

# Recent trends in the prevalence of overweight and obesity among Canadian children

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## ABSTRACT

**Background:** Previous studies have shown an increase in the prevalence of overweight and obesity among Canadian children from 23.3% to 34.7% during 1978–2004. We examined the most recent trends by applying current definitions of overweight and obesity based on World Health Organization (WHO) body mass index (BMI) thresholds and recently validated norms for waist circumference and waist:height ratio.

**Methods:** We examined directly measured height and weight data from the Canadian Community Health Survey (2004–2005) and the Canadian Health Measures Survey (2009–2013). We calculated z scores for BMI, height and weight based on the 2014 WHO growth charts for Canada, including the new extension of weight-for-age beyond 10 years. To calculate z scores for waist circumference and waist:height ratios, we used new charts from the reference population in the US NHANES III (National Health and Nutrition Examination Survey, 1988–1994).

**Results:** Data were available for 14 014 children aged 3–19 years for the period 2004–2013. We observed a decline in the prevalence of overweight or obesity, from 30.7% (95% confidence interval [CI] 29.7% to 31.6%) to 27.0% (95% CI 25.3% to 28.7%) ( $p < 0.001$ ) and stabilization in the prevalence of obesity at about 13%. These trends persisted after we adjusted for age, sex and race/ethnicity. Although they declined, the median z scores for BMI, weight and height were positive and higher than those in the WHO reference population. The z scores for waist circumference and waist:height ratio were negative, which indicated that the Canadian children had less central adiposity than American children in historic or contemporary NHANES cohorts.

**Interpretation:** After a period of dramatic growth, BMI z scores and the prevalence of overweight or obesity among Canadian children decreased from 2004 to 2013, which attests to progress against this important public health challenge.

**Competing interests:** None declared.

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Ongoing pan-Canadian surveys such as the Canadian Community Health Survey (CCHS) and Canadian Health Measures Survey (CHMS) are important to evaluate the health of our population using representative national samples.<sup>1,2</sup> Self-reported heights and weights replaced direct measurement during 1978–2004, which underestimated true rates of overweight and obesity.<sup>3</sup> A subsequent comparison of directly measured heights and weights during the same period showed an alarming increase in the prevalence of overweight or obesity among Canadian children aged 2–17 years, from 23.3% (95% confidence interval [CI] 20.5% to 26.0%) to 34.7% (95% CI 33.0% to 36.4%) based on the new World Health Organization (WHO) definitions.<sup>1</sup>

In Canada, the definitions of overweight and obesity changed with the introduction of the 2010 WHO growth charts for Canada.<sup>4,5</sup> Previ-

ous definitions were based on body mass index (BMI) percentiles from the 2000 US Centers for Disease Control and Prevention (CDC) growth charts.<sup>6</sup> In addition to revising these percentile thresholds, the WHO charts were based on a different reference population; as a result, the proportion of Canadian children classified as overweight or obese increased with the introduction of the new WHO charts.<sup>1,7,8</sup> Moreover, the absolute percentile thresholds now vary by age, with toddlers (2 to  $\leq 5$  yr) having higher thresholds to define overweight and obesity than older children (age  $> 5$  to 19 yr).<sup>4</sup>

Results from the United States have shown a decline in obesity rates among toddlers and a plateau in rates among older children;<sup>9,10</sup> stabilization has also been noted in other jurisdictions (e.g., Germany and Australia).<sup>11–16</sup> We undertook this study to determine the most recent trends in the prevalence of overweight and obesity among

Canadian children using the current WHO weight charts for Canada applied to a representative sample of children.

## Methods

### Data sources

The CCHS (the result of a partnership between Health Canada, the Canadian Institute for Health Information and Statistics Canada) consists of a series of cross-sectional national surveys with the objective of providing timely information on health determinants, status and health system utilization.<sup>17</sup> The 2004/05 survey (cycle 2.2) was a nationally representative cross-sectional survey specifically designed to collect information about the nutritional status of the Canadian population aged 2–79 years, including directly measured heights and weights for almost 9000 children aged 3–19 years.<sup>18</sup> The survey targeted the entire population except residents of the 3 territories, Indian reserves and military bases and had a response rate of 76.5%.

Beginning in 2007, the annual CHMS measured height, weight and waist circumference of Canadian children aged 3–19 years.<sup>19,20</sup> The target population included 96% of the Canadian population, excluding residents of Indian reserves, full-time members of the regular Canadian Forces, and residents in institutions and some remote regions. Of the households selected for the survey, 75.9% agreed to participate.

To permit detailed comparisons over time, we analyzed a decade of anthropometric data for children aged 3–19 years from CCHS cycle 2.2 (2004/05) and CHMS cycle 2 (2009–11) and cycle 3 (2012/13). Detailed descriptions of both surveys are available elsewhere.<sup>18,19,21</sup> We excluded CHMS cycle 1 (2007/08) because it did not include children less than 6 years of age. We restricted our analysis to a comparable age range (3–19 yr) across survey cycles so that the post-stratification and inverse-probability weights provided by Statistics Canada could be applied to account for non-response and underrepresentation, to permit generalizability of the results to the population as a whole with the complex survey design. To protect confidentiality, data were merged by age, sex or race/ethnicity for some analyses and presentations.

### Variables of interest

Anthropometric measurements were collected in the surveys using a standardized measurement protocol. In brief, heights were measured to the nearest 0.5 cm by trained staff; weight was measured to the nearest 0.1 kg.<sup>1,2</sup> A snug tape measure was used to measure waist circumference to the closest 0.1 cm after palpating the highest

point on the iliac crests (the so-called National Institutes of Health protocol).<sup>22</sup> To ensure adequate numbers and consistency across survey cycles, we pooled race/ethnicity categories as white (European-American) or nonwhite.

