

The Canadian Obesity Epidemic: An Historical Perspective

Peter T. Katzmarzyk

Abstract

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Objective: To examine temporal trends in stature, body mass, body mass index (BMI), and the prevalence of overweight and obesity in Canada.

Research Methods and Procedures: Data for adults 20 to 64 years of age were compared across eight Canadian surveys conducted between 1953 and 1998. Temporal trends in stature and body mass were examined using regression, and changes in weight-for-height were expressed as changes from 1953. BMI data were available from 1970 to 1972 to examine changes in overweight and obesity. Qualitative changes in the BMI distribution were examined using Tukey mean-difference plots.

Results: Significant temporal trends in stature and body mass have occurred since 1953 in Canada. Median stature increased 1.4 cm/decade in men and 1.1 cm/decade in women, whereas median body mass increased 1.9 kg/decade in men and 0.8 kg/decade in women. Increases in the 75th percentile of body mass were larger than the median. The average weight-for-height increased 5.1% in men and 4.9% in women from 1953. Furthermore, the prevalences of overweight and obesity have increased from 40.0% and 9.7% in 1970–1972 to 50.7% and 14.9% in 1998, respectively. The entire BMI distribution has shifted to the right since 1970–1972 and has become more skewed to the right for men than for women.

Discussion: There have been significant increases in stature and body mass in Canada over the last 45 years. Body mass has increased more than stature, particularly in the upper percentiles, which has resulted in the currently observed high prevalences of overweight and obesity.

Key words: obesity epidemic, Canada, weight-for-height, temporal analysis, qualitative

Introduction

Overweight and obesity in Canada have now reached epidemic proportions. However, the problem of excess adiposity was recognized in Canada almost 50 years ago and was the impetus for the 1953 Canadian Weight-Height Survey (1). The 1953 survey was the first nationally representative survey of stature and body mass in Canada, and its purpose was to “. . . indicate the situation as it actually existed and provide a baseline from which further and more complete studies could be started” (1). Unfortunately, there is currently no systematic monitoring of the population prevalence of obesity in Canada using measured stature and body mass. However, data from a variety of sources indicate that the prevalences of overweight and obesity have increased in Canada over the past 15 to 20 years, in both children and adults (2–4). A recent study demonstrated that the prevalence of overweight increased from 48% to 57% in men and from 30% to 35% in women in Canada from 1981 to 1996, whereas the prevalence of obesity increased from 9% to 14% in men and from 8% to 12% in women over the same period (3). The increasing prevalence of obesity in Canada is consistent with the notion that there is a worldwide epidemic of obesity (5), and these increases parallel the changes in obesity among children (6) and adults (7–10) in the United States.

Although there is consistent evidence that the average body mass index (BMI) in North Americans has been increasing in recent decades, there is little evidence that the historical positive secular trend in stature has persisted. An analysis of data from four studies collected in Toronto from 1891 to 1974 indicates that children 4 to 18 years of age were on average 10 cm taller in 1974 than in 1891 (11). The authors estimated that the rate of change in stature was 1 cm/decade in boys and 0.4 cm/decade in girls at the age of 15 years; however, data were not presented for statural changes among adults.

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School of Physical and Health Education, Queen's University, Kingston, Ontario, Canada.

Address correspondence to Dr. Peter T. Katzmarzyk, School of Physical and Health Education, Queen's University, Kingston, Ontario, K7L 3N6 Canada.

E-mail: katzmarz@post.queensu.ca

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Table 1. Canadian population surveys used in the study of temporal trends in stature, body mass and BMI among adults 20 to 64 years of age (1953 to 1998)

Year	Survey	Sample size*	Data collection method
1953	Canadian Weight-Height Survey	22,000†	Measured
1971 to 1972	Nutrition Canada Survey	2,687 men 3,428 women	Measured
1978 to 1979	Canada Health Survey	1,508 men 1,867 women	Measured
1981	Canada Fitness Survey	4,831 men 5,448 women	Measured
1986 to 1992	Canada Heart Health Surveys	7,565 men 7,813 women	Measured
1994	National Population Health Survey	5,857 men 6,461 women	Self-reported
1996	National Population Health Survey	23,059 men 23,138 women	Self-reported
1998	National Population Health Survey	4,670 men 5,133 women	Self-reported

* Sample sizes reported are for stature and body mass, which may differ from the sample size of the entire survey.

