Original Research Article

Gender Differences in Growth and Nutrition in a Sample of Rural Ontario Schoolchildren

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ABSTRACT This paper reports findings of a cross-sectional study of the growth and nutrition of children living in rural Ontario, Canada. The objectives of the research were threefold: (1) to obtain data on obesity prevalence and nutrient intake in a sample of rural Canadian schoolchildren, (2) to compare findings with rural and national-level data on obesity prevalence and nutrient intake, and (3) to provide data to school board and public health agencies planning and implementing nutrition policy and programs to this population. Measures of height and weight were obtained for 504 children ages 7–13 years. Height for age and body mass index scores were calculated and compared with 2000 data from the Centers for Disease Control (Kuczmarski et al. [2002]: Vital Health Stat 246:1–190). Weekday 24-h dietary recall was conducted on a subsample of 352 children and the results compared with Canada’s Food Guide (Health Canada, 1997) and dietary reference data from the US Institute of Medicine (2000).

Prevalence of overweight and obesity were high in this sample, with 17.7% of children classified as overweight and 10.9% of children classified as obese. Fifteen percent of boys were classified as obese, compared to 6.8% of girls. Boys consumed significantly more servings from the grain and meat food groups than girls. While mean daily intake of fiber and micronutrients was significantly low for both boys and girls, there were significant gender differences in nutrient intake, with boys consuming greater energy, protein, carbohydrate, calcium, iron, phosphorus, and sodium than girls. A number of limitations are discussed, in particular issues arising from the use of Dietary Reference Intakes. Am. J. Hum. Biol. 19:774–788, 2007.
Among these low socioeconomic status communities, rural areas are the focus of few studies of childhood obesity, perhaps due to the logistical challenges of conducting research in nonmetropolitan areas (Galloway, 2006). However there is a growing literature documenting obesity prevalence in rural Canadian and US children. Willms et al. (2003) report a west-to-east gradient in childhood obesity prevalence that may be attributable to the higher proportion of rural residents in Atlantic Canada. In a study of Canadian teens attending high schools in Alberta and Ontario, Plotnikoff et al. (2004) found that rural boys and girls had significantly higher prevalence of overweight (18% and 5% respectively) than urban boys and girls (12% and 2% respectively). Childhood obesity rates among rural Appalachian (Crooks, 1999; Demerath et al., 2003), Southern US (Davis et al., 2005), Mexican American (Lacar et al., 2000), and native North American (Gallo et al., 2005; Hanley et al., 2000; Young et al., 2000) populations are among the highest in North America, and point to a shared obesogenic environment that poses significant health risks to rural children and teens.

While there are few studies of obesity in rural North American adults, they consistently report a significant gender difference in obesity prevalence. Women have higher obesity prevalence than men in both Canadian and US studies (Borders et al., 2006; Liebman et al., 2003; MacLellan et al., 2004; Self et al., 2005). This gender difference is less consistently observed in studies of rural children. While some authors report gender differences in rural children’s obesity prevalence (Crooks, 1999) others do not (Demerath et al., 2003; Davis et al., 2005), indicating that gender-related differences in obesity risk may result from factors unique to the communities under study.

The research reported here is a cross-sectional study of child growth and nutrition in a rural Canadian population, undertaken from January to June 2004. In 2003, I contacted the Bluewater District School Board regarding a study of rural children’s nutrition and growth. The topic married well with the Board’s need for empirical data on local child nutrition in order to set new nutrition policy in its elementary schools. The collaboration proved timely, in that by 2004 Ontario school boards were required to respond to a number of provincial initiatives designed to promote healthy eating in schools (Ontario Ministry of Education, 2004a,b; Ontario Society of Nutrition Professionals in Public Health School Nutrition Workgroup, 2004). The resulting study was designed with the goal of evaluating child growth and nutrition at the local level while producing a data set large enough for statistical comparisons with a compatible reference sample. The objectives of the research were threefold: (1) to obtain data on growth and nutrition in a sample of rural Canadian schoolchildren, (2) to compare findings with rural and national-level data on obesity prevalence and nutrient intake, and (3) to provide data to school board and public health agencies planning and implementing nutrition policy and programs to this population. The data collection included anthropometry, dietary recall, observation of the school nutrition environment, interviews with parents and educators, and focus groups with children. Only the results of anthropometry and dietary recall are presented here.

METHODS

Population

The Bluewater Nutrition Project is a study of rural children’s growth and nutrition. The research was conducted in Grey and Bruce Counties, Ontario (Fig. 1). These counties lie east of Lake Huron and are located approximately 150 km northwest of Toronto, Canada. Socioeconomic descriptors of Grey and Bruce Counties paint a picture of a farming and resource-based seasonal economy, with lower income, greater reliance on government transfers, and lower postsecondary educational attainment than the provincial average (Statistics Canada 2001).

The study sample was drawn from the school populations of seven elementary schools located in Grey and Bruce Counties, Ontario. The participating schools were selected by the community partners in order to represent rural communities of varying size and socioeconomic status. The smallest two schools are entirely rural, with all students bused from large catchment areas in the surrounding townships. The three mid-size schools have catchment areas surrounding and including rural towns. The largest school is located in the small city of Owen Sound (population 30,000) and receives a portion of its students from a rural catchment to the west of the city.
Ethical approval for the study was obtained from the McMaster Research Ethics Board, McMaster University, as well as from two partner agencies: the local health unit, which provides public health and nutrition services to the schools, and the regional school board, which provides education services in Grey and Bruce Counties.