Although there are absolute BMI thresholds to define obesity and overweight in adults, direct comparison of absolute values is not feasible in children because most anthropometric measures vary by age and sex. To allow comparisons, pediatric definitions of obesity and overweight are based on age- and sex-specific *z* scores or (equivalently) BMI percentile values. For older children (age > 5 to < 19 yr), both the WHO and the Public Health Agency of Canada's Collaborative Group define obesity as a BMI *z* score above 2 (97th percentile) and overweight as a BMI *z* score of 1–2 (85th–97th percentiles). Although these values have been chosen in part to align with adult definitions at age 19 years, different cut-offs are applied to toddlers (age > 2 to ≤ 5 yr).

The LMS method summarizes growth data in terms of 3 parameters: L (skew), M (median) and S (coefficient of variation).<sup>23</sup> For a given physical measure *y*, we calculated sex- and age-adjusted *z* scores using the formula  $z = [(y/M)L - 1]/(LS)$ , with recommended modifications for *z* scores outside the range –3 to +3, where this formula does not apply.<sup>24</sup> We calculated *z* scores for height, weight and BMI using the LMS table from the 2014 WHO growth charts for Canada, which added weight-for-age beyond age 10 years to the 2010 iteration of the charts, based on our re-analysis of the original WHO reference data.<sup>7</sup> We calculated *z* scores for waist circumference and waist:height ratio using recently validated LMS tables based on data from the US NHANES III (National Health and Nutrition Examination Survey, 1988–1994) and the National Institutes of Health measurement protocol.<sup>25</sup>

We defined obesity according to the WHO criteria: BMI above the 97th percentile for older children (age > 5 to < 19 yr) and above the 99.9th percentile for toddlers (age > 2 to ≤ 5 yr). Similarly, we used 2 different BMI ranges to define overweight: above the 85th percentile to the 97th percentile for older children and above the 97th percentile to the 99.9th percentile for toddlers.<sup>4,5</sup>

### Statistical analysis

We performed all analyses using standardized survey weights in R version 3.0 (www.R-project.org), standardized for specific subsamples to ensure agreement between weighted and actual sample numbers. To accommodate skew, descriptive statistics are expressed as medians with interquartile range (IQR), unless specified otherwise. Statistical significance was set at  $p < 0.05$ .

To examine the association between mean  $z$  score and age graphically, we plotted individual  $z$  scores versus age and smoothed them with weighted, penalized regression splines after smoothing degrees of freedom were selected by generalized cross-validation. We used linear regression analysis to assess the change in mean  $z$  scores by survey cycle with and without adjustment for the covariates sex, age group and race/ethnicity. Using the most recent WHO definitions, we calculated the proportion of children who were overweight or obese and the proportion who were obese, by sex and survey cycle. We used logistic regression analysis to calculate odds ratios (ORs) to delineate further the effects of age, sex, race/ethnicity and survey period on the prevalence of overweight and obesity. All regression analyses included an interaction term for sex:survey.

### Ethics approval

Parents consented for children to be measured as part of the CCHS and CMHS surveys; children

over 12 years (CCHS) or 14 years (CHMS) provided assent. Approval to undertake our analyses was granted by the Research Ethics Board at the University of Manitoba and the Statistics Canada Research Data Centre.

### Results

Data were available for 14 014 children aged 3–19 years during the period 2004–2013 (Table 1). Overall, 11 233 (80.2%) of the children were white; the sex distribution was equal in each survey cycle, with 7005 girls and 7009 boys overall. The median  $z$  scores for BMI and weight decreased over the 3 survey periods, whereas the median  $z$  scores for height were stable (Table 2). The scores for all 3 measures were positive, which indicated that Canadian children were heavier and taller than the WHO reference population, with overall median  $z$  scores of 0.40 for BMI, 0.42 for weight and 0.20 for height. Compared with the NHANES III reference population, the  $z$  scores

**Table 1:** Distribution of race/ethnicity and age category among 14 014 Canadian children who participated in national health surveys from 2004 to 2013, by survey period

Variable	Survey period; no. (%) of children			
	2004/05 <i>n</i> = 8 976	2009–2011 <i>n</i> = 2 578	2012/13 <i>n</i> = 2 460	All <i>n</i> = 14 014
<b>Race/ethnicity</b>				
White	7 657 (85.3)	1 918 (74.4)	1 658 (67.4)	11 233 (80.2)
Nonwhite	1 319 (14.7)	660 (25.6)	802 (32.6)	2 781 (19.8)
<b>Age category*</b>				
Toddler	884 (9.8)	375 (14.5)	363 (14.8)	1 622 (11.6)
Older children	8 092 (90.2)	2 203 (85.5)	2 097 (85.2)	12 392 (88.4)

\*See Methods for definitions.