† The sample size reported for the 1953 Canadian Weight-Height survey is for the entire age range (≥ 2 years), rather than for 20 to 64-year-old adults. Sample sizes were not provided for males and females by age group (Pett and Ogilvie, 1956).

Tanner (12) indicated that the change in adult stature in North America and Europe was ~ 1 cm/decade between 1880 and 1950. Furthermore, based on data from Canada, the United States, Japan, and Norway, Meredith (13) suggested that the change in stature from the late 1860s to the late 1960s was 1.3 cm/decade in late childhood, 1.9 cm/decade in mid-adolescence, and 0.6 cm/decade in young adulthood. The only Canadian data included in the Meredith study were from studies of Toronto schoolchildren (1892–1939); thus, the Canadian data did not enter into the analyses of secular changes for adults. In a more recent review, Hauspie and colleagues (14) indicated that estimates of the secular trend in adult stature over recent decades ranged from 0.3 cm/decade to 3.0 cm/decade, depending on the population. However, Hauspie and colleagues (14) did not include data from Canada or the United States in their review.

In the United States, it appears as though the secular trend in stature ended in the early 1960s, because there have been no increases in stature observed in U.S. national surveys conducted since that time (15). Except for the data on Toronto schoolchildren included in the studies of Meredith (13) and Hoppa and Garlie (11), there apparently are no published studies that have directly tested hypotheses concerned with the secular trend in stature among Canadian adults.

Given the evidence for recent increases in the prevalences of overweight and obesity, and the lack of data on secular trends in stature in Canada, the purpose of this study is to provide a comprehensive examination of the temporal trends in stature, body mass, weight-for-height, and the prevalences of overweight and obesity in Canadian adults over the last 45 years.

Research Methods and Procedures

Samples and Measures

Data for stature and body mass were compiled from eight national surveys conducted in Canada between 1953 and 1998. Table 1 presents the surveys along with the sample sizes and the method of data collection. The earliest nationally representative survey of stature and body mass among Canadians was the 1953 Canada Weight-Height Survey (1). Unfortunately, the original data from the 1953 survey no longer exist; however, detailed tables of age- and sex-specific means, percentiles, and average weight-for-height values (1,16) allow the survey to be used as a baseline for comparison with subsequent surveys. Data for BMI were not available from the 1953 survey.

The original data were available for all of the national surveys in Table 1 conducted subsequent to the 1953 Canada Weight-Height survey. The 1970–1972 Nutrition Can-

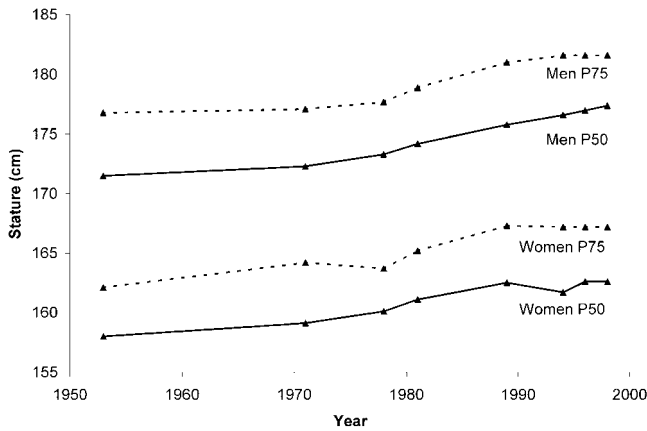


Figure 1: Changes in the 50th and 75th percentiles of stature among Canadian adults 20 to 64 years of age from 1953 to 1998.

