietary practices, the benefits of exercise, and the medical hazards of obesity.

Household income was also related to BMI, but the association was less clear. Obesity tended to be more common among people in lower income households. However, the prevalence of overweight tended to rise with income.

Provincial BMI ratings varied, reflecting, at least in part, different lifestyles and dietary practices. Obesity was more prevalent in the Atlantic region, Saskatchewan and Manitoba than in the other provinces (Chart 2).

Strong links with birthplace

Immigrants born in Asia tended to have lower BMIs than did Canadian-born adults or immigrants born in other parts of the world. In fact, 7% of immigrants born in Asia were underweight, compared with 2% of Canadian-born adults. Only 5% of Asian-born immigrants were obese. By contrast, obesity affected 13% of Canadian-born adults. BMI differences between ethnic groups could be due to differences in body build¹⁹ and may also be related to diet during early childhood.

Drinking, smoking and exercise

BMI was associated with lifestyle behaviour, notably, alcohol consumption, smoking and physical activity. More than a third of current drinkers were overweight, compared with just over a quarter of people who had never been drinkers (Table 2). Obesity, however, was more prevalent among former than current drinkers.

The prevalence of overweight and obesity was highest among former smokers. Whereas 37% of former smokers were overweight, the figure was 34% for current smokers and 33% for people who had never smoked. The corresponding rates of obesity were 14%, 11% and 12%.

As might be expected, obesity was related to physical activity. The obesity rate was 13% among people who were not physically active in their leisure time. For those who were moderately active, the rate was 11%; for those who were active, 9%. By contrast, the prevalence of overweight did not vary substantially with physical activity.

Table 2
Percentage distribution of body mass index categories, population aged 20 to 64, by selected lifestyle behaviour characteristics, Canada excluding territories, 1996/97

	Population '000	Under- weight	Acceptable weight	Over- weight	Obese	Not stated
		%				
Total 20-64	17,702	2	48	34	12	3
Alcohol consumption[†]						
Current drinker	14,173	2	48	35	12	2
Former drinker	2,016	3	46	32	15	4
Never drinker	1,334	4	49	27	12	7
Missing	179	--	38	29	4	21
Smoking[†]						
Current smoker	5,533	3	50	34	11	2
Former smoker	4,996	1 [‡]	45	37	14	3
Never smoker	7,117	2	49	33	12	4
Missing	55	--	33 [‡]	30 [‡]	9 [§]	26 [‡]
Leisure-time physical activity[†]						
Active	3,190	2	51	36	9	2
Moderately active	3,941	2	50	35	11	2
Inactive	10,191	3	47	34	13	3
Missing	380	2 [§]	38	33	15	12 [‡]

Data source: 1996/97 National Population Health Survey 1996/97, cross-sectional sample, Health file

Note: Because of rounding, detail may not add to totals.

[†] Age-adjusted to the 1996/97 Canadian population, both sexes

[‡] Coefficient of variation between 16.6% and 25.0%

[§] Coefficient of variation between 25.1% and 33.3%

-- Amount too small to provide reliable estimate

Limitations

Since the National Population Health Survey (NPHS) data used in this analysis are cross-sectional, relationships between variables can be described, but causality cannot be inferred. For instance, it is not possible to determine the temporal relationship between BMI and the presence of chronic diseases. Some diseases cause weight loss, while others are associated with weight gain. Cross-sectional data do not indicate whether a given BMI preceded the respondent's chronic condition, or whether the condition was antecedent to a change in weight.

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 various chronic conditions or other health problems were actually afflicted. Equally important, there was no independent measurement of height and weight. Many studies have concluded that self-reported data tend to underreport the prevalence of overweight and obesity by approximately 10%.^{2,18,20,21}

BMI is useful for a general analysis of weight categories and their relationship to health. However, BMI is more valuable when used in conjunction with a Waist-to-Hip Circumference ratio or a waist circumference measurement,¹ variables that were not collected by the NPHS.

Although BMI is correlated with body fat,^{20,22} it is not a perfect measurement. For example, individuals whose BMI is 31 are considered obese, although some may, in fact, be very muscular and lean. Consequently, they may not be as susceptible to health problems that tend to affect people with the same BMI who have a very high level of body fat.