**Sample**

Letters of information were distributed to all 1042 students in grades 2–8 in participating schools. The guardians of 535 children returned written consent for their children’s participation in the study. The overall participation rate of 51% is comparable to that of other recent school studies in Canada (Moffat et al., 2005; Veugelers et al., 2005).

**Anthropometry protocol**

Between January and March, 2004, children with parental consent participated in anthropometric measures of height and weight. Children were measured by the researcher in a private room located on school premises. A research assistant was present to record data. Verbal assent was obtained from children prior to measurement. Twenty-nine children were absent from school or involved in school activities that prevented their participation. Two children declined to be measured and were excluded from the sample. Measurements were completed for 504 children (253 boys and 251 girls).

Children were asked to remove their shoes. Height was measured with a portable stadiometer (Perspective Enterprises PE-AIM-101). Weight was measured with a portable digital scale (Tanita TBF-551). Measurement procedures were consistent with standardized anthropometric procedures (Lohman et al., 1988).

A sub-sample of children were randomly selected to be measured a second time in order to test for intra-observer error. Fifty-seven children were measured at a minimum 1 h interval from their previous measure. Technical error of measurement (TEM) and coefficient of variation (CV) were within acceptable limits for both height (TEM = 0.263; CV = 0.183) (Ulijaszek and Lourie, 1994) and weight (TEM = 0.116; CV = 0.300) (Bouchard, 1985). Coefficient of reliability ($R$) for both variables was 0.999.
Dietary recall protocol

Between March and May, 2003, children with parental consent participated in dietary recalls. The number of participants was limited by school activities and the length of time required for each dietary recall interview (15–20 min). Because 24-hour recalls have been validated for children 8–9 years and older (Lytle et al., 1993; McPherson et al., 2000), efforts were focused on children in grades 4–8. This resulted in a dietary recall sample of 364 children.

Dietary recalls were conducted interview-style in a private room on school premises. All recalls were administered by the investigator with a research assistant present to record responses. Verbal assent was elicited prior to each interview.

The duration of each interview ranged from 15–30 min, depending on the child's ease of recall. Through a series of open-ended questions and neutral prompts (Domel et al., 1994; Domel, 1997; Domel Baxter et al., 2000), the investigator asked the child to trace the events and activities of the previous day, from the time the child awoke until the time the child went to sleep. Recalls were conducted Tuesday through Friday, thus yielding data on weekday food consumption. All reported foods and drinks were recorded, along with, where possible, detailed descriptions of ingredients, preparation, portions served, and portions consumed. Because of the large number of school lunches consumed, particular emphasis was placed on shared, traded, or discarded foods. Children were assisted in their recall by the presence of calibrated food models and a range of grocery items. Accurate portion size estimation was facilitated by sample cups, dishware, and graduated measuring containers. At the end of the interview children's reported intake was summarized for their verbal estimation.

The recall records of 8 children were excluded from the data set because (1) the children reported feeling ill during the previous 24 h or (2) they were uncertain about their ability to recall the previous day's dietary intake. The records of four children aged 8 years were removed to facilitate comparison with Dietary Reference Intakes (Institute of Medicine, 2000), which are provided for children in age groupings above and below 9 years. The recall records of the remaining children constitute the primary nutrient data set (n = 352; 169 boys and 182 girls). This data set is used in analyses of nutrient intake by age and gender groupings.

A secondary nutrient data set (n = 328; 159 boys and 169 girls) was constructed of recalls from children who participated in both dietary recall and anthropometry. This involved the removal of recall records for 24 children who had not participated in anthropometry. This data set is used in analyses of nutrient intake by anthropometric indices.

Data analysis

Anthropometric measures were converted to z-scores and percentiles using Epiinfo Version 3.3, and analyzed using SPSS Version 12.0 software. Student's t tests were conducted on mean z-scores to permit comparison with the 2000 CDC reference (Kuczmarski et al., 2002). Low height was defined as height for age centile (HAC) below the 15th percentile of the reference. BMI centiles were categorized as overweight (BMIC ≥ 85 and <95) or obese (BMIC ≥ 95). While there has been some discussion around the cutoffs developed by the International Obesity Task Force (Cole et al., 2006; Zimmerman et al., 2004), I have elected to use the cutoffs (Frisancho, 1990; Roberts and Dallal, 2001) and terminology that are most consistent with North American usage to facilitate comparison with other North American studies (see Crooks, 1999; Moffat et al., 2005; Plotnikoff et al., 2004 for examples). One-way analysis of variance (ANOVA) was used to compare mean height for age z-score (HAZ) and body mass index for age z-score (BMIZ) by age. Pearson r squares were used to compare frequencies of low height, overweight, and obesity with the 2000 CDC growth reference (Kuczmarski et al., 2002). Cross-tabulations were used to compare overweight and obesity prevalence by gender.

Using the primary nutrient data set (n = 352), dietary recall data were categorized by food group and serving and compared with Canada's Food Guide to Healthy Eating (Health Canada, 1997) to assess the mean number of daily servings and the proportion of children with inadequate intake in each of the four food groups. The guidelines consist of a recommended range of servings for each food group. The lowest value in the range was used as the minimum number of daily servings recommended.
Student’s t tests (two-tailed) were used to compare mean nutrient intake by gender. Cross tabulations were conducted to compare the prevalence of nutrient inadequacy by age and gender groupings. Using the secondary data set (n = 328), which includes both anthropometric and nutrient data, linear regression was performed to examine the effects of age, gender, and dietary intake on various anthropometric indices.