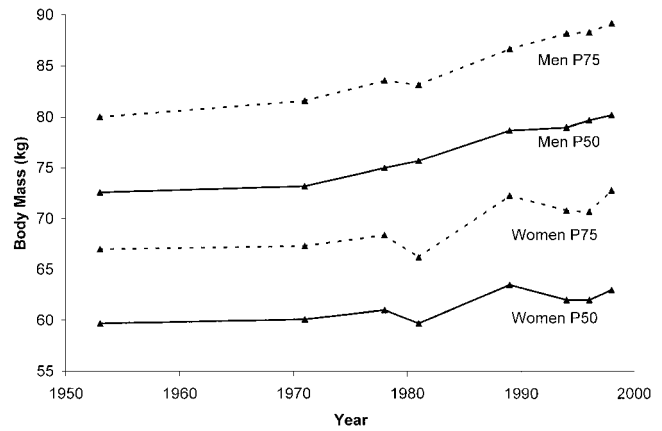


Figure 2: Changes in the 50th and 75th percentiles of body mass among Canadian adults 20 to 64 years of age from 1953 to 1998. BMI, body mass index.

ada Survey (17), the 1978–1979 Canada Health Survey (18), the 1981 Canada Fitness Survey (CFS) (19), and the 1986–1992 Canada Heart Health Surveys (20) all included measured values of both stature and body mass, whereas these values were self-reported in the National Population Health Surveys (NPHS; 1994, 1996, and 1998). The use of self-reported data was a limitation of this analysis, because people tend to over-report their stature and under-report their body mass (21,22). The misreporting of stature and body mass tends to result in underestimates of the population prevalences of overweight and obesity (23). Thus, given that the three most recent surveys used self-reported data, the increasing trends for overweight and obesity should be considered conservative estimates.

Statistical Analysis

All statistical analyses were conducted using SAS software and procedures (24). The analyses presented in this study are mainly limited to descriptive changes in stature, mass, and BMI across surveys. The statistical significance of the changes are generally not emphasized (except where noted), because the surveys used complex sampling strategies, and there is a lack of information available about the designs of the earlier surveys. However, all estimates were weighted, using the sample weights provided by each survey. The 50th (median) and 75th percentiles for stature and body mass were determined for all surveys and regressed on the year of the survey to quantify the temporal trends. In multiyear surveys, the midpoint year of the survey represented the survey year.

Pett and Ogilvie (1) presented average sex-specific body mass values for 1-in (2.54-cm) increments of stature in adults in six age groups (20 to 24 years, 25 to 29 years, 30 to 34 years, 35 to 44 years, 45 to 54 years, and 55 to 64 years of age) for the 1953 weight–height survey. The av-

erage weight-for-height values for adults in the same age groups were computed for the other seven surveys in the same manner, and changes in weight-for-height were expressed as the percentage of the baseline values in 1953.

The BMI (kg/m²) was derived from stature and body mass from all surveys conducted from 1970–1972 to 1998, and the prevalences of overweight (BMI ≥ 25 kg/m²) and obesity (BMI ≥ 30 kg/m²) were calculated following the recommendations of the World Health Organization (5) and U.S. National Institutes of Health (25).

Qualitative changes in the distribution of BMI between 1970–1972 and 1998 in Canada were examined using Tukey mean-difference plots (26), similar to the recent analysis of shifts in the distribution of BMI in the United States by Flegal and Troiano (27). Given that the 1998 NPHS relied on self-reported data, the changes in the distribution between the 1970–1972 and 1986–1992 surveys also were examined to confirm the observed trends. Briefly, a mean-difference plot was constructed by plotting the difference between two percentile values (y-axis) vs. the mean of the two percentiles (x-axis). The weighted even percentile values (2nd, 4th, 6th up to the 98th) for each of the surveys were then calculated. For each percentile level, the mean of the two values (i.e., [1970–1972 + 1998]/2) and the difference between the two values (i.e., 1998 – 1970–1972) were calculated. Each point on the mean-difference plots represents the mean (x-axis) and the difference (y-axis) between the corresponding BMI percentile values. Analyses were performed in men and women separately and then divided into younger (20- to 39-year) and older (40- to 64-years) age groups.