**Table 2:** Median  $z$  scores for anthropometric measurements for Canadian children, by survey period and sex

Survey	Measurement; median $z$ score (IQR)				
	BMI	Weight	Height	Waist circumference	Weight:height ratio
<b>Overall</b>	0.40 (–0.31 to 1.28)	0.42 (–0.30 to 1.18)	0.20 (–0.49 to 0.85)	–0.12 (–0.80 to 0.64)	–0.31 (–0.99 to 0.48)
<b>2004/05</b>					
All	0.47 (–0.25 to 1.33)	0.45 (–0.21 to 1.20)	0.19 (–0.53 to 0.90)	–	–
Males	0.55 (–0.20 to 1.43)	0.53 (–0.14 to 1.31)	0.28 (–0.48 to 0.98)	–	–
Females	0.40 (–0.29 to 1.23)	0.38 (–0.28 to 1.12)	0.11 (–0.58 to 0.81)	–	–
<b>2009–11</b>					
All	0.41 (–0.29 to 1.26)	0.42 (–0.29 to 1.17)	0.19 (–0.50 to 0.81)	–0.22 (–0.86 to 0.53)	–0.45 (–1.09 to 0.30)
Males	0.53 (–0.19 to 1.37)	0.54 (–0.16 to 1.26)	0.23 (–0.44 to 0.91)	–0.11 (–0.70 to 0.62)	–0.35 (–1.05 to 0.41)
Females	0.36 (–0.39 to 1.19)	0.32 (–0.37 to 1.05)	0.17 (–0.53 to 0.72)	–0.41 (–0.99 to 0.43)	–0.56 (–1.16 to 0.22)
<b>2012/13</b>					
All	0.27 (–0.39 to 1.23)	0.37 (–0.40 to 1.15)	0.21 (–0.43 to 0.85)	0.04 (–0.73 to 0.78)	–0.19 (–0.88 to 0.56)
Males	0.41 (–0.33 to 1.38)	0.49 (–0.38 to 1.20)	0.24 (–0.40 to 0.81)	0.05 (–0.75 to 0.84)	–0.21 (–0.88 to 0.65)
Females	0.18 (–0.43 to 1.10)	0.25 (–0.41 to 1.04)	0.21 (–0.48 to 0.90)	0.01 (–0.68 to 0.67)	–0.15 (–0.90 to 0.60)

Note: BMI = body mass index, IQR = interquartile range.

for waist circumference and waist:height ratio were negative (overall median  $z$  scores  $-0.12$  and  $-0.31$ , respectively).

Tables 3 and 4 show the results of the linear regression analysis of temporal changes in mean  $z$  scores, with and without adjustment for several covariates. The intercepts representing the mean  $z$  scores in the 2004/05 survey all differed significantly from zero. The unadjusted mean  $z$  score for BMI declined by  $-0.13$  (95% CI  $-0.18$  to  $-0.08$ ) from 2004/05 to 2012/2013. The mean  $z$  score for weight showed a similar decline, but the score for height remained static (Table 3). After adjustment for age, sex and race/ethnicity, the mean  $z$  scores for BMI and weight were still lower in the 2012/2013 survey cycle than in the 2004/05 cycle. Compared with toddlers, older children had lower BMI  $z$  scores. Girls had lower  $z$  scores than boys for BMI, weight and height. For the sex:survey interaction term, there was a small, selective increase in  $z$  scores for height among girls in the 2012/13 survey cycle (mean change  $0.09$  [95% CI  $0.03$  to  $0.15$ ] for girls v.  $-0.05$  [95% CI  $-0.11$  to  $0.01$ ] for boys;  $p$  for interaction =  $0.02$ ).

Although both measures of central adiposity lacked 2004/05 CCHS survey data for comparison (Tables 2 and 4), the mean  $z$  scores for waist circumference and weight:height ratio were negative in 2009–2011 (i.e., below the NHANES III reference population). In the 2012/13 survey cycle, there was an increase in mean  $z$  scores for waist circumference and weight:height ratio that persisted after we adjusted for age, sex and race/ethnicity. Although girls had lower  $z$  scores than boys in the 2009–2011 survey cycle, a sex:survey interaction was noted for 2012/13, with girls effectively catching up to their male counterparts.

When we examined the mean (smoothed)  $z$  scores for BMI as a function of age and survey cycle (Figure 1), we found that young toddlers had higher mean  $z$  scores than older children and the WHO reference population. The observed decline in BMI  $z$  scores occurred largely among children 5–12 years of age.

Using the current definitions, we observed a significant decline in the prevalence of overweight or obesity among children across survey cycles, from 30.7% (95% CI 29.7% to 31.6%) to 27.0% (95% CI 25.3% to 28.7%;  $p < 0.001$ ) (Figure 2 and