Broad groupings within variables can result in underestimation of the strength of relationships. For instance, a significant relationship between BMI and cancer could be found only among underweight current smokers. In 1996/97 (and in 1994/95²), no relationship could be detected between overweight/obesity and cancer, although certain types of cancer (prostate and colon cancer among men; breast, endometrial and ovarian cancer among women) have been associated with excess weight. The lack of a significant association may be due to the generality of the NPHS question. Questions on specific forms of cancer might have yielded significant results. Similarly, the association of BMI with diabetes may be obscured to some degree because the NPHS did not ask whether it was Type I or Type II diabetes, only the latter of which is linked to obesity.²³

As well, a selection effect may have influenced response rates, in that people with some chronic conditions may have declined to participate in the survey.

Health associated with thinness

Aside from eating disorders such as anorexia nervosa and bulimia, comparatively little attention has been paid to the health of Canadians who are underweight. Although the NPHS did not ask about eating disorders, information is available about a number of other conditions that may be associated with a low BMI (see *Health outcomes*).¹⁵

With a few exceptions, the health of people who were underweight did not differ substantially from that of people of acceptable weight. The age- and sex-adjusted odds of suffering from asthma were significantly low for people who were underweight, and their odds of reporting ulcers and depression were significantly high (Table 3).

A much different picture emerges when smoking status is taken into account. Of all weight categories, those who were underweight tended to be most

sharply divided into current smokers (42%) and never smokers (43%). Just 15% of underweight individuals were former smokers.

Among current smokers, those who were underweight had significantly high odds of reporting migraine, cancer, ulcers, bowel disorders, and activity limitations than those of normal weight. These associations did not hold for former smokers and never smokers: the odds that those who were underweight would report these conditions were not significantly different from the odds for their counterparts whose weight was in the acceptable range.

The medical problems of underweight current smokers were further reflected in their self-rated health: their odds of assessing their health positively were just a third of those for smokers whose weight was acceptable. Former smokers who were

Table 3
Age- and sex-adjusted odds ratios for selected health characteristics, underweight population aged 20 to 64, by smoking status, Canada excluding territories, 1996/97

	Total†		Current smokers‡		Former smokers§		Never smokers¶¶	
	Odds ratio	95% confidence interval	Odds ratio	95% confidence interval	Odds ratio	95% confidence interval	Odds ratio	95% confidence interval
Chronic conditions								
Asthma	0.66*	0.48, 0.91	0.76	0.47, 1.23	0.67	0.23, 2.00	0.56*	0.35, 0.92
Arthritis	1.01	0.64, 1.61	1.26	0.63, 2.49	0.80	0.37, 1.73	0.65	0.26, 1.61
Back problems	0.86	0.59, 1.23	0.98	0.59, 1.63	0.57	0.32, 1.03	0.69	0.33, 1.43
High blood pressure	0.83	0.40, 1.74	0.78	0.23, 2.66	--	--	--	--
Migraine	1.21	0.86, 1.70	1.59*	1.00, 2.51	1.81	0.65, 5.05	0.68	0.45, 1.03
Diabetes	1.27	0.24, 6.67	--	--	--	--	--	--
Heart disease	0.59	0.32, 1.07	0.50	0.19, 1.32	--	--	--	--
Cancer	1.74	0.70, 4.31	3.29*	1.17, 9.29	--	--	--	--
Ulcers	2.11*	1.25, 3.59	2.24*	1.09, 4.61	1.45	0.50, 4.22	1.49	0.62, 3.62
Stroke	1.75	0.64, 4.77	--	--	--	--	--	--
Urinary incontinence	1.29	0.52, 3.24	1.96	0.45, 8.49	--	--	1.12	0.30, 4.12
Bowel disorders	1.96	0.97, 3.95	2.81*	1.14, 6.94	0.71	0.25, 1.97	0.99	0.41, 2.38
Thyroid disorders	0.75	0.34, 1.62	0.87	0.15, 4.93	1.34	0.40, 4.43	0.41	0.14, 1.19
Other physical conditions								
Activity limitations	1.12	0.82, 1.53	1.62*	1.05, 2.49	0.54	0.28, 1.04	0.47*	0.32, 0.70
Repetitive strain injuries	0.76	0.51, 1.12	0.85	0.49, 1.47	1.05	0.41, 2.68	0.53	0.27, 1.03
Depression¶¶								
	1.76*	1.00, 3.09	1.93	0.84, 4.45	1.84	0.73, 4.64	0.99	0.48, 2.06
Self-rated health§§								
	0.37*	0.24, 0.58	0.31*	0.17, 0.56	0.39*	0.20, 0.76	0.94	0.56, 1.59

Data source: 1996/97 National Population Health Survey, cross-sectional sample, Health file

Note: Because of rounding, some confidence intervals with 1.00 as the lower limit were significant.

† Reference category is population aged 20 to 64 of acceptable weight.

‡ Reference category is current smokers aged 20 to 64 of acceptable weight.