RESULTS

Anthropometry

In the total anthropometry sample (N = 504), the mean HAZ of 0.229 (sd = 0.93) was significantly higher than that of the 2000 CDC growth reference (Kuczmarski et al., 2002) (t = 5.51, P = 0.000), as were mean HAZ for both boys (t = 4.22, df = 252, P = 0.000) and girls (t = 3.55, df = 250, P = 0.000) (Table 1). One-way ANOVA yielded no significant relationship between HAZ and age. While there was no difference in HAZ by gender in the total sample, boys had significantly greater HAZ than girls in the 7-year age category (t = 2.270, df = 39, P = 0.029).

The prevalence of low height (HAC < 15) was not significantly different than that of the 15% expected, except in the 10-year age group where the prevalence (4.96%) was significantly lower (χ² = 11.94, df = 1, P = 0.001) (Table 2). There was no significant difference in prevalence of low height by gender.

The overall mean BMIZ of 0.47 (sd = 0.94) was significantly greater than that of the reference population (t = 11.17, P = 0.000), as were mean BMIZ for both boys (t = 8.55, df = 252, P = 0.000) and girls (t = 7.23, df = 250, P = 0.000) (Table 1). One-way ANOVA yielded no
significant relationship between BMIz and age. Boys’ overall mean BMIz was higher than girls, with a difference approaching statistical significance (t = 1.768, df = 502, P = 0.078).

In the overall sample, the prevalence of overweight (17.66%; χ² = 32.85, df = 1, P = 0.000) and obesity (10.91%; χ² = 37.09, df = 1, P = 0.000) were significantly greater than the expected frequencies of 10% and 5% respectively (Table 3). Overweight and obesity prevalence were greatest in the 7–10 year age category (Table 3). Overweight and obesity prevalence were greatest in the 7–10 year age category, with the majority of those groups significantly exceeding expected frequencies.

The prevalence of overweight was significantly greater than expected for both boys (χ² = 17.04, df = 1, P = 0.000) and girls (χ² = 15.81, df = 1, P = 0.000), as was the prevalence of obesity for boys (χ² = 53.47, df = 1, P = 0.000) (Table 3). While the prevalence of overweight was comparable for boys and girls (17.79% and 17.53% respectively), there was a significant difference in obesity prevalence between boys (15.02%) and girls (6.77%) (χ² = 8.81, df = 1, P = 0.000).

**Dietary recall**

The results of food group analysis for the total dietary recall sample (n = 352) indicate that mean daily servings were below the recommended level for all four food groups: grain products, milk products (In Canada’s Food Guide to Healthy Eating, recommended servings for milk products are provided for 4–9 and 10–16 year age categories (Health Canada, 1997). It is recommended that children ages 4–9 years consume 2–3 servings of milk products per day. It is recommended that youth ages 10–16 years increase their consumption of milk products to 3–4 servings per day during this period of rapid linear growth.), vegetables and fruit, and meat and alternatives. Proportions of children with inadequate servings were high. For example, 79.31% of 7- to 9-year-old children failed to meet the minimum 2 daily servings of milk products.

One-way ANOVA yielded no association between age and mean daily servings for any of the food groups. There was a trend toward decreasing prevalence of inadequate milk product servings with age. However, there were no other observed relationships between food group consumption and age.

The results of food group analysis by gender (Table 4) indicate that boys consumed significantly more servings of grain products (t = 3.04, P = 0.003) and meat and alternatives (t = 4.13, P = 0.000) than girls. Compared to girls, boys’ prevalence of inadequate intake was significantly lower for grain products (χ² = 9.189, P = 0.002) and meat and alternatives (χ² = 8.941, P = 0.003). Boys’ overall prevalence of inadequate milk product consumption did not differ from girls’. However, in the 7- to 9-year age category, where girls’ prevalence of inadequate intake was 90.32%, boys’ prevalence of inadequate milk intake was significantly lower at 65.22% (χ² = 5.130, P = 0.024).

Nutrient intake analysis was performed on the primary dietary recall data set (n = 352). As a percentage of daily caloric intake, mean protein, carbohydrate and fat consumption fell within acceptable ranges. Mean g/day fiber consumption was less than half the recommended level. Mean consumption of calcium, magnesium, phosphorus, potassium, zinc, and total folate were low, resulting in prevalence of inadequacy for these nutrients as high as 84.66% for magnesium and 97.16% for total folate. In contrast, mean sodium intake, at 3.41 g/day, exceeded the recommended Upper Limit (UL) of 2.2 g/day (Institute of Medicine, 2000).

One-way ANOVA showed a significant increase in mean daily fiber (F = 3.26, P = 0.000) and total folate (F = 1.70, P = 0.018) consumption with age. There was no relationship between prevalence of inadequacy and age for any of the reported nutrients.

There were a number of significant differences in nutrient intake by gender (Table 5).