**Table 3:** Temporal changes in mean  $z$  scores for BMI, weight and height

Variable	Measurement; change in mean $z$ score (95% CI)					
	BMI		Weight		Height	
	Unadjusted	Adjusted*	Unadjusted	Adjusted*	Unadjusted	Adjusted*
Intercept		0.63 (0.58 to 0.68)		0.62 (0.57 to 0.67)		0.31 (0.26 to 0.35)
2009–2011 survey (v. 2004/05)	$-0.06$ ( $-0.11$ to $-0.01$ )	$-0.03$ ( $-0.10$ to $0.04$ )	$-0.04$ ( $-0.09$ to $0.01$ )	$-0.02$ ( $-0.09$ to $0.04$ )	$-0.01$ ( $-0.05$ to $0.03$ )	$-0.04$ ( $-0.10$ to $0.02$ )
2012/13 survey (v. 2004/05)	$-0.13$ ( $-0.18$ to $-0.08$ )	$-0.12$ ( $-0.20$ to $-0.05$ )	$-0.07$ ( $-0.12$ to $-0.03$ )	$-0.08$ ( $-0.15$ to $-0.02$ )	$-0.01$ ( $-0.03$ to $0.06$ )	$-0.05$ ( $-0.11$ to $0.01$ )
Older children (v. toddlers)†	$-0.09$ ( $-0.16$ to $-0.03$ )	$-0.09$ ( $-0.16$ to $-0.03$ )	0.15 (0.09 to 0.22)	0.16 (0.09 to 0.22)	0.31 (0.26 to 0.37)	0.31 (0.26 to 0.37)
Female (v. male)	$-0.16$ ( $-0.21$ to $-0.12$ )	$-0.14$ ( $-0.21$ to $-0.07$ )	$-0.17$ ( $-0.21$ to $-0.13$ )	$-0.17$ ( $-0.23$ to $-0.10$ )	$-0.09$ ( $-0.13$ to $-0.06$ )	$-0.16$ ( $-0.22$ to $-0.10$ )
Nonwhite (v. white)	$-0.01$ ( $-0.04$ to $0.06$ )	0.03 ( $-0.02$ to $0.07$ )	$-0.00$ ( $-0.05$ to $0.04$ )	0.01 ( $-0.04$ to $0.05$ )	$-0.02$ ( $-0.06$ to $0.02$ )	$-0.02$ ( $-0.06$ to $0.02$ )
<b>Stratification by sex</b>						
2009–2011 survey						
Male	$-0.03$ ( $-0.10$ to $0.04$ )	$-0.03$ ( $-0.10$ to $0.04$ )	$-0.02$ ( $-0.09$ to $0.05$ )	$-0.02$ ( $-0.09$ to $0.04$ )	$-0.03$ ( $-0.09$ to $0.03$ )	$-0.04$ ( $-0.10$ to $0.02$ )
Female	$-0.09$ ( $-0.16$ to $-0.01$ )	$-0.09$ ( $-0.15$ to $-0.02$ )	$-0.06$ ( $-0.13$ to $0.01$ )	$-0.06$ ( $-0.12$ to $0.01$ )	0.01 ( $-0.05$ to $0.07$ )	0.01 ( $-0.04$ to $0.08$ )
2012/13 survey						
Male	$-0.12$ ( $-0.19$ to $-0.05$ )	$-0.12$ ( $-0.20$ to $-0.05$ )	$-0.08$ ( $-0.15$ to $-0.01$ )	$-0.08$ ( $-0.20$ to $-0.01$ )	$-0.05$ ( $-0.11$ to $0.01$ )	$-0.05$ ( $-0.11$ to $0.01$ )
Female	$-0.14$ ( $-0.21$ to $-0.07$ )	$-0.14$ ( $-0.20$ to $0.07$ )	$-0.07$ ( $-0.13$ to $0.00$ )	$-0.06$ ( $-0.13$ to $0.00$ )	0.08 (0.02 to 0.14)	0.09 (0.03 to 0.15)

Note: BMI = body mass index, CI = confidence interval.

\*Adjusted for survey cycle, age, sex, race/ethnicity and sex:survey interaction. To clarify the interaction, the adjusted model was stratified by sex, with the survey effect shown in the lower portion of the table for comparison. Unadjusted results are from univariate analyses with covariates age, sex, race/ethnicity, survey cycle and sex:survey interaction.

†See Methods for definitions.

Table 5). In contrast, the prevalence of obesity was stable at about 13%. Fewer girls than boys were overweight or obese (Figure 2 and Table 5).

The results of the multivariable logistic regression analysis are shown in Table 6. The decline in the prevalence of overweight or obesity was statistically significant with and without adjustment for age, sex and race/ethnicity. In the unadjusted comparison, this corresponded to an OR of 0.84 (95% CI 0.77 to 0.92) for the 2012/13 survey cycle compared with the 2004/05 cycle. In the multivariable model, the rate was further reduced among girls (adjusted OR 0.81, 95% CI 0.72 to 0.92). Rates were higher among nonwhite children than white children (adjusted OR 1.15, 95% CI 1.06 to 1.25) and among older children than among toddlers (adjusted OR 3.66, 95% CI 3.14 to 4.31). The latter observation contrasts with the lower BMI *z* scores among older children in Figure 1. In contrast, overall obesity rates plateaued across survey periods, as confirmed by the absence of significant results in the unadjusted and adjusted logistic regression models reported in Table 6. Obesity was more prevalent among boys, older children and nonwhite children than among girls, toddlers and white children, respectively.

## Interpretation

Using the current definitions of overweight and obesity, we found a significant decrease in the prevalence of overweight or obesity and a stabilization in the prevalence of obesity among Canadian children from 2004 to 2013. This change can be attributed to a general decrease in *z* scores for

weight and BMI, whereas *z* scores for height were stable across the survey periods. Our findings persisted after adjustment for age, sex and race/ethnicity. Rates of overweight or obesity and of obesity were lower among girls and white children than among boys and nonwhite children, respectively. Despite having higher mean BMI *z* scores, toddlers had lower rates in both categories; this observation was explained in part by the higher BMI thresholds for toddlers, because obesity is defined as a BMI above the 97th percentile for older children and above the 99.9th percentile for toddlers.