§ Reference category is former smokers aged 20 to 64 of acceptable weight.

¶ Reference category is never smokers aged 20 to 64 of acceptable weight.

¶¶ Re-coded as 1 (0.9 probability of major depressive episode in past year) and 0 (0 to 0.8 probability of major depressive episode in past year)

§§ Re-coded as 1 (good, very good, excellent) and 0 (fair, poor)

* $p < 0.05$

-- Amount too small to provide reliable estimate

underweight also had low odds of rating their health favourably, but this was not the case for underweight people who had never smoked.

Any examination of the health of underweight Canadians is confounded by the composition of this group. The underweight are likely a combination of healthy people who have always been thin, and people who have lost weight as a result of illness. Because the NPHS data used for this analysis are cross-sectional, neither causality, nor even a temporal sequence, can be determined. It is, in fact, plausible that the underlying cause of low BMI may be diseases such as cancer and ulcers.

The high odds of depression among underweight people overall did not hold for any group when smoking was taken into account. This may reflect the small number of respondents in these categories rather than a lack of association with depression.

High risks for overweight

Much BMI research has been devoted to the health of overweight and obese people. An earlier study, in fact, used the 1994/95 NPHS for this purpose.²

This analysis of 1996/97 data shows that after age and sex were controlled, the odds that overweight individuals would have asthma, arthritis,

back problems, high blood pressure, diabetes,⁵ thyroid problems, activity limitations, and repetitive strain injuries were significantly high, compared with those whose weight was acceptable (Table 4). For example, the odds that overweight individuals would have high blood pressure were 1.86 times higher than those for acceptable-weight people; their odds of diabetes were 1.73 times higher.

However, the health of overweight people varied substantially with their smoking status. Among people who were overweight, the percentages of current and former smokers were almost equal: 30% and 32%, respectively. The largest group, 38%, had never smoked.

Overweight current smokers had significantly higher odds of reporting only two of these health problems—high blood pressure and repetitive strain injuries—than did current smokers of normal weight. Overweight former smokers had high odds of arthritis, high blood pressure, activity limitations, and depression.

Among overweight people who had never smoked, the association between weight and health is evident without the confounding influence of smoking. Compared with never smokers of acceptable weight, those who were overweight had

Health outcomes

Respondents to the National Population Health Survey (NPHS) were asked whether they had “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 read a list of conditions. The *chronic conditions* selected for this analysis are: asthma, arthritis, back problems, high blood pressure, migraine, diabetes, heart disease, cancer, ulcers, stroke, urinary incontinence, bowel disorders and thyroid disorders.

Activity limitation refers to a derived variable that is based on a positive response to either of the following questions: “Because of a long-term physical or mental condition or a health problem, are you limited in the kind or amount of activity you can do ... 1) at home, 2) at school, 3) at work, 4) in other activities?” or “Do you have any long-term disabilities or handicaps?”

Repetitive strain injuries are injuries caused by repetitive strain in the past 12 months that were serious enough to have limited respondents’ normal activities.

Using the methodology of Kessler et al.,²⁴ 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)*.²⁵ 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. The variable was re-coded to a dichotomous variable: 1 (serious risk) and 0 (possible or no risk).

General health was assessed with the question: “In general, would you say your health is: excellent, very good, good, fair, poor?” *Self-rated health* was re-coded to a dichotomous variable: 1 (good, very good or excellent) and 0 (fair or poor).

high odds of reporting arthritis, back problems, high blood pressure, diabetes, urinary incontinence, and activity limitations. However, it is possible that some people never smoked because their health was poor to begin with.

Regardless of their smoking status, overweight Canadians viewed their health as relatively good. Their odds of rating their health as good to excellent were not significantly different from those of people whose BMI was in the acceptable range.

Higher risks for obese

Like people who were overweight, those who were obese had high odds of having been diagnosed with asthma, arthritis, back problems, high blood pressure, diabetes, thyroid disorders, activity limitations and repetitive strain injuries (Table 5). In addition, their odds of having heart disease and

urinary incontinence were significantly high, compared with people of acceptable weight.

As was true of people in the other BMI categories, the health of those who were obese varied with their smoking status. Of all weight categories, the obese accounted for the smallest percentage of current smokers—just 27%. About a third (34%) were former smokers, and 39% had never smoked.

Whereas overweight current smokers tended to report relatively few health problems, this was not the situation of current smokers who were obese. Compared with current smokers of acceptable weight, those who were obese had significantly high odds of reporting asthma, arthritis, high blood pressure, diabetes and urinary incontinence.

