Secular trends in the body mass index of Canadian children

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Abstract

Background: Various changes in society have created the opportunity for more sedentary behaviour and the consumption of food that is high in kilojoules, which may lead to a progressive increase in body mass over time. The purpose of this study was to examine secular changes in the body mass index (BMI) of Canadian children between 1981 and 1996.

Methods: Nationally representative data from the 1981 Canada Fitness Survey, the 1988 Campbell's Survey on the Well-being of Canadians and the 1996 National Longitudinal Survey of Children and Youth were used in the analysis. Regression analyses were used to assess population changes in BMI from 1981 to 1996 for children aged 7–13 years. Changes in the distribution of BMI results were evaluated by plotting the residuals from regression analyses of BMI on age, assessed separately by sex, using the 1981 data as baseline. The proportions of children exceeding the 85th and 95th age- and sex-specific percentiles from the 1981 (baseline) data were also calculated.

Results: Since 1981, BMI has increased at the rate of nearly 0.1 kg/m^2 per year for both sexes at most ages, indicating a clear secular trend toward an increase in BMI of Canadian children. The prevalence of overweight among boys increased from 15% in 1981 to 28.8% in 1996 and among girls from 15% to 23.6%. The prevalence of obesity in children more than doubled over that period, from 5% to 13.5% for boys and 11.8% for girls.

Interpretation: Secular trends indicate that Canadian children aged 7–13 years are becoming progressively overweight and obese.

There is growing concern that the current behaviour patterns of children and youth may accelerate lifestyle-related disease processes and result in premature morbidity and mortality. Children are choosing to watch television, surf the Internet and play video games instead of engaging in more active leisure pursuits. A consequence of this behaviour is a sustained positive energy balance that may lead to an increase in the prevalence of obesity and cardiovascular disease risk factors.[1–6] In Australia[7] and the United States,[8–11] there is evidence that children are becoming progressively obese,[4,5] despite consuming similar numbers of kilojoules[5] or fewer kilojoules.[1] Canada does not have a health surveillance system to monitor the prevalence of obesity among Canadian children and youth.[12] The most current data available indicate that the prevalence of obesity, based on skinfold thickness measurements, increased from 16% to 22% among males and from 15% to 26% among females between 1981 and 1988.[13,14] However, these findings pertain only to youth aged 15–19 years, and the data are now 12 years old. There are no published data examining secular changes in body mass index (BMI) for nationally representative samples of Canadian children. Therefore, the purposes of this study were to assess changes in BMI over a 15-year period using representative samples of Canadian children and youth and to examine changes in the proportion of children classified as overweight or obese.

Methods

Three national databases were used to assess secular changes in BMI. Data from the 1981 Canada Fitness Survey (CFS), the 1988 Campbell's Survey on the Well-being of Canadians

Research

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(CSWB) and the second wave (1996) of the Canadian National Longitudinal Survey of Children and Youth (NLSCY) were used for comparison. The CFS was conducted between February and July 1981, using a geographically stratified sample that represented 97% of the Canadian population.[15] A total of 23 400 people participated in the CFS. The information obtained made it possible to calculate BMI for 4176 children and youth (49% female) aged 7–19 years. The CSWB was a longitudinal follow-up of a representative subsample of the CFS and was performed between March and April 1988. BMI measurements were available for 481 children and youth (49.5% female) aged 7–19 years. Details on the sampling procedures from the CFS and CSWB have been published previously.[13–15] Exact age at the time of measurement was estimated from birthdate information in both the CFS and CSWB. Height and body mass were directly measured according to standardized procedures.[16] BMI was calculated from height and mass data using the following formula: BMI = mass (kg)/height $(m)^2$.

The 1996 NLSCY data[17] were collected between December 1996 and May 1997. The target population comprised all Canadian children from newborn to the age of 13 years. The participating households were selected from the sampling frame of Statistics Canada's Labour Force Survey (as was the CFS), which is representative of Canada's population. The children's exact ages at the time of the interview were available for each child. In this survey, the height and body mass data were gathered through parental report, which in some cases (proportion not known) included direct measurement. This is clearly a limitation to this analysis and is discussed later. BMI results were available for 7847 children aged 7–13 years from the NLSCY.