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**TABLE 3. Proportion of children (%) in categories of overweight (BMIz > 85th and <95th percentiles) and obese (BMIz ≥ 95th percentile) relative to the 2000 CDC growth reference for total sample (N = 504) by age and gender**

<table>
<thead>
<tr>
<th>Age</th>
<th>Overweight (%)</th>
<th>Obese (%)</th>
<th>Total overweight (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>14.63**</td>
<td>0.00</td>
<td>14.63**</td>
</tr>
<tr>
<td>8</td>
<td>13.04</td>
<td>9.05</td>
<td>22.09**</td>
</tr>
<tr>
<td>9</td>
<td>10.00</td>
<td>7.66</td>
<td>17.66**</td>
</tr>
<tr>
<td>10</td>
<td>14.05**</td>
<td>14.55**</td>
<td>28.60**</td>
</tr>
<tr>
<td>11</td>
<td>11.00</td>
<td>18.27**</td>
<td>29.27**</td>
</tr>
<tr>
<td>12</td>
<td>11.00</td>
<td>20.66**</td>
<td>31.72**</td>
</tr>
<tr>
<td>13</td>
<td>13.03</td>
<td>17.66**</td>
<td>30.69**</td>
</tr>
<tr>
<td>Total</td>
<td>17.53**</td>
<td>19.51*</td>
<td>37.04**</td>
</tr>
</tbody>
</table>

**Notes:**
- *Significantly different from 2000 CDC reference (Kuczmarski et al. 2002), P < 0.05.
- **Significantly different from 2000 CDC reference (Kuczmarski et al. 2002), P < 0.001.
Boys had significantly greater mean daily intake of energy (t = 3.83, P = 0.000), protein (t = 4.47, P = 0.000), carbohydrate (t = 3.13, P = 0.002), fat (t = 2.87, P = 0.004), calcium (t = 2.39, P = 0.020), iron (t = 2.25, P = 0.025), phosphorus (t = 2.75, P = 0.006), and sodium (t = 2.96, P = 0.003) than girls. Boys were less likely to consume inadequate iron ($\chi^2 = 1806.81$, df = 1, P = 0.000) than girls. Boys had lower prevalence of inadequacy for g/day protein ($\chi^2 = 3.267$, P = 0.071), percent carbohydrate ($\chi^2 = 2.709$, P = 0.100), and phosphorus ($\chi^2 = 3.60$, P = 0.058) with differences approaching statistical significance.

Linear regression was performed on the secondary data set (n = 328). There was a significant correlation between calcium intake and HAZ ($F = 2.641$, P = 0.009) but the r value

### TABLE 4. Mean daily servings (mean (SD)) and prevalence of inadequate daily intake (%) of food groups listed in Canada’s Food Guide to Healthy Eating for children 9 years and over who participated in dietary recall (n = 352) by gender

<table>
<thead>
<tr>
<th>Food group</th>
<th>Boys</th>
<th>Girls</th>
<th>Boys</th>
<th>Girls</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean n of servings per day (sd)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grain products</td>
<td>5.21* (2.30)</td>
<td>4.47* (2.08)</td>
<td>42.60*</td>
<td>59.14*</td>
</tr>
<tr>
<td>Milk products Ages 7–9 years</td>
<td>2.26 (1.88)</td>
<td>1.72 (1.03)</td>
<td>65.22*</td>
<td>90.32*</td>
</tr>
<tr>
<td></td>
<td>2.31 (1.52)</td>
<td>2.06 (1.58)</td>
<td>65.75</td>
<td>66.23</td>
</tr>
<tr>
<td>Vegetables and fruit</td>
<td>4.31 (3.18)</td>
<td>4.83 (2.96)</td>
<td>61.54</td>
<td>53.23</td>
</tr>
<tr>
<td>Meat and alternatives</td>
<td>1.83** (1.03)</td>
<td>1.43** (0.82)</td>
<td>46.75*</td>
<td>61.29*</td>
</tr>
</tbody>
</table>

*Significantly different between boys and girls, P < 0.05.  
**Significantly different between boys and girls, P < 0.001.

### TABLE 5. Observed mean daily intake (mean (SD)) and prevalence of inadequate daily intake (%) of selected nutrients for children 9 years and over who participated in dietary recall (n = 352) by gender