Unfortunately, Canadian children are still relatively heavy. The median *z* scores for BMI and

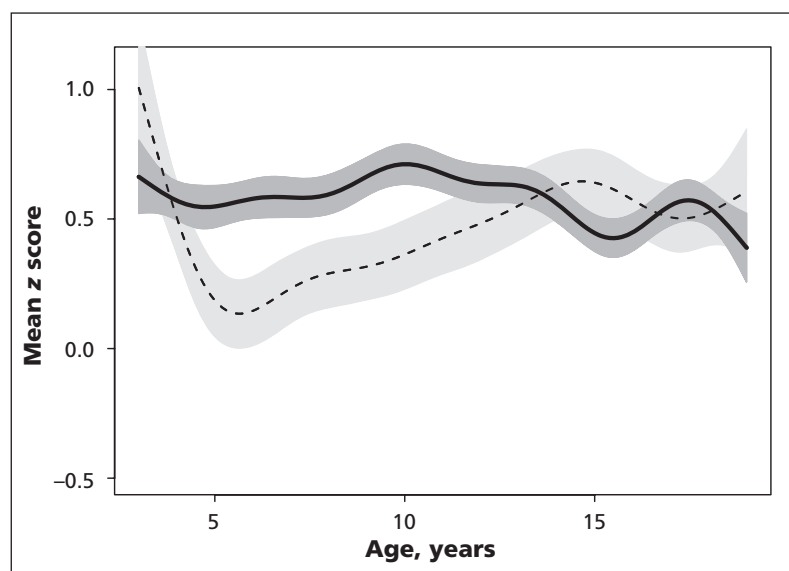


Figure 1: Mean (smoothed) *z* scores for body mass index as a function of age and survey period (2004/05 [solid line] v. 2012/13 [dashed line]). Grey zones represent 95% confidence intervals.

**Table 4:** Temporal changes in mean *z* scores for waist circumference and waist:height ratio

Variable	Measurement; change in mean <i>z</i> score (95% CI)			
	Waist circumference		Weight:height ratio	
	Unadjusted	Adjusted*	Unadjusted	Adjusted*
Intercept		-0.07 (-0.13 to -0.01)		-0.30 (-0.36 to -0.24)
2012/13 survey (v. 2009–2011)	0.24 (0.17 to 0.29)	0.13 (0.05 to 0.21)	0.24 (0.18 to 0.30)	0.14 (0.06 to 0.22)
Older children (v. toddlers)†	0.03 (-0.06 to 0.12)	0.04 (-0.05 to 0.12)	-0.13 (-0.23 to -0.04)	-0.13 (-0.22 to -0.04)
Female (v. male)	-0.13 (-0.19 to -0.07)	-0.24 (-0.32 to -0.15)	-0.09 (-0.15 to -0.03)	-0.19 (-0.27 to -0.11)
Nonwhite (v. white)	0.00 (-0.06 to 0.06)	-0.02 (-0.08 to 0.04)	0.01 (-0.06 to 0.07)	-0.01 (-0.08 to 0.05)
<b>Stratified by sex</b>				
2012/13 survey				
Male	0.10 (0.06 to 0.21)	0.13 (0.05 to 0.22)	0.14 (0.06 to 0.23)	0.15 (0.06 to 0.23)
Female	0.34 (0.26 to 0.42)	0.34 (0.26 to 0.42)	0.34 (0.26 to 0.43)	0.34 (0.26 to 0.42)

Note: CI = confidence interval.  
 \*Adjusted for survey cycle, age, sex, race/ethnicity and sex:survey interaction. To clarify the interaction, the adjusted model was stratified by sex, with the survey effect shown in the lower portion of the table for comparison. Unadjusted results are from univariate analyses with covariates age, sex, race/ethnicity, survey cycle and sex:survey interaction.  
 †See Methods for definitions.

weight in 2012/13 remained above those for the WHO growth charts. Although our study was unable to identify the mechanism for the observed decline in BMI *z* scores and rates of overweight or obesity, the introduction of BMI growth charts in 2000 may have encouraged health care providers to discuss children's overweight or obese status more openly with families.<sup>6</sup> In addition, numerous weight management programs, both regional and national, have been implemented (for review, see Ball and colleagues<sup>26</sup>), and increasing media scrutiny may have increased public awareness of the health issues. Failure to observe a corresponding reduction in obesity rates over time may reflect greater impact of such interventions among children who are overweight or, alternatively, a lack of statistical power given the smaller numbers in the obese category.

These findings are difficult to compare directly with many past Canadian reports because of the new criteria introduced with the 2010 WHO growth charts for Canada<sup>4</sup> and different age ranges. Our analysis of the CCHS data from the

2004/05 cycle is similar to that of Shields and Tremblay,<sup>1</sup> although we specifically extended the ages studied to include children between 17 and 19 years old to conform to the WHO charts. Compared with earlier analyses of CHMS data,<sup>2</sup> we were able to add younger children (3–5 yr) and provide additional time points to examine secular trends. Moreover, our recent extension of WHO weight-for-age norms to older children (> 10 yr) and NHANES III reference charts for waist circumference and weight:height ratio permitted a novel and perhaps more nuanced analysis than was previously possible, by allowing us to calculate *z* scores for weight, waist circumference and waist:height ratio.<sup>7,25</sup> These data based on up-to-date thresholds and growth-chart percentiles are therefore important benchmarks for the analysis of future surveys examining temporal trends.

In the US, the prevalence of obesity among children has remained static over the same study period, at about 17%, with the exception of children aged 2–5 years, among whom there was a decline to about 8%.<sup>9</sup> The overall US rate of overweight or obesity remained at about 30%.<sup>27</sup> Importantly, the US definitions use CDC cutoffs; if these data were re-analyzed using WHO criteria, the rates of overweight or obesity and of obesity in the US would be about 8%–10% higher.<sup>1</sup> Thus, Canada appears to be faring better than the US in the war on obesity.<sup>9,10</sup>