Among those who were obese, being a former smoker was associated with a somewhat different set of health problems: arthritis, back problems, high

Table 4
Age- and sex-adjusted odds ratios for selected health characteristics, overweight population aged 20 to 64, by smoking status, Canada excluding territories, 1996/97

	Total [†]		Current smokers [‡]		Former smokers [§]		Never smokers ^{††}	
	Odds ratio	95% confidence interval	Odds ratio	95% confidence interval	Odds ratio	95% confidence interval	Odds ratio	95% confidence interval
Chronic conditions								
Asthma	1.21*	1.01, 1.45	1.17	0.88, 1.57	1.17	0.77, 1.78	1.26	0.97, 1.63
Arthritis	1.30*	1.14, 1.49	1.00	0.80, 1.26	1.35*	1.09, 1.67	1.67*	1.30, 2.15
Back problems	1.13*	1.01, 1.26	1.00	0.82, 1.22	1.19	0.97, 1.45	1.27*	1.05, 1.54
High blood pressure	1.86*	1.56, 2.22	1.45*	1.06, 1.99	2.01*	1.49, 2.71	2.06*	1.51, 2.79
Migraine	1.05	0.88, 1.26	0.94	0.67, 1.31	1.18	0.84, 1.65	1.11	0.85, 1.46
Diabetes	1.73*	1.22, 2.45	2.13	0.97, 4.69	--	--	1.76*	1.05, 2.95
Heart disease	1.08	0.82, 1.41	0.95	0.58, 1.57	--	--	1.04	0.59, 1.81
Cancer	1.13	0.82, 1.55	1.57	0.89, 2.77	--	--	--	--
Ulcers	0.99	0.77, 1.26	0.93	0.63, 1.38	0.94	0.55, 1.62	1.22	0.80, 1.87
Stroke	1.44	0.81, 2.58	--	--	--	--	--	--
Urinary incontinence	1.04	0.74, 1.48	1.29	0.71, 2.34	0.46*	0.26, 0.79	1.83*	1.06, 3.16
Bowel disorders	0.71*	0.52, 0.98	0.73	0.43, 1.22	0.70	0.39, 1.25	0.70	0.44, 1.11
Thyroid disorders	1.39*	1.08, 1.78	1.52	0.96, 2.42	1.44	0.94, 2.20	1.26	0.86, 1.84
Other physical conditions								
Activity limitations	1.14*	1.01, 1.29	0.96	0.78, 1.19	1.27*	1.01, 1.59	1.31*	1.06, 1.62
Repetitive strain injuries	1.22*	1.08, 1.39	1.42*	1.13, 1.78	1.18	0.92, 1.51	1.05	0.82, 1.33
Depression^{‡‡}								
	1.07	0.88, 1.30	0.98	0.70, 1.36	1.81*	1.21, 2.72	0.97	0.68, 1.38
Self-rated health^{§§}								
	0.86	0.73, 1.00	0.84	0.65, 1.07	0.92	0.68, 1.24	0.77	0.56, 1.04

Data source: 1996/97 National Population Health Survey, cross-sectional sample, Health file

[†] Reference category is population aged 20 to 64 of acceptable weight.

[‡] Reference category is current smokers aged 20 to 64 of acceptable weight.

[§] Reference category is former smokers aged 20 to 64 of acceptable weight.

^{††} Reference category is never smokers aged 20 to 64 of acceptable weight.

^{‡‡} Re-coded as 1 (0.9 probability of major depressive episode in past year) and 0 (0 to 0.8 probability of major depressive episode in past year)

^{§§} Re-coded as 1 (good, very good, excellent) and 0 (fair, poor)

* $p < 0.05$

-- Amount too small to provide reliable estimate

blood pressure, migraine, and activity limitations. And as was the case for people who were overweight, former smokers were the only group among the obese to have significantly high odds of having had a major depressive episode.

For never smokers, the health risks of obesity alone are evident: asthma, arthritis, back problems, high blood pressure, ulcers, bowel disorders, thyroid disorders, activity limitations, and repetitive strain injuries.