Results

Figures 1 and 2 present the changes in the 50th (median) and 75th percentiles of stature and body mass from 1953 to

Table 2. Results of regression analyses for secular trends in stature and body mass in the Canadian population, 1953–1998

	R^2	Intercept	β (per decade)	SE	p^*
Height, cm					
Men					
P50	0.92	-107.82	1.42	0.17	0.0002
P75	0.85	-78.07	1.30	0.23	0.001
Women					
P50	0.92	-57.09	1.10	0.14	0.0002
P75	0.89	-83.67	1.26	0.18	0.0004
Body mass, kg					
Men					
P50	0.90	-295.63	1.87	0.26	0.0004
P75	0.92	-347.38	2.20	0.26	0.0002
Women					
P50	0.60	-88.28	0.75	0.25	0.02
P75	0.59	-185.83	1.29	0.44	0.03

* These p values should be interpreted with caution and should not be considered to be exact. There is a lack of information about the sample designs in the earlier surveys, so the complex sampling strategies have not been taken into account in this analysis.

1998. There have been increases in both stature and body mass in both men and women. The magnitudes of the increases are quantified in Table 2. Median stature increased by 1.4 cm/decade in men and 1.1 cm/decade in women, and the 75th percentile increased by 1.3 cm/decade in men and 1.3 cm/decade in women. Median body mass increased 1.9 kg/decade in men and 0.8 kg/decade in women. Increases at the 75th percentile of body mass were larger than for the median in both men and women, increasing 2.2 kg/decade in men and 1.3 kg/decade in women.

The percentage change in weight-for-height from baseline levels in 1953 are shown in Figure 3. Over the last 45 years, the average weight-for-height of Canadian adults has increased 5.1% in men and 4.9% in women. The increases observed in the average weight-for-height are reflected in increases in the prevalences of overweight and obesity (Figure 4). The prevalences of overweight and obesity have increased from 40.0% and 9.7% in 1970–1972 to 50.7% and 14.9% in 1998, respectively, in the total sample. Among men, the prevalence of overweight has increased from 46.1% to 60.1%, whereas it has increased from 31.7% to 38.0% in women. The prevalence of obesity has increased from 7.6% to 15.4% in men and from 11.7% to 14.4% in women over the same period.

An examination of the mean-difference plots (Figures 5–7) indicates that the shift to increasing levels of obesity from 1970–1972 to 1998 is not consistent among all sex and age groups. Among men (Figure 5A), the BMI increased

more in the upper extremes of the distribution (>90th percentile) than in the mid-range, indicating that the right tail has been extended. The same trends are evident in younger and older men (Figure 6). In contrast, the increase in women seems to be more consistent across all levels of BMI, because the line of points in Figure 5B is horizontal and hovers between 0 and 1 BMI unit. Figure 7 illustrates that much of the shift in the BMI distribution in women has occurred due to an increase in the mid-range of the distribution ($BMI = 25$ to 30 kg/m^2) in younger women.

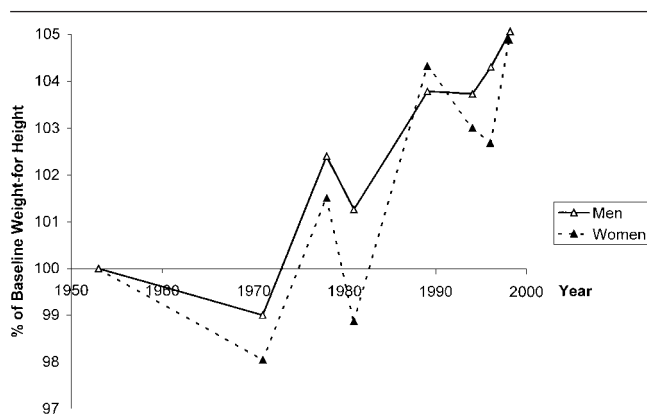
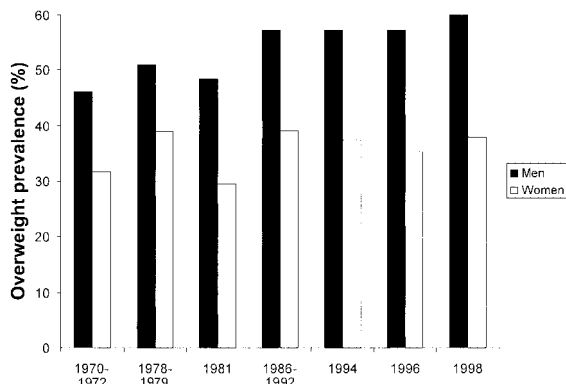


Figure 3: The percentage changes in weight-for-height among Canadian adults 20 to 64 years of age from 1953 to 1998. The 1953 Canadian Weight-Height Survey was used as the baseline (100%).