Other jurisdictions (e.g., Poland, Australia, the Netherlands, Germany and Denmark) have shown variable changes with either small declines or plateaus in obesity rates.<sup>11–15</sup> Some developing countries are undergoing the same surge in obesity witnessed in Canada from 1978 to 2004.<sup>16</sup> Other investigators have identified higher rates of obesity among Canadian boys using self-reported measures.<sup>28</sup> As we found, nonwhite children in many countries have increased odds of being overweight or obese.<sup>15,29,30</sup> In contrast, a recent study involving immigrant and nonimmigrant Canadian children aged 12–18 years reported a lower rate of obesity among immigrant children (18% v. 22%) using self-reported metrics.<sup>28</sup> These differences may be attributed to socioeconomic status or other factors that we could not explore.<sup>29–31</sup>

Although others have directly compared Canadian and US rates of overweight or obesity and obesity using BMI thresholds,<sup>1,27</sup> we were further able to study 2 measures of central adiposity (*z* scores for waist circumference and weight:height ratio) using data for the NHANES III reference population.<sup>25</sup> Compared with the reference population, our overall median *z* scores for both measures were  $-0.12$  and  $-0.31$ , respectively, which confirms that Canadian children have less central adiposity than American children in the

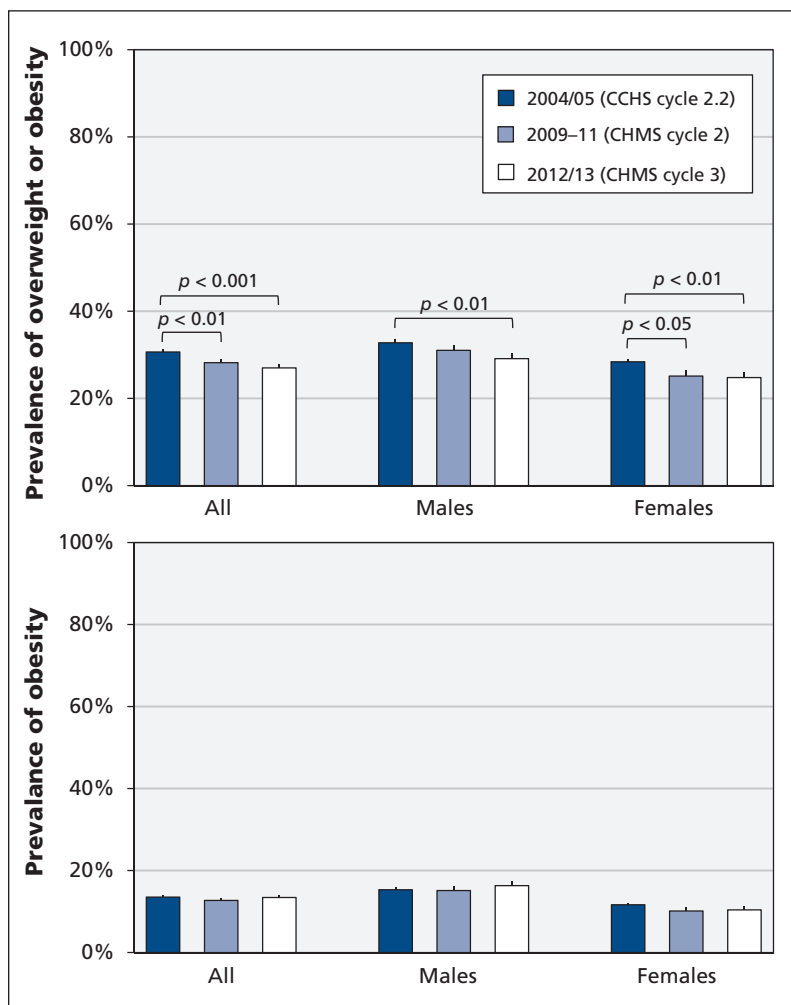


Figure 2: Prevalence of overweight or obesity (top) and obesity (bottom) among Canadian children. CCHS = Canadian Community Health Survey, CHMS = Canadian Health Measures Survey. Error bars = standard errors.

1988–1994 reference population. In contrast, in a contemporary American cohort aged 5–19 years, we reported mean  $z$  scores of 0.33 (95% CI 0.30 to 0.36) for waist circumference and 0.35 (95% CI 0.32 to 0.38) for weight:height ratio,<sup>25</sup> which are significantly different from the  $z$  scores in Tables 2–4. These results are particularly reassuring in light of our recent study showing that  $z$  scores for these measures of central adiposity are better predictors of cardiometabolic risk factors (e.g., hypercholesterolemia, hypertriglyceridemia, metabolic syndrome) than  $z$  scores for BMI, at least among North American children.<sup>25</sup>

### Limitations

Our findings are not without limitations. Because of the need to protect confidentiality and the smaller size of the annual CHMS surveys, not all data could be cross-tabulated by year, sex and age. Moreover, given the relatively small numbers, we could not examine regional or racial differences. Despite the use of survey weights, non-responder biases may have been present. In addition, the data are cross-sectional in nature and cannot be used to infer causality or predict future trends. Nonetheless, our study is important in providing a glimpse of trends since the last

**Table 5:** Prevalence of overweight or obesity, by survey period and sex

Measurement; survey period	Prevalence, % (95% CI)*		
	All	Males	Females
<b>Overweight or obesity</b>			
2004/05	30.7 (29.7 to 31.6)	32.8 (31.4 to 34.1)	28.4 (27.1 to 29.8)
2009–2011	28.2 (26.4 to 29.9)†	31.0 (28.5 to 33.5)	25.1 (22.7 to 27.5)‡
2012/13	27.0 (25.3 to 28.7)§	29.1 (26.7 to 31.6)†	24.8 (22.4 to 27.2)†
<b>Obesity</b>			
2004/05	13.5 (12.8 to 14.2)	15.3 (14.3 to 16.4)	11.6 (10.6 to 12.6)
2009–2011	12.7 (11.4 to 14.0)	15.1 (13.2 to 17.0)	10.1 (8.5 to 11.8)
2012/13	13.4 (12.1 to 14.8)	16.3 (14.3 to 18.3)	10.4 (8.7 to 12.1)

Note: CI = confidence interval.  
 \*Weighted proportions, calculated using inverse probability survey weights.  
 † $p < 0.01$ , for pairwise comparison with baseline survey (2004/05).  
 ‡ $p < 0.05$ , for pairwise comparison with baseline survey.  
 § $p < 0.001$ , for pairwise comparison with baseline survey.