The following regression model — $BMI = b_0 + b_1(age) + b_2(age)^2 + \varepsilon$ — was fitted separately for boys and girls for each set of data, using the calculated BMI values and the estimated exact ages of the children. The regression lines are displayed in Fig. 1. The 1981 regression results were treated as the baseline for assessing changes in BMI and establishing criteria for overweight and obesity. The unstandardized residuals (individual data point deviations from the plotted regression lines) for the 1981 data were saved. For the 1996 data, however, each child's residual was calculated from the 1981 regression line. An examination of the variance of the residuals by age revealed that the variance tended to increase with age; therefore, we formed 2 groups (ages 7–10 years and 11–13 years) for both boys and girls that had relatively homogeneous variance. The distributions of the 2 sets of residuals for each sex were examined and summary statistics calculated.

At each age, in 1-year increments, we estimated the 85th and 95th percentiles for BMI using the 1981 data as baseline. These cutoff points have been previously established as indicators for being overweight and obese respectively.[18–20] The 1981 criteria were applied to the 1996 data to assess changes in the prevalence of overweight and obesity from 1981 to 1996.

Results

Fig. 1 shows the secular changes that occurred in BMI from 1981 to 1996. For boys aged 7–10 years, the results reveal a substantial increase in BMI between 1981 and 1996, although the differences between 1981 and 1988 were quite small. At ages 11–19 years, there is a discernible increase in BMI at all ages, increasing progressively from 1981 to 1988 and then from 1988 to 1996.

Table 1 provides the means, standard deviations and sample sizes for the body mass of boys and girls aged 7–13

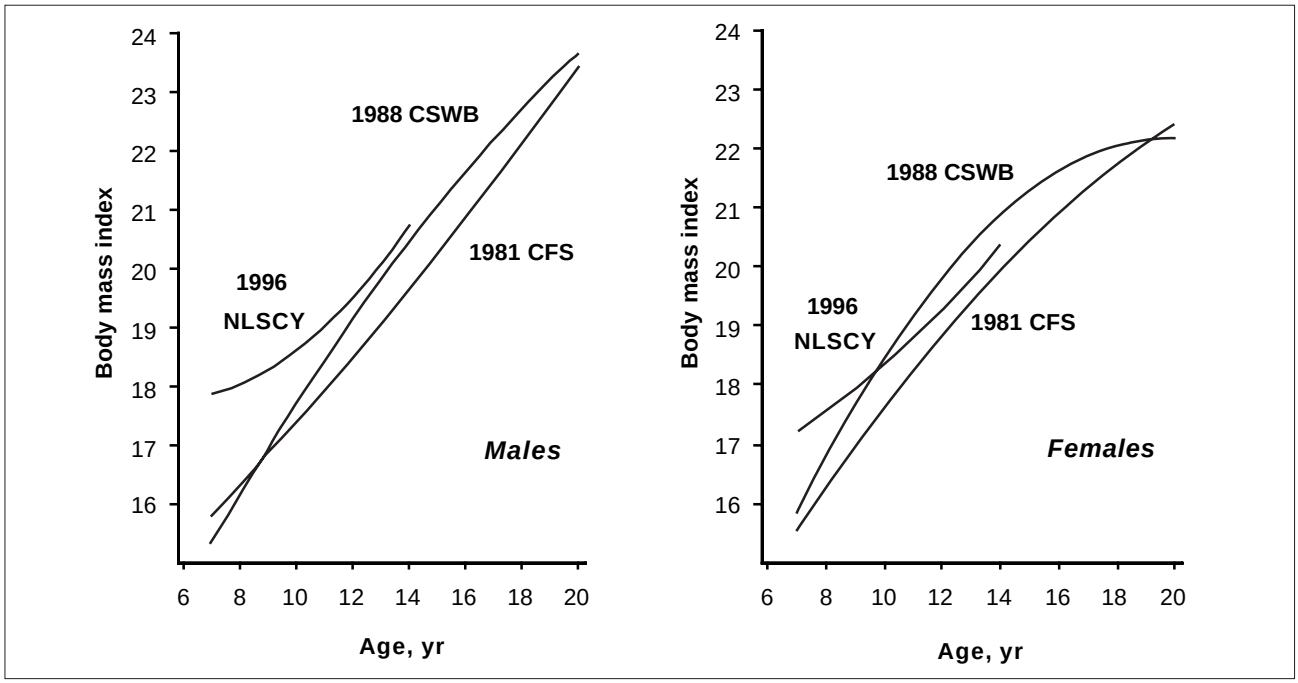

Fig. 1: Regression lines for body mass index on age (7–19 years) from 3 national surveys for males and females. CFS = Canada Fitness Survey,[14] CSWB = Campbell's Survey on the Well-being of Canadians,[13] NLSCY = National Longitudinal Survey of Children and Youth.[17]