A) Overweight



B) Obesity

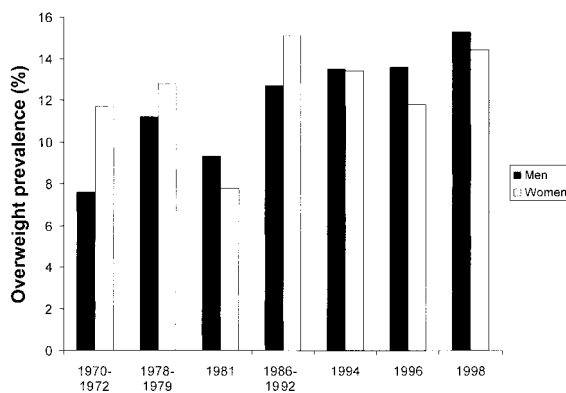


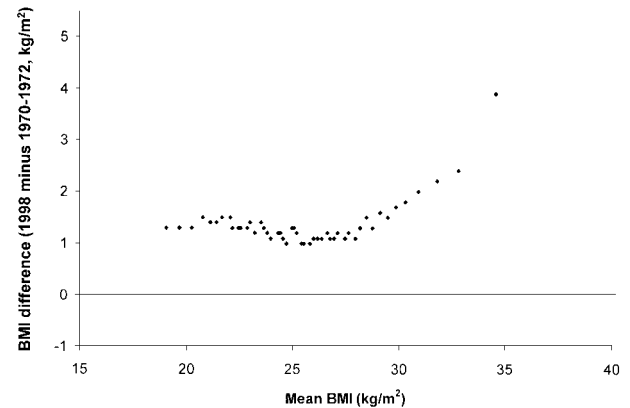
Figure 4: Changes in the prevalence of (A) overweight (BMI ≥ 25 kg/m²) and (B) obesity (BMI ≥ 30 kg/m²) in Canadian men and women 20 to 64 years of age from 1970–1972 to 1998. BMI, body mass index.

The qualitative results are more consistent between men and women when comparing 1970–1972 to 1986–1992 (both with measured BMI). In both men and women (Figure 8), the BMI increased more at the upper extremes of the distribution (> 90th percentile) than in the mid-range, indicating that the right tail of the distribution has been extended.

Discussion

The results indicate that there has been consistent positive temporal trends in stature, body mass, weight-for-height, and the prevalences of both overweight and obesity in Canada over the last 45 years. The finding that the 75th percentile for body mass has been increasing at a faster rate than the 50th percentile is consistent with other observations. MacDonald and colleagues (28) previously noted that the prevalence of overweight did not seem to be increasing in Canada, but the prevalence of obesity was increasing. Furthermore, a recent analysis of