**Table 6:** Results of multivariable logistic regression analysis of factors associated with increased risk of overweight and obesity

Factor	Overweight or obesity		Obesity	
	Unadjusted OR (95% CI)	Adjusted OR* (95% CI)	Unadjusted OR (95% CI)	Adjusted OR* (95% CI)
2009–2011 survey (v. 2004/05)	0.89 (0.81 to 0.97)	0.91 (0.80 to 1.02)	0.93 (0.83 to 1.05)	0.97 (0.83 to 1.13)
2012/13 survey (v. 2004/05)	0.84 (0.77 to 0.92)	0.83 (0.73 to 0.93)	0.99 (0.88 to 1.12)	1.06 (0.90 to 1.23)
Older children (v. toddlers)†	3.62 (3.10 to 4.26)	3.66 (3.14 to 4.31)	2.12 (1.75 to 2.58)	2.15 (1.78 to 2.62)
Female (v. male)	0.79 (0.73 to 0.85)	0.81 (0.72 to 0.92)	0.65 (0.59 to 0.72)	0.73 (0.62 to 0.86)
Nonwhite (v. white)	1.10 (1.01 to 1.19)	1.15 (1.06 to 1.25)	1.16 (1.04 to 1.29)	1.17 (1.05 to 1.31)
<b>Stratified by sex</b>				
2009–2011 survey				
Male	0.92 (0.82 to 1.04)	0.90 (0.80 to 1.02)	0.99 (0.84 to 1.15)	0.97 (0.83 to 1.13)
Female	0.85 (0.74 to 0.96)	0.83 (0.73 to 0.95)	0.86 (0.71 to 1.04)	0.84 (0.70 to 1.02)
2012/13 survey				
Male	0.84 (0.75 to 0.95)	0.82 (0.73 to 0.93)	1.08 (0.93 to 1.26)	1.06 (0.91 to 1.23)
Female	0.83 (0.73 to 0.95)	0.81 (0.71 to 0.93)	0.89 (0.74 to 1.06)	0.86 (0.71 to 1.04)

Note: CI = confidence interval, OR = odds ratio.  
 \*Adjusted for survey cycle, age, sex, race/ethnicity and sex:survey interaction. To clarify the interaction, the adjusted model was stratified by sex, with the survey effect shown in the lower portion of the table for comparison. Unadjusted results are from univariate analyses with covariates age, sex, race/ethnicity, survey cycle and sex:survey interaction.  
 †See Methods for definitions.

comprehensive report based on CCHS cycle 2.2 (2004/05)<sup>1</sup> or earlier iterations of the CHMS,<sup>2</sup> with robust numbers of representative Canadian children at multiple time points.

### Conclusion

Despite a welcome decline in the prevalence of overweight or obesity and a plateau in the prevalence of obesity among Canadian children, we must continue ongoing surveillance and control measures for all children. Using the latest definitions and tools to describe anthropometric measurements in Canadian children, this study should be considered a benchmark for future comparisons.