years. In addition to the 3 data sets used for analysis in this paper, summary values are included for directly measured body mass from an unbiased sample of 10 000 children aged 7–17 years from Canadian schools in 1966.[21] With few exceptions, a systematic increase in body mass for boys and girls is observed, starting in 1966.

An examination of the residuals from the regression analysis provides strong evidence that BMI values have increased for both boys and girls aged 7–13 years. For the younger cohort (ages 7–10 years), the average increases in BMI are 1.35 and 1.16 for boys and girls respectively. For the older cohort (ages 11–13 years), the average increases are 1.38 and 0.58 for boys and girls respectively. Given that the 2 studies span 15 years, the average increase is nearly 0.1 of a BMI unit per year. Moreover, the results indicate that variation in BMI has increased from 1981 to 1996. This change, in addition to an increased proportion of children with high BMI values, has resulted in a dramatic increase in the prevalence of overweight and obesity. Furthermore, in the younger cohort, there is a slightly greater prevalence of children with a very low BMI.

Fig. 2 shows the prevalence of children classified as overweight (> 85th percentile) or obese (> 95th percentile) from these samples. The 1981 data were used to establish the criteria for being overweight and obese when the prevalence of overweight among children at every age was 15% and the prevalence of obesity among children at every age was 5%. For both boys and girls, and at almost every age, the proportion of children classified as overweight or obese increased from 1981 to 1996. This finding supports the observation from the analysis of the residuals, suggesting that the progressive increase in average BMI observed in Canadian children is influenced considerably by an increased proportion of children in the top percentiles. Overall, the prevalence of overweight among boys increased from 15% in 1981 to 28.8% in 1996 and among girls from 15% to 23.6%. The prevalence of obese children (5%) more than doubled over that period to 13.5% for boys and to 11.8% for girls.

Discussion

The results of this paper provide compelling evidence that there was a progressive increase in BMI for Canadian children from 1981 to 1996. Furthermore, changes in the distribution of BMI values have resulted in a marked increase in the proportion of Canadian children who exceed earlier thresholds for overweight and obesity. These findings are remarkable in their magnitude and consistency and draw serious attention to the escalating problem of pediatric obesity in Canada.

Using BMI as an indicator of overweight or obesity has its limitations.[22] Nevertheless, Malina and Katzmarzyk[22] have demonstrated that BMI has high specificity (correctly classifying those not obese) and variable sensitivity (proportion of subjects truly at risk of being overweight or obese) as an indicator of overweight and obesity based on analyses of several ethnically diverse samples.

A second limitation of our study is that the 1996 BMI estimates were derived from parents' reports. The results show that in both sexes, and at almost all ages between 7 and 19 years, Canadian children and youth had higher measured BMIs in 1988 than in 1981. For males, the parent-reported information from the 1996 NLSCY demon-