A) Men



B) Women

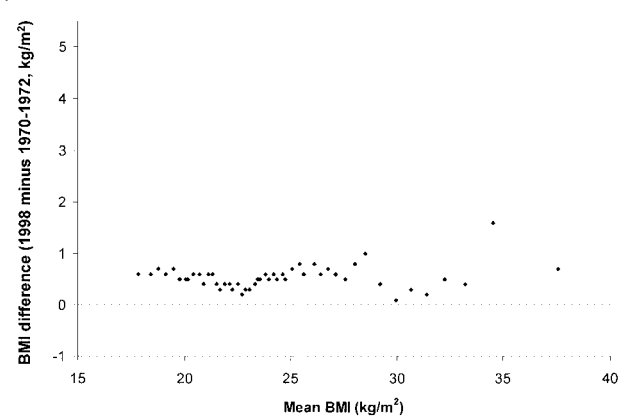


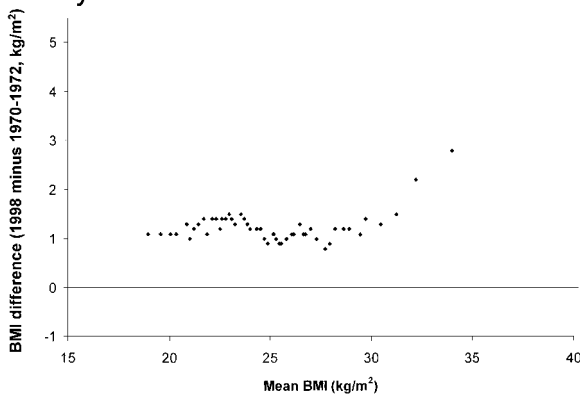
Figure 5: Mean-difference plots for the distribution of BMI from 1970–1972 to 1998 for (A) men and (B) women. BMI, body mass index.

data from the United States (27) indicates that the shift in the BMI distribution has not been uniform; there has generally been an increase in the rightward skewness of the distribution.

The differences in the change in the distribution of BMI when using measured vs. self-reported data are interesting. Overweight and obese women tend to under-report their body mass to a greater extent than men (22), and because the three most recent surveys (NPHS) used self-reported stature and body mass, not only may the findings in this study be underestimates of the changes in obesity, but the rightward shift in the distribution may also be underestimated when using the 1998 data, particularly in women. Indeed, when the 1986–1992 measured data are used, similar results are obtained for men and women.

Figures 3 and 4 indicate a fairly linear increase in weight-for-height and the prevalences of overweight and obesity over time. The one notable exception is the 1981 CFS, which demonstrates lower values than one would expect based on the overall trends. The temporary reversal of the

A) 20-39 years



B) 40-64 years

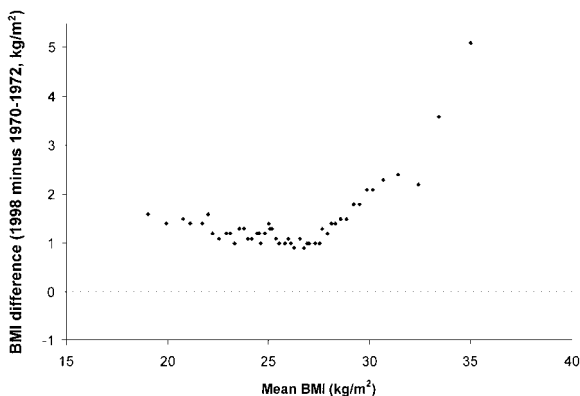
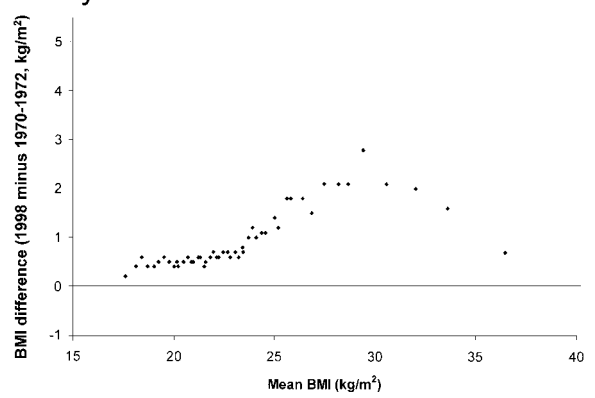


Figure 6: Mean-difference plots for the distribution of BMI from 1970–1972 to 1998 for men (A) 20 to 39 years of age and (B) 40 to 64 years of age. BMI, body mass index.

increasing trend in obesity in the 1981 CFS is difficult to explain, because the underlying design of the survey was to produce a representative sample. In contrast, the purpose of the CFS was to characterize the physical activity and fitness levels of the Canadian population, and as such, there could have been some selection bias toward leaner, more physically fit participants undertaking the physical measures component of the survey. Most of the other surveys had a broad health-related focus rather than a physical fitness focus, and the bias toward leaner participants might not have been as great. Whatever the source of the discordant results, this finding has implications for future research. For example, studies that use the 1981 CFS as a baseline for comparison to future surveys will arrive at greater changes in the prevalence of obesity than studies that use the 1978–1979 Canada Health Survey.