Not surprisingly, whatever their smoking status, the odds that obese individuals would rate their health positively were only about half those of people with acceptable weight. (This figure is roughly equal to that in an analysis of the 1994/95 NPHS.²) The low assessments of health could be influenced by self-image as well as by actual medical

problems. An American study suggested that obese people may rate their health as poor even if they are not really in poor health. A negative self-rating may reflect an awareness of how society views individuals who are obese.²⁶

Added risks of obesity

The additional health risks of obesity are evident when the odds of obese adults having various medical problems are compared with the odds for those who were overweight (Table 6). The odds that obese individuals would report diabetes and urinary incontinence were more than twice the odds for those who were overweight. Other research, too, has shown a significant association between higher BMI and the development and recurrence of urinary incontinence.^{1-3,27} It can be brought on

Table 5
Age- and sex-adjusted odds ratios for selected health characteristics, obese population aged 20 to 64, by smoking status, Canada excluding territories, 1996/97

	Total†		Current smokers‡		Former smokers§		Never smokers¶¶	
	Odds ratio	95% confidence interval	Odds ratio	95% confidence interval	Odds ratio	95% confidence interval	Odds ratio	95% confidence interval
Chronic conditions								
Asthma	1.59*	1.29, 1.96	1.65*	1.20, 2.28	1.52	1.00, 2.31	1.55*	1.16, 2.08
Arthritis	2.01*	1.67, 2.41	1.85*	1.35, 2.54	2.04*	1.53, 2.71	2.23*	1.68, 2.97
Back problems	1.36*	1.16, 1.58	1.20	0.93, 1.55	1.46*	1.13, 1.89	1.48*	1.11, 1.96
High blood pressure	3.26*	2.74, 3.87	2.69*	1.87, 3.87	3.60*	2.64, 4.90	3.27*	2.46, 4.35
Migraine	1.10	0.88, 1.38	0.81	0.57, 1.16	1.54*	1.05, 2.24	1.01	0.71, 1.45
Diabetes	3.97*	2.92, 5.41	3.33*	1.72, 6.47	--	--	--	--
Heart disease	1.56*	1.20, 2.04	1.75	0.98, 3.12	--	--	1.61	0.94, 2.76
Cancer	0.80	0.48, 1.33	0.62	0.28, 1.35	--	--	--	--
Ulcers	1.36	0.96, 1.92	1.31	0.73, 2.37	1.23	0.68, 2.22	1.82*	1.03, 3.24
Stroke	1.45	0.70, 2.98	--	--	--	--	--	--
Urinary incontinence	2.57*	1.77, 3.72	4.00*	2.13, 7.50	--	--	--	--
Bowel disorders	1.49	0.99, 2.23	1.35	0.57, 3.21	1.12	0.67, 1.87	2.08*	1.17, 3.68
Thyroid disorders	1.75*	1.33, 2.31	1.38	0.81, 2.35	1.43	0.94, 2.17	2.22*	1.41, 3.51
Other physical conditions								
Activity limitations	1.64*	1.44, 1.86	1.26	1.00, 1.60	1.73*	1.35, 2.21	2.13*	1.69, 2.69
Repetitive strain injuries	1.26*	1.07, 1.50	1.10	0.78, 1.54	1.27	0.93, 1.73	1.35*	1.02, 1.80
Depression**								
	1.21	0.95, 1.55	0.97	0.67, 1.41	2.10*	1.40, 3.15	1.24	0.75, 2.04
Self-rated health**§§								
	0.51*	0.44, 0.60	0.64*	0.49, 0.83	0.39*	0.29, 0.54	0.45*	0.34, 0.60

Data source: 1996/97 National Population Health Survey, cross-sectional sample, Health file

† Reference category is population aged 20 to 64 of acceptable weight.

‡ Reference category is current smokers aged 20 to 64 of acceptable weight.

§ Reference category is former smokers aged 20 to 64 of acceptable weight.

¶¶ Reference category is never smokers aged 20 to 64 of acceptable weight.

** Re-coded as 1 (0.9 probability of major depressive episode in past year) and 0 (0 to 0.8 probability of major depressive episode in past year)

§§ Re-coded as 1 (good, very good, excellent) and 0 (fair, poor)

* $p < 0.05$

-- Amount too small to provide reliable estimate

by, among other things, restricted mobility and medications such as diuretics and diet pills,²⁸ which have a greater likelihood of being used by obese Canadians (data not shown).

Obese adults' odds of having high blood pressure and bowel disorders were close to two times those for people who were overweight. The odds of asthma, arthritis, back problems, heart disease, and activity limitations were all significantly high for obese people. In light of these findings, it is hardly surprising that obese adults had significantly low odds of rating their health positively, compared with overweight individuals.

Once again, smoking makes a difference, although regardless of smoking status, obese individuals had higher odds of reporting activity limitations and lower odds of assessing their health favourably than did their overweight counterparts. Obese current

smokers had high odds of asthma, arthritis and high blood pressure, compared with those who were overweight. For former smokers, the odds of arthritis were higher among those who were obese. Never smokers who were obese had elevated odds of high blood pressure, diabetes, urinary incontinence, and thyroid disorders.