### References

- Shields M, Tremblay MS. Canadian childhood obesity estimates based on WHO, IOTF and CDC cut-points. *Int J Pediatr Obes* 2010;5:265-73.
- Roberts KC, Shields M, de Groh M, et al. Overweight and obesity in children and adolescents: results from the 2009 to 2011 Canadian Health Measures Survey. *Health Reports* 2012;23(3):3-7.
- Shields M, Connor-Gorber S, Tremblay MS. Methodological issues in anthropometry: self-reported versus measured height and weight. In: *Symposium 2008: data collection: challenges, achievements and new directions*. Ottawa: Statistics Canada; 2009. Cat no. 11-522-X.
- Corby L, Secker D. Growth monitoring of infants and children using the 2006 World Health Organization [WHO] child growth standards and 2007 WHO growth references. *Current Issues [PEN; Dietitians of Canada]* 2010 [updated March 2012 and Nov 2013]. Available: [https://www.dietitians.ca/Downloads/Public/Growth\\_Charts\\_background\\_eng.aspx](https://www.dietitians.ca/Downloads/Public/Growth_Charts_background_eng.aspx) (accessed 2016 Apr 19).
- Rolland-Cachera MF. Childhood obesity: current definitions and recommendations for their use. *Int J Pediatr Obes* 2011;6:325-31.
- Ogden CL, Kuczmarski RJ, Flegal KM, et al. Centers for Disease Control and Prevention 2000 growth charts for the United States: improvements to the 1977 National Center for Health Statistics version. *Pediatrics* 2002;109:45-60.
- Rodd C, Metzger DL, Sharma AK. Extending World Health Organization weight-for-age reference curves to older children. *BMC Pediatr* 2014;14:32.
- Sharma A, Chanoine JP, Cummings E, et al. A proposed extension to the WHO weight-for-age centile curves: statistical methods and models manual. Canadian Paediatric Endocrine Group; 2014. Available: [http://cpeg-gcep.net/sites/default/files/upload/bookfiles/CPEG\\_StatisticalMethods%26Models\\_Jan30.pdf](http://cpeg-gcep.net/sites/default/files/upload/bookfiles/CPEG_StatisticalMethods%26Models_Jan30.pdf) (accessed 2016 Apr. 26).
- Ogden CL, Carroll MD, Kit BK, et al. Prevalence of childhood and adult obesity in the United States, 2011–2012. *JAMA* 2014; 311:806-14.
- Broyles S, Katzmarzyk PT, Srinivasan SR, et al. The pediatric obesity epidemic continues unabated in Bogalusa, Louisiana. *Pediatrics* 2010;125:900-5.
- Mazur A, Klimek K, Telega G, et al. Ten-year secular trend of overweight and obesity in school children in south-eastern Poland. *Ann Agric Environ Med* 2014;21:634-8.
- Martin K, Rosenberg M, Pratt IS, et al. Prevalence of overweight, obesity and underweight in Western Australian school-aged children; 2008 compared with 2003. *Public Health Nutr* 2014;17:2687-91.
- Schmidt Morgen C, Rokholm B, Sjoberg Brixval C, et al. Trends in prevalence of overweight and obesity in Danish infants, children and adolescents — Are we still on a plateau? *PLoS One* 2013;8:e69860.
- Blüher S, Meigen C, Gausche R, et al. Age-specific stabilization in obesity prevalence in German children: a cross-sectional study from 1999 to 2008. *Int J Pediatr Obes* 2011;6(2-2):e199-206.
- de Wilde JA, van Dommelen P, Middelkoop BJ, et al. Trends in overweight and obesity prevalence in Dutch, Turkish, Moroccan and Surinamese South Asian children in the Netherlands. *Arch Dis Child* 2009;94:795-800.
- Ng M, Fleming T, Robinson M, et al. Global, regional, and national prevalence of overweight and obesity in children and adults during 1980-2013: a systematic analysis for the Global Burden of Disease Study 2013. *Lancet* 2014;384:766-81.
- Canadian Community Health Survey. Ottawa: Health Canada; 2012. Available: [www.hc-sc.gc.ca/fn-an/surveill/nutrition/commun/index-eng.php](http://www.hc-sc.gc.ca/fn-an/surveill/nutrition/commun/index-eng.php) (accessed 2015 July 17).
- Canadian Community Health Survey cycle 2.2, nutrition focus. Ottawa: Health Canada. Available: [www.hc-sc.gc.ca/fn-an/surveill/nutrition/commun/cchs\\_focus-volet\\_escce-eng.php](http://www.hc-sc.gc.ca/fn-an/surveill/nutrition/commun/cchs_focus-volet_escce-eng.php) (accessed 2015 Oct. 29).
- Canadian Health Measures Survey (CHMS) data user guide: cycle 2. Ottawa: Statistics Canada; 2012. Available: [www23.statcan.gc.ca/imdb-bmdi/document/5071\\_D2\\_T1\\_V2-eng.htm](http://www23.statcan.gc.ca/imdb-bmdi/document/5071_D2_T1_V2-eng.htm) (accessed 2016 Apr. 26).
- Canadian Health Measures Survey (CHMS): detailed information for January 2012 to December 2013 (cycle 3). Ottawa: Health Canada; 2014. Available: [www23.statcan.gc.ca/imdb/p2SV.pl?Function=getSurvey&SDDS=5071](http://www23.statcan.gc.ca/imdb/p2SV.pl?Function=getSurvey&SDDS=5071) (accessed 2015 July 17).
- Giroux S. Canadian Health Measures Survey: sampling strategy overview. *Health Rep* 2007;18(Suppl):31-6.
- Patry-Parisien J, Shields M, Bryan S. Comparison of waist circumference using the World Health Organization and National Institutes of Health protocols. *Health Rep* 2012;23:53-60.
- Cole TJ, Green PJ. Smoothing reference centile curves: the LMS method and penalized likelihood. *Stat Med* 1992;11:1305-19.
- WHO Multicentre Growth Reference Study Group. *WHO child growth standards: length/height-for-age, weight-for-age, weight-for-length, weight-for-height and body mass index-for-age: methods and development*. Geneva: World Health Organization; 2006.
- Sharma AK, Metzger DL, Daymont C, et al. LMS tables for waist-circumference and waist-height ratio Z-scores in children aged 5-19y in NHANES III: association with cardio-metabolic risks. *Pediatr Res* 2015;78:723-9.
- Ball GD, Ambler KA, Chanoine JP. Pediatric weight management programs in Canada: Where, what and how? *Int J Pediatr Obes* 2011;6:e58-61.
- Carroll MD, Navaneelan T, Bryan S, et al. *Prevalence of obesity among children and adolescents in the United States and Canada*. Hyattsville (MD): National Center for Health Statistics; 2015. NCHS data brief no. 211:1-8.
- Wahi G, Boyle M, Morrison K, et al. Body mass index among immigrant and non-immigrant youth: evidence from the Canadian Community Health Survey. *Can J Public Health* 2014;105: e239-44.
- Achat HM, Stubbs JM. Socio-economic and ethnic differences in the prevalence of overweight and obesity among school children. *J Paediatr Child Health* 2014;50:E77-84.
- Khanolkar AR, Sovio U, Bartlett JW, et al. Socioeconomic and early-life factors and risk of being overweight or obese in children of Swedish- and foreign-born parents. *Pediatr Res* 2013;74:356-63.
- May AL, Freedman DS, Sherry B, et al. Obesity — United States, 1999–2010. *MMWR Surveill Summ* 2013;62(Suppl 3):120-8.

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