Malina (29) suggested that it is very difficult to study true secular changes in stature in the United States, given the more or less constantly changing demography of the country, and the same holds true for the study of overweight and obesity. An analysis of the 1994 NPHS indicated that time

A) 20-39 years



B) 40-64 years

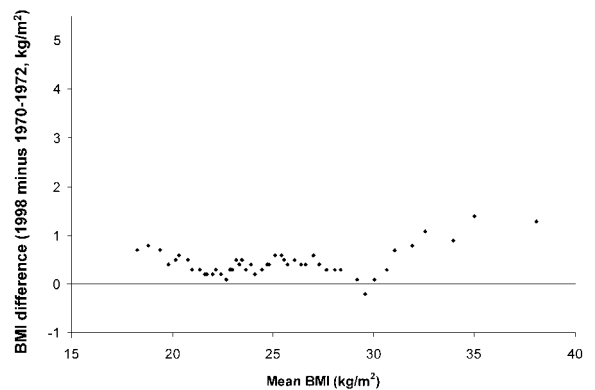


Figure 7: Mean-difference plots for the distribution of BMI from 1970–1972 to 1998 for women (A) 20 to 39 years of age and (B) 40 to 64 years of age. BMI, body mass index.

since immigration into Canada was an important predictor of overweight (30). The prevalence of overweight (BMI ≥ 25 kg/m²) increased with the length of time in Canada in both men and women. Thus, changes in the demography of Canada based on immigration over the last 45 years have undoubtedly had an effect on the changes on the prevalences of overweight and obesity.

Increases in the prevalence of obesity have been reported in many industrialized countries around the world (5). Recent estimates of the prevalence of obesity in the United States (2000) are 20.2% for men and 19.4% for women, based on self-reported heights and weights from the Behavioral Risk Factor Surveillance System (BRFSS) (10). Furthermore, an analysis of data from the U.S. National Health and Nutrition Examination Surveys (measured heights and weights) showed an increase in the prevalence of obesity from 10.4% to 19.9% in men, and from 15.1% to 24.9% in women between 1960–1962 and 1988–1994 (8). The most direct comparison of prevalences of obesity between Canada and the United States are arguably between the 1998 NPHS and the 1998 BRFSS (both self-reported data). The prevalences of obesity in Canadian men and women (ages

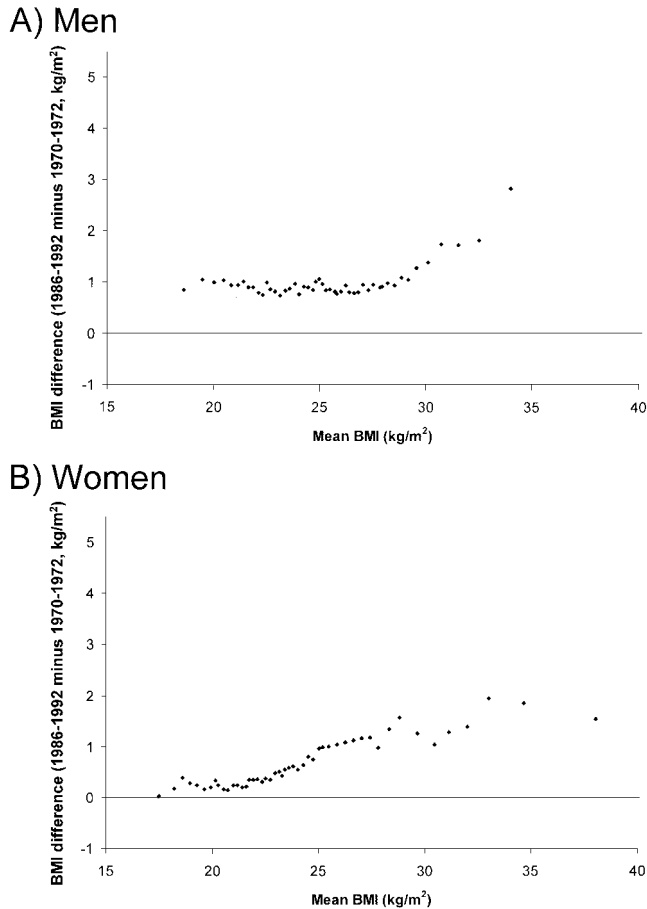


Figure 8: Mean-difference plots for the distribution of BMI from 1970–1972 to 1986–1992 for (A) men and (B) women.