Table 1: Body mass for Canadian children aged 7–13 years from 4 national surveys

	Age, yr; mean body mass (and SD), kg						
Survey	7	8	9	10	11	12	13
Boys							
CAHPER, 1966	25.7 (3.7) *n = 95*	27.7 (3.8) *n = 101*	30.5 (4.4) *n = 119*	33.7 (6.4) *n = 101*	37.7 (6.5) *n = 122*	42.2 (8.7) *n = 101*	47.1 (10.3) *n = 110*
CFS, 1981	24.4 (3.5) *n = 140*	28.4 (5.4) *n = 144*	31.1 (5.4) *n = 147*	35.0 (6.5) *n = 155*	38.4 (8.2) *n = 155*	42.5 (8.0) *n = 152*	48.0 (8.2) *n = 153*
CSWB, 1988	24.1 (3.4) *n = 8*	30.6 (6.7) *n = 7*	32.2 (5.0) *n = 6*	36.4 (6.3) *n = 20*	39.5 (9.2) *n = 17*	45.1 (8.1) *n = 15*	49.8 (10.1) *n = 18*
NLSCY, 1996	26.1 (5.0) *n = 667*	29.0 (5.8) *n = 660*	33.5 (7.7) *n = 656*	36.1 (7.3) *n = 670*	41.6 (8.6) *n = 678*	47.7 (9.5) *n = 460*	52.9 (9.2) *n = 547*
Girls							
CAHPER, 1966	24.9 (4.6) *n = 96*	27.2 (5.0) *n = 114*	30.1 (4.9) *n = 104*	33.5 (5.9) *n = 103*	36.2 (6.2) *n = 101*	43.1 (9.5) *n = 101*	49.8 (8.9) *n = 89*
CFS, 1981	24.8 (4.0) *n = 132*	28.3 (5.1) *n = 135*	30.9 (5.5) *n = 139*	35.6 (7.0) *n = 147*	38.0 (8.4) *n = 147*	43.5 (8.6) *n = 145*	48.8 (8.7) *n = 147*
CSWB, 1988	24.9 (4.6) *n = 6*	28.7 (7.6) *n = 6*	36.7 (10.8) *n = 10*	36.2 (9.0) *n = 13*	41.5 (7.5) *n = 17*	46.4 (10.6) *n = 15*	54.3 (9.9) *n = 16*
NLSCY, 1996	25.0 (4.8) *n = 648*	28.9 (5.9) *n = 621*	32.0 (6.7) *n = 598*	36.3 (7.5) *n = 625*	40.7 (8.3) *n = 631*	46.7 (8.6) *n = 520*	51.3 (9.3) *n = 558*

Note: SD = standard deviation, CAHPER = Canadian Association for Health, Physical Education and Recreation,[21] CFS = Canada Fitness Survey,[14] CSWB = Campbell's Survey on the Well-being of Canadians,[13] NLSCY = National Longitudinal Survey of Children and Youth.[17]

strated a continuation of the trend toward progressively higher BMI values. In girls, however, this trend was evident only at the ages of 7–9 years, after which the 1996 values fell somewhere between the 1981 and 1988 results.

The anomaly for preadolescent girls is consistent with the findings of a US study that examined the bias in self-reported body mass and height. Using results from the NHANES III study, Strauss compared measured *versus* self-reported body mass and height values for a large group (n = 1657) of children and youth aged 12–16 years.[23] Correlations ranged from 0.87 to 0.94 for body mass and from 0.82 to 0.91 for height, depending on age, sex and ethnic origin. Correlations for BMI ranged from 0.79 to 0.89. Strauss observed that females were much more likely than males to underreport body mass.[23] Given the magnitude and direction of the biases observed by Strauss, and the consistency of our findings with his findings, we expect that the prevalence of overweight and obesity has been *underestimated* in this study.

Our findings are consistent with recent studies conducted in other high-income countries. The prevalence of pediatric obesity has progressively increased in the United States, especially between 1976–1980 and 1988–1994.[11] The BMI thresholds (in kg/m^2) used to define obesity in our study are similar to those in the United States,[8,9] yet the magnitude of change observed in the present Canadian analysis is greater than that observed in the United States and has occurred over a shorter period of time. Between 1985 and 1997, an increased proportion of schoolchildren with high BMI values was observed in Australia.[7] The current findings from Canadian children demonstrate a similar trend. This apparently international trend is disturbing because an increase in pediatric obesity increases the risk of subsequent morbidities.

The health risk of having a high BMI in adulthood is well established.[24–27] Because clinical evidence of disease in children is generally absent, the health consequences of