Concluding remarks

Admittedly, body mass index is a less-than-perfect measure. Yet even allowing for its shortcomings, the estimate of the number of people whose weight is inappropriate for their height is considerable. In 1996/97, only about half of Canadians aged 20 to 64 were in an "acceptable" weight range. Moreover, millions, even by the relatively lenient international BMI standard, were obese. While underweight was much less common, a substantial number of adults—about 400,000—were affected.

Table 6

Age- and sex-adjusted odds ratios for selected health characteristics among obese population aged 20 to 64 compared with overweight population aged 20 to 64, by smoking status, Canada excluding territories, 1996/97

	Total [†]		Current smokers [‡]		Former smokers [§]		Never smokers ^{††}	
	Odds ratio	95% confidence interval	Odds ratio	95% confidence interval	Odds ratio	95% confidence interval	Odds ratio	95% confidence interval
Chronic conditions								
Asthma	1.32*	1.08, 1.61	1.42*	1.01, 1.99	1.32	0.93, 1.86	1.22	0.87, 1.71
Arthritis	1.54*	1.29, 1.82	1.90*	1.42, 2.55	1.51*	1.15, 1.98	1.32	0.99, 1.76
Back problems	1.19*	1.02, 1.39	1.18	0.89, 1.55	1.23	0.95, 1.58	1.18	0.90, 1.54
High blood pressure	1.82*	1.54, 2.15	2.00*	1.44, 2.79	--	--	1.65*	1.24, 2.20
Migraine	1.04	0.83, 1.31	0.85	0.60, 1.19	1.26	0.90, 1.77	0.96	0.63, 1.45
Diabetes	2.28*	1.70, 3.04	--	--	--	--	1.98*	1.21, 3.23
Heart disease	1.47*	1.10, 1.96	--	--	--	--	--	--
Cancer	0.72	0.44, 1.17	--	--	--	--	--	--
Ulcers	1.34	0.99, 1.82	1.38	0.79, 2.43	1.29	0.76, 2.19	1.44	0.85, 2.42
Stroke	1.06	0.46, 2.45	--	--	--	--	--	--
Urinary incontinence	2.71*	1.81, 4.04	--	--	--	--	2.07*	1.11, 3.84
Bowel disorders	1.93*	1.31, 2.85	1.81	0.81, 4.04	--	--	--	--
Thyroid disorders	1.24	0.93, 1.66	--	--	--	--	1.65*	1.07, 2.56
Other physical conditions								
Activity limitations	1.41*	1.23, 1.62	1.31*	1.01, 1.71	1.37*	1.08, 1.73	1.58*	1.23, 2.02
Repetitive strain injuries	1.02	0.86, 1.21	0.78	0.53, 1.14	1.07	0.80, 1.43	1.28	0.98, 1.67
Depression^{‡‡}								
	1.12	0.88, 1.43	0.96	0.66, 1.39	1.28	0.83, 1.96	1.21	0.70, 2.07
Self-rated health^{§§}								
	0.60*	0.51, 0.71	0.77*	0.60, 0.98	0.44*	0.33, 0.57	0.59*	0.44, 0.80

Data source: 1996/97 National Population Health Survey, cross-sectional sample, Health file

[†] Reference category is overweight population aged 20 to 64.

[‡] Reference category is overweight current smokers aged 20 to 64.

[§] Reference category is overweight former smokers aged 20 to 64.

^{††} Reference category is overweight never smokers aged 20 to 64.

^{‡‡} Re-coded as 1 (0.9 probability of major depressive episode in past year) and 0 (0 to 0.8 probability of major depressive episode in past year)

^{§§} Re-coded as 1 (good, very good, excellent) and 0 (fair, poor)

* $p < 0.05$

-- Amount too small to provide reliable estimate

The health characteristics of the population aged 20 to 64 depended, to some extent, on whether they were smokers. However, when the influence of smoking was isolated, the associations between BMI and health emerged. Underweight people who had never smoked tended to be in good health. This was not the case for those who were overweight or obese.

The analysis of NPHS data indicates the importance of literally “balancing the scale.” Being overweight was associated with several potentially serious medical conditions. Among those who were

obese, the number of related health problems was greater, and the associations stronger.

Moreover, the health consequences of obesity are not confined to the individuals affected. For example, a recent Canadian study²⁹ estimated that the direct cost of obesity (BMI 27+) as it related to hypertension was about \$657 million in 1997. The same study put the cost of obesity-related Type II diabetes at \$432 million.