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Boys</th>
<th>Girls</th>
<th>Boys</th>
<th>Girls</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean (SD)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Energy (kcal)</td>
<td>2350.32** (927.58)</td>
<td>2017.83** (690.06)</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Carbohydrate (%)</td>
<td>55.97 (8.81)</td>
<td>56.61 (7.44)</td>
<td>9.47</td>
<td>4.95</td>
</tr>
<tr>
<td>Fat (%)</td>
<td>31.24 (7.05)</td>
<td>31.20 (6.49)</td>
<td>17.16</td>
<td>14.84</td>
</tr>
<tr>
<td>Protein (%)</td>
<td>12.79 (3.39)</td>
<td>12.19 (2.92)</td>
<td>18.93</td>
<td>25.27</td>
</tr>
<tr>
<td>Carbohydrate (%)</td>
<td>73.31** (27.41)</td>
<td>61.48** (22.14)</td>
<td>1.18</td>
<td>4.40</td>
</tr>
<tr>
<td>Fat (%)</td>
<td>335.64* (177.20)</td>
<td>287.51* (104.38)</td>
<td>0</td>
<td>0.55</td>
</tr>
<tr>
<td>Calcium (mg)</td>
<td>836.11* (448.33)</td>
<td>712.07* (398.18)</td>
<td>72.19</td>
<td>80.77</td>
</tr>
<tr>
<td>Iron (mg)</td>
<td>1.83 (1.03)</td>
<td>1.66 (0.78)</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Magnesium (mg)</td>
<td>3.63* (1.37)</td>
<td>3.21* (1.27)</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Zinc (mg)</td>
<td>2.59 (3.57)</td>
<td>4.79 (3.17)</td>
<td>79.29</td>
<td>81.87</td>
</tr>
<tr>
<td>Vitamin A RE (mg)</td>
<td>141.54 (76.14)</td>
<td>126.41 (68.44)</td>
<td>82.84</td>
<td>86.26</td>
</tr>
<tr>
<td>Thiamin (mg)</td>
<td>856.11* (448.33)</td>
<td>712.07* (398.18)</td>
<td>72.19</td>
<td>80.77</td>
</tr>
<tr>
<td>Riboflavin (mg)</td>
<td>1.83 (1.03)</td>
<td>1.66 (0.78)</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Sodium (mg)</td>
<td>3.63* (1.37)</td>
<td>3.21* (1.27)</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Potassium (mg)</td>
<td>2.59 (3.57)</td>
<td>4.79 (3.17)</td>
<td>79.29</td>
<td>81.87</td>
</tr>
<tr>
<td>Thiamin (mg)</td>
<td>1.29 (0.76)</td>
<td>1.14 (0.69)</td>
<td>23.67</td>
<td>28.57</td>
</tr>
<tr>
<td>Riboflavin (mg)</td>
<td>1.43 (0.78)</td>
<td>1.28 (0.67)</td>
<td>23.67</td>
<td>23.08</td>
</tr>
<tr>
<td>Nicacin (mg)</td>
<td>4.94 (5.08)</td>
<td>4.96 (5.19)</td>
<td>50.89</td>
<td>50.00</td>
</tr>
<tr>
<td>Vitamin B6 (mg)</td>
<td>0.79 (0.54)</td>
<td>0.74 (0.53)</td>
<td>59.76</td>
<td>63.19</td>
</tr>
<tr>
<td>Total Folate (ug)</td>
<td>65.37 (70.94)</td>
<td>55.90 (71.52)</td>
<td>96.45</td>
<td>97.80</td>
</tr>
<tr>
<td>Vitamin C (mg)</td>
<td>154.54 (362.83)</td>
<td>116.91 (86.58)</td>
<td>21.89</td>
<td>19.23</td>
</tr>
</tbody>
</table>

*Nutrients without prevalence data have no reference value for calculation of inadequacy.  
**Prevalence data for iron calculated from weighted probabilities based on published data in Tables I-5 to I-6, Appendix I, Institute of Medicine (2000).  
*Significantly different between boys and girls, P < 0.05.  
**Significantly different between boys and girls, P < 0.001.

American Journal of Human Biology DOI 10.1002/ajhb
was low (0.158), indicating that calcium intake accounts for little of the variability in height for age in this sample. Similarly, a weak correlation ($r = 0.152$) between % calories from protein and BMIZ ($F = 2.577$, $P = 0.010$) accounted for little of the variability of BMIZ in this sample. In the overall regression model, only male gender was positively associated with obesity ($r = 0.162$, $P = 0.005$).

DISCUSSION

Anthropometry

In the total sample ($N = 504$), the combined prevalence of total overweight and obesity (24%) is lower than US figures from the National Health and Nutrition Examination Survey (NHANES), which reports combined prevalence of overweight and obesity of 35% in boys and 30% in girls aged 6–11 years (Hedley et al., 2004). However the results of the present study are comparable with existing Canadian data from the 1996 National Longitudinal Surveys of Children and Youth (NLSCY) in which 29% of boys and 24% of girls ages 7–13 years are either overweight or obese (Tremblay and Willms, 2000). The more recent 2004 Canadian Community Health Survey (Shields, 2005) finds overweight prevalence of 17.0% in boys and 18.8% in girls, compared to 17.8% and 17.5% respectively in the present sample.

The significantly high BMIZ, and the high overweight prevalence in boys and girls and obesity prevalence in boys in the present study, are consistent with studies that document increased childhood adiposity in economically disadvantaged neighborhoods. In comparative studies, Alaimo et al. (2001) document greater prevalence of obesity among white non-Hispanic boys and girls from low- and middle-income families versus those from families with high income; and Moffat et al. (2005) report higher mean BMIZ and combined prevalence of overweight and obesity in 6- to 10-year-old children living in high-poverty neighborhoods in Hamilton, Canada, compared with children living in an affluent neighborhood. Johnson-Down et al. (1997) report combined prevalence of overweight and obesity of 42% for boys and 37% for girls living in a low income inner city neighborhood in Montreal, Canada.

In the present study, the overall obesity prevalence of 11% is slightly lower than published US data, in which 16% of children are obese (Baskin et al., 2005; Hedley et al., 2004). This is likely due to the significantly lower obesity prevalence in girls (7%) in the present study. Both Canadian and US surveys report slightly lower prevalence of obesity in girls, though the differences are not statistically significant. The NLSCY reports obesity prevalence of 12% in girls, compared with 14% in boys (Tremblay and Willms, 2000). Results from the 1999–2002 NHANES report obesity prevalence of 15% in girls, compared with 17% in boys (Baskin et al., 2005; Hedley et al., 2004). More localized studies in US and Canadian urban communities also fail to document a gender difference in obesity prevalence (Alaimo et al., 2001; Evers and Hooper, 1995; Johnson-Down et al., 1997; Moffat et al., 2005).

However, Crooks (1999) documents significant gender differences in obesity prevalence among children living in a rural Appalachian community. Twenty-one percent of boys aged 7–11 years were obese, compared with only 9% of girls. The combined prevalence of overweight and obesity was 43% for boys, compared with 24% for girls.