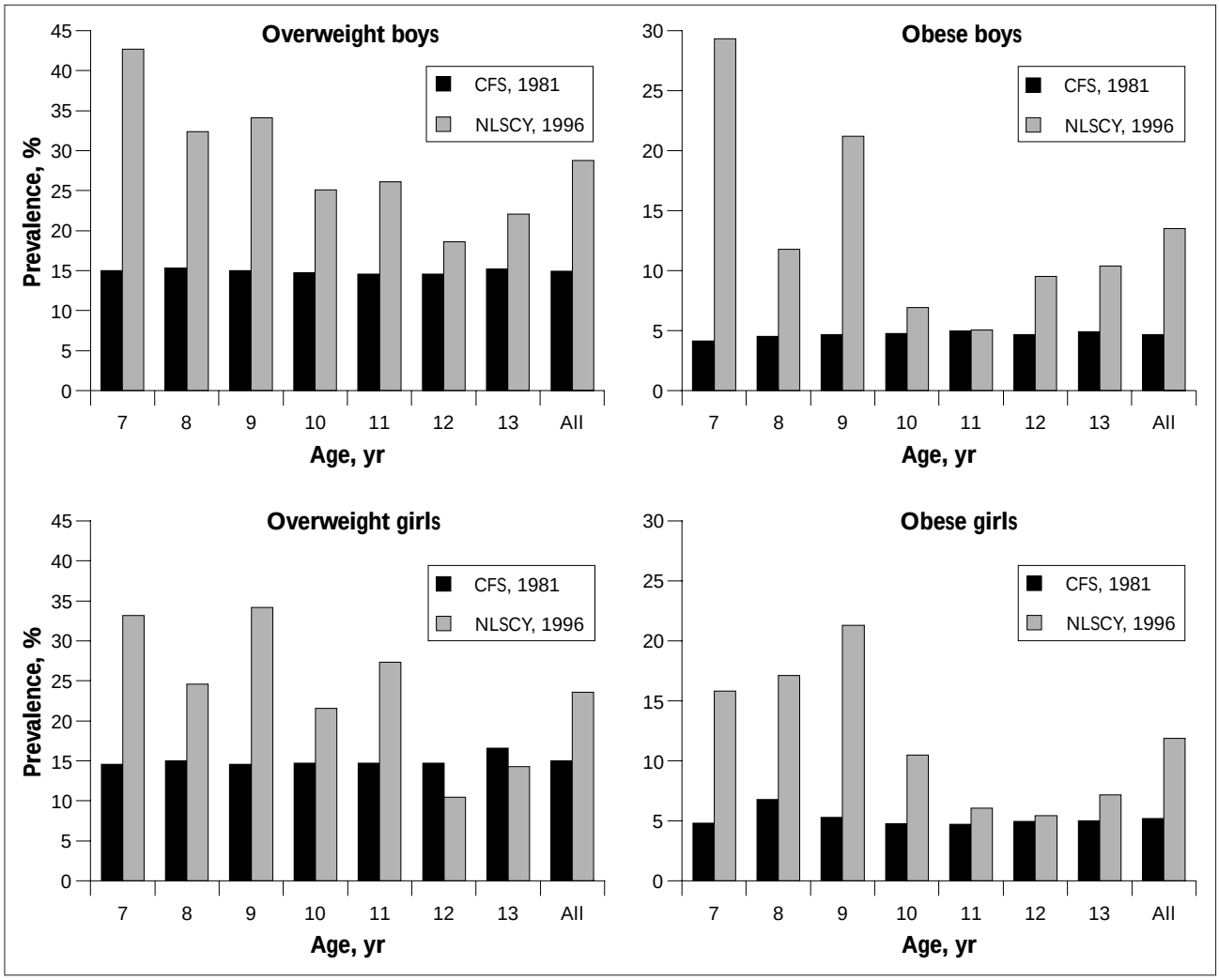

Fig. 2: Prevalence of overweight (> 85th age- and sex-specific percentile) and obesity (> 95th age- and sex-specific percentile) using the 1981 CFS data[14] as baseline for boys and girls aged 7–13 years.

having a high BMI during childhood are less obvious, however, cases of type 2 diabetes mellitus, hyperlipidemia and hypertension are becoming more common in severely overweight children.[28] Furthermore, such children may have an undesirable body image and poor self-esteem.[29,30] Excessive body mass during childhood and adolescence is associated with an increased risk of becoming overweight in adulthood[31,32] and with higher morbidity and mortality rates in adulthood.[2,3]

The rapid increases in overweight and obesity that have been observed over the past 2 decades strongly suggest that environmental causes are responsible.[11] The most recent report from the Heart and Stroke Foundation of Canada acknowledges that pediatric obesity is a problem and concedes that behaviours that increase the risk of cardiovascular disease begin early in life and, therefore, it is essential that prevention begins in early childhood.[12] More attention to the promotion of healthy nutrition and physical activity throughout childhood and adolescence is required, and a systematic and ongoing collection of relevant body composition and physical activity measurements is needed for effective health promotion planning and policy and legislation development.[12]

Competing interests: None declared.

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