20 to 64 years) in 1998 were 15.4% and 14.4%, respectively, whereas the prevalences in American men and women (ages 18+ years) in 1998 were 17.7% and 18.1%, respectively (9). Thus, the problem of obesity seems to be similar in Canada and the United States.

The finding of a persistent secular trend in stature in Canada is interesting, given that it apparently stopped in the United States ~40 years ago (15). The magnitude of the trend (1 to 1.4 cm/decade) is consistent with those found in other countries, which generally range from 0.3 cm to 3 cm/decade (14). The main effect of these trends is that the median height of men has increased by 7 cm over the last 50 years, whereas the median height of women has increased by 5 cm. Many potential causes of the historical positive secular trends in stature have been hypothesized, including improvements in nutrition and environmental circumstances, a reduction in average family size, reductions in infant and childhood morbidity and mortality, and genetic factors (31).

A limitation in this study is the reliance on self-reported stature and body mass from the 1994, 1996, and 1998

NPHS. As previously noted, there is a systematic bias in the reporting because people tend to under-report their body mass and over-report their stature (21,22), which may result in lower average BMI values when self-reported data are compared with measured data (23). Also, the level of bias and unreliability with which people report their body mass increases with increasing levels of overweight (22); thus, as the prevalence of truly overweight individuals increases in Canada, the level of under-reporting will likely also increase. This will result in a further reduction in the estimation of the problem of overweight and obesity if self-reported data continue to be used for obesity surveillance.

The causes of the current obesity epidemic are unknown. Obesity is a chronic condition that results from a chronic positive energy balance, which could result from decreased energy expenditure (resting metabolic rate, physical activity, etc.) or increased dietary energy intake, or a combination of both factors. In Canada, it seems there has been a reduction in dietary energy and fat intake over the last 30 years (32). It was also reported that physical inactivity in leisure time has also decreased over the last 20 years (33). One potential explanation for this may be that there has been a temporal shift toward lower occupational physical activity levels that has occurred since the technological revolution. More research is required to determine the temporal shifts in occupational physical activity levels.

A genetic hypothesis has also been suggested as one of the causes of the obesity epidemic, whereby assortative mating for body fatness may have had an impact on the increasing levels of obesity (34,35). There is some evidence that genetic factors may be playing a more important role in high levels of BMI than in the mid-range of the BMI distribution (36). The finding in this study that the increases in the upper end of the distribution in the population have been greater than in the mid-range would suggest that a complex genotype-by-environment interaction may exist, whereby those with a susceptible genotype may have an increased risk of obesity in a society (environment) that is conducive to positive energy balance and weight gain. One thing is clear: the obesity epidemic has resulted from a decoupling of energy intake and expenditure, which is regulated, to a certain extent, by genes. It seems that current methods of measuring dietary intake and physical activity levels are probably not sensitive enough to detect the small energy imbalance that could result in long-term weight gain in the population.

The Canadian Task Force on Preventive Health Care published a report in 1999 that indicated that there was insufficient evidence to either recommend the inclusion or exclusion of BMI measurements as part of periodic health examinations of individuals without obesity-related disorders (37). This is in direct contrast to recent recommendations from the U.S. National Institutes of Health (38) that call for the use of BMI in the detection and treatment of

obesity and obesity-related disorders. The detection of overweight and obesity in people before they develop obesity-related disorders is an important public health priority, because obesity is a difficult condition to treat once it becomes established.

Unfortunately, there is currently no obesity surveillance in Canada using measured stature and body mass. The most recent population-level statistics available for measured body mass and stature are from the 1986–1992 Canada Heart Health Surveys (28). The World Health Organization has called for the continued monitoring of population levels of overweight and obesity, using BMI as the indicator (5). Thus, there is a need for new Canadian population surveys that include measurements of stature and body mass. Nevertheless, the available data indicate that there have been significant increases in the prevalences of overweight and obesity in recent decades in the Canadian population. Thus, the reversal of the current trends in obesity is a public health priority.

Acknowledgments

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