Nonetheless, the cross-sectional nature of the data used in this analysis limits the conclusions that can be drawn. While strong associations between BMI

Definitions

To determine *height*, National Population Health Survey (NPHS) respondents were asked how tall they were without shoes. To determine *weight*, they were asked how much they weighed. Women aged 15 to 49 were asked if they were pregnant. If they replied affirmatively, their responses were excluded from the calculations of body mass index.

Respondents were grouped into four *educational attainment* categories: less than high school, high school completion, some postsecondary, and postsecondary graduation. Education was age-standardized to account for the tendency of younger age groups to have higher levels of education than older people.

Household income was divided into five groups based on household size. Income was age-standardized.

Income group	Number of household members	Household income
Lowest	1 to 4	Less than \$10,000
	5 or more	Less than \$15,000
Lower-middle	1 or 2	\$10,000 to \$14,999
	3 or 4	\$10,000 to \$19,999
	5 or more	\$15,000 to \$29,999
Middle	1 or 2	\$15,999 to \$29,999
	3 or 4	\$20,000 to \$39,999
	5 or more	\$30,000 to \$59,999
Upper-middle	1 or 2	\$30,000 to \$59,999
	3 or 4	\$40,000 to \$79,999
	5 or more	\$60,000 to \$79,999
Highest	1 or 2	\$60,000 or more
	3 or more	\$80,000 or more

To determine *birthplace*, respondents were asked: “In what country were you born?” Answers were grouped into four categories: Canada; the United States, Europe or Australia; Asia; and elsewhere.

The NPHS defined a drink as: one bottle or can of beer or a glass of draft; one glass of wine or a wine cooler; or one drink or cocktail

with 1 ½ ounces of liquor. Respondents were asked how often they drank alcoholic beverages in the last 12 months. For this analysis, responses were classified into three categories: current drinkers, former drinkers and never drinkers. *Current drinkers* comprised regular drinkers (at least one drink per month) and occasional drinkers (less than one drink per month). *Former drinkers* had consumed alcohol in the past but had not done so for at least 12 months. *Never drinkers* were abstainers who had never consumed alcohol.

Respondents were asked if, at the time of the interview, they smoked cigarettes daily, occasionally, or not at all. Those who indicated that they did not smoke cigarettes were asked if they had ever done so. The categories used in this analysis are: current smokers, former smokers and never smokers. *Current smokers* included daily and occasional smokers. *Former smokers* were former daily and occasional smokers. *Never smokers* were those who had never smoked cigarettes.

To derive *physical activity*, respondents' energy expenditure (EE) was estimated for each activity they engaged in during their leisure time. EE was calculated by multiplying the number of times a respondent engaged in an activity over a 12-month period by the average duration in hours and by the energy cost of the activity (expressed in kilocalories expended per kilogram of body weight per hour of activity). To calculate an average daily EE for the activity, the estimate was divided by 365. This calculation was repeated for all leisure-time activities reported, and the resulting estimates were summed to provide an aggregate average daily EE. Respondents whose estimated leisure-time EE was below 1.5 kcal/kg/day were considered physically inactive. A value between 1.5 and 2.9 kcal/kg/day indicated moderate physical activity. Respondents with an estimated EE of 3.0 or more kcal/kg/day were considered physically active. This measure likely underestimated total physical activity, as it did not account for activity at work or while doing household chores.

and various chronic conditions have been demonstrated, it is not possible to determine whether an individual's BMI contributed to the development of a chronic condition or resulted from it. ●

Acknowledgements

The author thanks Marie P. Beaudet, Ai Chau and Pamela White for their help and guidance.