The results of other rural studies of childhood obesity prevalence lend little support to the hypothesis of gendered growth outcomes in rural North American children. Demerath et al. (2003) found no significant gender difference in obesity prevalence among children living in rural West Virginia. Similarly, Davis et al. (2005) observed no gender differences in obesity and its metabolic correlates in a study of children living in rural Georgia.

The literature on adult rural populations does report a gender difference in obesity prevalence, but in the opposite direction. MacLellan et al. (2004) report obesity prevalence of 29% in women, compared with 20% in men living in Prince Edward Island, a largely rural province in Eastern Canada. Similarly, Liebman et al. (2003) report that 30% of rural US women under 50 are obese compared with 25% of rural US men. Borders et al. (2006) report higher obesity prevalence in low income females living in rural Texas than in their male counterparts.

Dietary recall

The results of food group analysis in the present study describe a pattern of undernutrition, which is typical of North American studies. Fewer than half of children consume the recommended servings of grain products, vegetables and fruit, and meat and alterna-
tives. An alarming four-fifths of 7- to 9-year-olds consume too few milk products, resulting in a mean calcium intake significantly below the recommended level. Low milk and calcium intakes have been reported in other North American populations: Veugeler et al. (2005) document low milk product consumption in 42% of 10- to 11-year-old children, and mean calcium intake 11% below recommended. Moffat et al. (unpublished data) report that 68% of 8- to 10-year-old children consume too few servings of milk, resulting in mean calcium intake 20% below recommended levels. In a study of 10- to 16-year-old children, Salamoun et al. (2005) observe that 88% had calcium intake below the AI of 1,300 mg/day. And Cavadini et al. (2000) report a steady decline in milk consumption for adolescent boys and girls between 1965 and 1996.

There is evidence that adequate milk consumption in childhood confers a number of health benefits throughout the lifespan, including lower risk of dental caries (Marshall et al., 2005; Petti et al., 1997), higher bone mineral density, and lower risk of osteoporotic fracture (Kalkwarf et al., 2003). On its own, the low milk intake observed in the present study may have a significant negative impact on population health.

However, low milk intake is rarely an isolated phenomenon. In school-age children, it is commonly associated with high consumption of fruit juice and sugar-sweetened soft drinks. Harnack et al. (1999) report a consistent negative relationship between soft drink consumption and milk consumption. Among 6- to 12-year-olds, those who drank more than 9 oz of soft drinks per day were three times more likely to report inadequate milk consumption than those who did not consume soft drinks. At the US national level, Nielsen and Popkin (2004) report that as a proportion of daily caloric intake milk consumption declined by 4.9% among 2- to 18-year-olds between 1977 and 2001. During the same period, fruit juice consumption rose by 1.8% and soft drink consumption rose by 3.9%.

Much of the literature on milk consumption focuses on low intake in girls. In a study of adolescent girls’ beverage intake, Bowman (2002) reported decreased milk and increased soft drink consumption with age. Girls’ mean soft drink intake of 276 g/day at age 12 was much lower than the 423 g/day observed at age 19. In contrast, 78% of 12-year-old girls consumed milk daily, a proportion that fell to only 36% by age 19. In the present study, which examined the diets of 9- to 13-year-olds, the proportion of children with inadequate milk intake declined only slightly with age, while mean calcium intake rose slightly with age. However the high prevalence of inadequate intake of milk products in children, and particularly young girls, raises concern over the future osteologic and dental health of girls in this population. Future analysis of this data set will examine the volume and frequency of sweetened juice and soft drink intake and its relationship to milk consumption in this sample.

Mean fiber intake in the present study was considerably lower than recommended, a finding that parallels a number of recent studies of child nutrition (Champagne et al., 2004; Moffat et al., unpublished data; Veugeler et al., 2005). Though mean fiber intake increased significantly with age, levels remained about half the reference value. US Department of Agriculture survey data indicate that 55–90% of children consume too little fiber (Saldanha, 1995). Kimm (1995) observes that an inverse relationship between fiber intake and obesity prevalence could be explained through a number of mechanisms: diets rich in fiber may be low in caloric density; high dietary fiber content may speed gastrointestinal transit, allowing less time for protein and carbohydrate absorption; and fiber may play a role in mediating insulin release in response to carbohydrate ingestion. Interventions aimed at increasing children’s fiber intake may be effective in decreasing their risk of obesity.

In the present study, children’s average meat consumption was consistently lower than the recommended 2 servings. Iron levels, supplied by meat, some vegetables, and fortified breads and cereals, were on average adequate. In contrast, the prevalence of inadequacy for magnesium, phosphorus, zinc, and total folate was extremely high. The prevalence of inadequacy for the B vitamins Thiamin, Riboflavin, Niacin, and B6 ranged from 23–61%. This pattern is consistent with low intake of fresh fruit and vegetables and fortified breads and cereals (Champagne et al., 2004), and is supported by food group data in which 57% of children consumed too few fruits and vegetables and 51% of children consumed inadequate servings of grain products. The pattern is also supported by the large proportion of children (60%) with inadequate Vitamin A consumption, despite mean intake above the reference value. Large standard
deviations in Vitamin A intake suggest that consumption of this nutrient is highly variable among children in the sample. In the present study, overall mean energy intake was comparable with findings from other studies of child nutrition (Bell et al., 2005; Moffat et al., unpublished data; Veugelers et al., 2005). The lack of physical activity data in this study precludes the calculation of average energy requirements for individual children and thus the assessment of the adequacy of energy intake in this sample.