References

- 1 Expert Panel of the National Institutes of Health. Clinical guidelines on the identification, evaluation and treatment of overweight and obesity in adults: Executive Summary. *American Journal of Clinical Nutrition* 1998; 68(4): 899-917.
- 2 Cairney J, Wade TJ. Correlates of body weight in the 1994 National Population Health Survey. *International Journal of Obesity* 1998; 22: 584-91.
- 3 Rabkin SW, Chen Y, Leiter L, et al. Risk factor correlates of body mass index. *Canadian Medical Association Journal* 1997; 157(Supplement): s26-s31.
- 4 Rottensten K. Monograph Series on Aging-related Diseases: IX. Osteoarthritis. *Chronic Diseases in Canada* 1996; 17(3/4): 99-116.
- 5 Heart and Stroke Foundation, Health Canada, Statistics Canada and University of Saskatchewan. *Heart Disease and Stroke in Canada, 1995*. Ottawa: Heart and Stroke Foundation, 1995.
- 6 Pi-Sunyer FX. Health implications of obesity. *American Journal of Clinical Nutrition* 1991; 53: 1595S-630S.
- 7 Health Canada. *The Nature and Dimension of Nutrition and Diet-Related Problems*. Country Paper Canada Supplement. Ottawa: Health Canada, 1994.
- 8 Manson JE, Stampfer MJ, Hennekens CH, et al. Body weight and longevity: A reassessment. *Journal of the American Medical Association* 1987; 257(3): 353-8.
- 9 Tambay J-L, Catlin G. Sample design of the National Population Health Survey. *Health Reports* (Statistics Canada, Catalogue 82-003) 1995; 7(1): 29-38.
- 10 Swain L, Catlin G, Beaudet MP. The National Population Health Survey—its longitudinal nature. *Health Reports* (Statistics Canada, Catalogue 82-003) 1998; 10(4): 69-82.
- 11 Rao JNK, Wu CFJ, Yue K. Some recent work on resampling methods for complex surveys. *Survey Methodology* (Statistics Canada, Catalogue 12-001) 1992; 18: 209-17.
- 12 Rust KF, Rao JNK. Variance estimation for complex surveys using replication techniques. *Statistical Methods in Medical Research* 1996; 5: 283-310.
- 13 United Kingdom Department of Health. *The Health of the Nation: Briefing Pack*, 2nd edition. London: Health of the Nation Publications Unit, United Kingdom Department of Health, 1997.
- 14 World Health Organization. *Physical Status: The Use and Interpretation of Anthropometry, Report of the WHO Expert Committee* (WHO Technical Report Series, No. 854) Geneva: World Health Organization, 1995.
- 15 National Health and Welfare. *Canadian Guidelines for Healthy Weights*. Report of an Expert Group convened by Health Promotion Directorate, Health Services and Promotion Branch. Ottawa: Minister of National Health and Welfare, 1988.
- 16 Organisation for Economic Co-operation and Development, CREDES. *OECD Health Data 98*, Version 2.0. Paris: Organisation for Economic Co-operation and Development, 1998.
- 17 World Health Organization. *Obesity: Preventing and Managing the Global Epidemic*, Report of a WHO Consultation on Obesity. Geneva: World Health Organization, 1997.
- 18 Hill A, Roberts J. Body mass index: a comparison between self-reported and measured height and weight. *Journal of Public Health Medicine* 1998; 20(2): 206-10.
- 19 Deurenberg P, Yap M, van Staveren WA. Body mass index and percent body fat: a meta analysis among different ethnic groups. *International Journal of Obesity and Related Metabolic Disorders* 1998; 22(12): 1164-71.
- 20 Roberts, RJ. Can self-reported data accurately describe the prevalence of overweight? *Public Health* 1995; 109(4): 275-84.
- 21 Kuczmarski R, Carroll MD, Flegal KM, et al. Varying Body Mass Index cutoff points to describe overweight prevalence among U.S. adults: NHANES III (1988 to 1994). *Obesity Research* 1997; 5(6): 542-8.
- 22 Bray GA. An approach to the classification and evaluation of obesity. In: Bjorntorp P, Brodoff BN, eds. *Obesity*. Hagerstown, Maryland: J.B. Lippincott Company, 1992: 294-308.
- 23 Bray GA. Obesity increases risk for diabetes. *International Journal of Obesity and Related Metabolic Disorders* 1992; 16 (Supplement 4): s13-s17.
- 24 Kessler RC, McGonagle KA, Zhao S, et al. Lifetime and 12-month prevalence of DSM-III-R psychiatric disorders in the United States. Results from the National Comorbidity Survey. *Archives of General Psychiatry* 1994; 51: 8-19.
- 25 American Psychiatric Association. *Diagnostic and Statistical Manual of Mental Disorders*. 3rd rev. ed. Washington, D.C.: American Psychiatric Association, 1987.
- 26 Ferraro K, Yu Y. Body weight and self-ratings of health. *Journal of Health and Social Behavior* 1995; 36: 274-84.
- 27 Noblett KL, Jensen JK, Ostergard DR. The relationship of body mass index to intra-abdominal pressure as measured by multichannel cystometry. *International Urogynecology Journal and Pelvic Floor Dysfunction* 1997; 8(6): 323-6.

28 Orbis-AHCN. Incontinence: symptom. [HealthAnswers Website]. Available at: <http://www.healthanswers.com/database/ami/converted/003142.html>. Accessed November 6, 1998.

29 Birmingham CL, Muller JL, Palepu A, et al. The cost of obesity in Canada. *Canadian Medical Association Journal* 1999; 160: 483-8.