Although there was a significant difference in energy intake between genders, this difference is difficult to interpret. Boys’ mean daily energy intake (2,350 kcal) was significantly higher than girls’ (2,018 kcal). While boys’ greater energy intake would appear consistent with their higher BMIZ and prevalence of obesity in this sample, logistic regression reveals no relationship between energy intake and BMIZ. A lack of relationship between energy intake and body size in children has been observed elsewhere. In a study of overweight and nonoverweight schoolchildren, both energy and carbohydrate intake were significantly lower in the overweight children than in the nonoverweight children (Rocandio et al., 2001). Crooks (2000) observed no significant relationship between overweight status and food consumption.

Veugelers et al. (2005) report mean daily energy intakes of 2,256 kcal for boys and 2,077 kcal for girls, but do not comment on the significance of the difference. Other authors report no gender difference in children’s mean daily energy intake (Champagne et al., 2004; Crooks, 2000). The lack of gender comparisons in the literature likely reflects the challenge of collecting both diet and activity data in order to accurately estimate energy requirements. In addition, across all age ranges boys’ energy requirements are slightly higher than girls, obscuring gender comparisons (Institute of Medicine, 2001).

However, the gender differences in the present sample are not confined to greater energy intake in boys. Boys have higher mean daily intakes of all nutrients excepting Vitamin A and carbohydrate as a proportion of dietary energy. Boys have significantly higher mean daily intakes of protein, carbohydrate, fat, calcium, iron, phosphorus, and sodium than girls. Boys have lower prevalence of inadequacy for the majority of nutrients excepting fat, riboflavin, niacin, Vitamins A and C, and carbohydrate as a proportion of dietary energy. Boys’ prevalence of iron deficiency is 10%, compared with the 16% of iron-deficient girls in the sample.

While linear regression produced only a weak association between gender and growth outcomes, it is difficult to ignore the gendered results of both anthropometric and nutrient analyses. It is clear that there is a pattern of dietary intake in this sample that produces greater energy and micronutrient intake in boys. It is possible that this gendered pattern of intake supplies excess dietary energy to boys, placing them at greater risk of obesity. Girls’ lower energy intake may protect them from extreme obesity, but like the boys in the sample they suffer significant risk of being overweight. And the overall pattern of micronutrient deficiency could be costly to children’s health and development, especially in girls.

Crooks (1999, 2000) observed similar outcomes in rural Appalachian boys and girls. Differential feeding practices have been observed in cross-cultural settings (Ross, 1987). A review of this literature reveals that almost all research on differential feeding centers around the distribution of nutritionally important protein resources. While few North American studies have looked for gendered patterns of child nutrition that derive from cultural beliefs, Crooks (1999) suggests that rural children’s dietary patterns may be influenced by a variety of cultural factors.

Cultural assumptions about greater energy requirements for boys may come into play; boys may be more readily taken to the doctor when they are ill, reducing the intensity and/or duration of illness; or boys may be fed higher quality food than girls, all of which can produce differential outcomes in growth. (Crooks, 1999:139)

In a study of Mexican schoolchildren aged 6–12 years, Brewis (2003) describes a strong relationship between male gender and obesity that appears to be mediated through cultural values around the role of boys in middle-class families: “while Mexican parents treasure and desire both daughters and sons, there is a special primacy given to male children” (Brewis, 2003:457). It is conceivable that similar cultural processes are at work in the present study population, leading to increased risk of obesity in rural boys. Future directions for research will explore these cultural dimensions affecting children’s growth and nutrition, which may have particular historical and social contexts in different rural communities.
Limitations

There are a number of methodological considerations that may hinder the applicability of the results of the present study. The low overall participation rate (51%) reflects difficulties with sampling a school population. On the advice of teachers, forms were circulated in December, in order to avoid the concentration of forms sent to parents during other months. Only 61% of consent forms were returned: of those returned, 84% provided consent. Variability in the proportion of forms returned by classroom (from 20% to 100%) reflects varying degrees of teacher involvement, and might have been improved by directly rewarding teachers for this task.

BMI has been cross validated in numerous studies (Field et al., 2003; Marshall et al., 1991; Mei et al., 2002; Pietrobelli et al., 1998; Zimmerman et al., 2004) and is currently the accepted screening tool for population-level studies of obesity prevalence (Power et al., 1997). However, its use as a measure of childhood adiposity has been challenged on a number of levels. Prevailing wisdom asserts that rapid fluctuations in linear growth complicate the interpretation of BMI in children (Horlick, 2001) and that the validity of BMI may be compromised in cross-population comparisons and by environmental circumstances such as prior under-nutrition (Dietz and Bellizi, 1999). The cross-sectional design of the present study precludes consideration of longitudinal growth patterns in this population. Data on population origin were not collected in this or most other studies of childhood obesity, limiting cross-population comparisons. However the lack of low height for age in the present sample suggests that prior under-nutrition is not a complicating factor.

The accuracy of 24-h recall with children has been validated using doubly-labeled water (Johnson et al., 1996; Fisher et al., 2000) and this method is used to assess both macro- and micronutrient intake in adults and children (Gibson, 1990). As young as 8–9 years, children demonstrate reliability as self-reporters (Lytle et al., 1993; McPherson et al., 2000). However authors suggest the accuracy of children's self-reports can be improved by using the previous meal (Domel Baxter et al., 2002) or the previous 24 h (Domel Baxter et al., 2004), rather than the previous day, as the time frame for recall. Use of previous day recall in the present study may have compromised accuracy to some degree.

The large number of recalls (n = 352) in the present data set supports the validity of mean intakes calculated for this sample. While there is no way of estimating whether the sample is representative of the population as a whole, it is hoped that sources of selection bias are limited. For dietary recall in particular it is likely that there was participation bias operating in favor of children whose school performance would not suffer from their absence from class to participate in lengthy dietary recalls. That said, I observed a tendency in teachers to encourage the participation of children who they deemed “at risk” of poor nutrition.

In the school setting, each dietary recall represents a lengthy disruption in both the child's and his or her classmates' education. It was necessary in this case to limit recalls to one per child. While the literature supports the use of a single 24-h dietary recall for estimating average group intake in a random sample of the population (McPherson et al., 2000), there is evidence that children's dietary intake varies substantially by meal, day, and season (Cullen et al., 2002; Gagne et al., 2004; Roth et al., 2005). The use of a single recall in the present study may have obscured some of this variability in food consumption. For example, in the present study, recalls were completed between April and June of a single year. It is possible that this limited time frame may have obscured seasonal variability in diet, though there is evidence that seasonality of diet may be minimal in industrialized contexts (Ma et al., 2006).

Because of the school context of this study, and the applicability of the results to questions surrounding school food sales and fundraising, I opted to conduct all of the recalls on Tuesday through Friday. The data reflect weekday intake only, and do not reflect variations in food intake that may occur in weekend diet. While this practice is not uncommon in school-based studies of children's nutrition (Frank, 1991), the results of the present study may actually underestimate mean daily energy and fat intake, as numerous authors find fast food intake (O'Dwyer et al., 2005) and energy and fat consumption (Haines et al., 1992, 2003; Matheson et al., 2004) are greater in the weekend diets of both adults and children.

Of final concern is the limited number of existing publications that employ the new DRIs as reference standards. While DRIs represent a harmonization of Canadian and US approaches to dietary evaluation that is extremely valuable to researchers, their use presents a number of challenges to the inter-
The present study represents a cautious approach to determining dietary quality based on the newest reference information available. Interpreting dietary recall results. For group intake analysis, the new guidelines recommend comparisons to the EAR, which represents the "average daily nutrient intake level estimated to meet the requirement of half the healthy individuals in a particular life stage and gender group" (Murphy et al., 2002:268). The EAR value is calculated as one standard deviation above the median of a normal distribution of nutrient requirements. The recommended daily allowance (RDA), which was the old unit of comparison, now represents "the average daily nutrient intake level sufficient to meet the nutrient requirement of nearly all (97%) healthy individuals in a particular life stage and gender group" (Murphy et al., 2002:268). The RDA can be calculated as the EAR plus two standard deviations of nutrient requirement. In theory, the use of EAR represents a more nuanced approach to determining dietary adequacy, as the distribution of intake values below the RDA includes some values near the RDA that are probably adequate to individual needs. Authors caution that the EAR should never be used as a definitive cutpoint for evaluation of intake, as individuals with intake above the EAR have probabilities of inadequacy as high as 50% (Murphy et al., 2002). In addition, where requirement distributions cannot be described, reference values are given as adequate intakes (AIs). Like RDAs, AIs describe target intakes for individuals and are not recommended for group intake analysis.

These recommendations present a number of obstacles to group intake analysis: the lack of EARs for many nutrients, the significant gap between the EAR and the RDA, and the large probability of nutrient insufficiency above the EAR cutpoint. These obstacles have been addressed in the present study by the use of EARs wherever possible, by the use of AIs where no EAR is provided, by calculating the prevalence intake below the EAR, by avoiding calculation of prevalence of inadequacy based on AI, and by the use of caution in determining the significance of mean intake below the EAR. These methods are consistent with other early publications using the new system of DRIs (Champagne et al., 2004; Moffat et al., unpublished data; Veugelers et al., 2005). That said, the use of EAR cutoffs for determining adequate intake and prevalence of inadequacy ensures that estimates of mean intake and inadequacy are conservative in the extreme. The present study represents a cautious approach to determining dietary quality based on the newest reference information available.

CONCLUSION

The results of the present study describe high prevalence of overweight in both boys and girls. This finding is consistent with data on childhood obesity in other rural North American settings, where socioeconomic factors such as income, employment, and education contribute to elevated obesity risk in both adults and children. In addition, children in this sample are generally consuming inadequate servings from the four food groups, resulting in widespread nutritional inadequacies. Interventions for this population of rural children need to target overall dietary inadequacies and replace existing caloric intake with nutrient-rich foods from across all four food groups.

Analysis of anthropometry and dietary recall indicates that, compared with girls in this rural Ontario sample, boys have higher obesity prevalence and receive significantly greater levels of dietary energy and nutrients than girls. This finding is less common in the literature on child nutrition and may be evidence of gendered dietary patterns in this population that are significantly impacting children's growth. Whether the growth and nutrition outcomes observed in the present study are the result of local or larger-scale forces remains to be discovered. However, the fact that they are not universally observed, and run counter to the general pattern of obesity risk in rural North American adults, suggests that there are local values, attitudes, and practices that are influencing children's diet, growth, and likely physical activity in this population. These arise from the particular historical and social environments in which children live. Interventions directed at improving health outcomes in this population will require sensitivity to the factors influencing growth and nutrition differently in boys and girls. Future research will examine environments, attitudes, beliefs, and practices in order to better understand the processes that engender rural children's growth and nutrition in this and other rural North American communities.

LITERATURE CITED

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