Gender Differences in Physiologic Markers and Health Behaviors Associated With Childhood Obesity

abstract

BACKGROUND: Previous studies have demonstrated gender-related differences in body composition, physical activity, and diet. This observational study assesses gender variance in independent predictors for obesity to determine targeted areas for intervention.

METHODS: Data from 1714 sixth-grade students enrolled in Project Healthy Schools were compared by using health behaviors and physiologic markers (lipids, random glucose, blood pressure, and resting and recovery heart rates). Students were stratified by gender and obesity (BMI ≥95th percentile by age and gender). Physiologic markers and behaviors were compared by using $\chi^2$ analysis. Univariate associations with $P < .10$ were included in a stepwise logistic regression model to determine independent predictors for obesity by gender.

RESULTS: Nonobese students (both boys and girls) showed significantly healthier physiologic parameters compared with their obese counterparts. Two behaviors independently correlated with obesity in both boys and girls: regularly eating school lunches (odds ratio [OR] 1.29, 95% confidence interval [CI] 1.01–1.64; OR 1.27, 95% CI 1.00–1.62, respectively) and watching ≥2 hours of television per day (OR 1.19, 95% CI 1.07–1.32; OR 1.19, 95% CI 1.06–1.34, respectively). Vigorous physical activity and involvement in school sports teams appeared to be protective against obesity in boys (OR 0.90, 95% CI 0.82–0.98, OR 0.77, 95% CI 0.64–0.94, respectively), whereas milk consumption appeared protective in girls (OR 0.81, 95% CI 0.67–0.98).

CONCLUSIONS: Among middle-school children, we observed gender-related differences in factors associated with obesity. Additional research is warranted to determine the beneficial impact of improving school lunches and decreasing screen time, while improving our understanding of gender-related differences in milk consumption and physical activities in relation to BMI. Pediatrics 2013;132:468–474

Authors: Morgen Govindan, BA,a Roopa Gurm, MS,a Sathish Mohan,a Eva Kline-Rogers, RN,a Nicole Corriveau, BS,a Caren Goldberg, MD,a,c Jean DuRussel-Weston, RN, MPH,a Kim A. Eagle, MD,a,b and Elizabeth A. Jackson, MD, MPH,a,b on behalf of the University of Michigan Health System

Mich. Cardiovascular Research and Reporting Program, Division of Cardiovascular Medicine, Department of Internal Medicine, and Division of Cardiovascular Medicine, Department of Pediatrics, University of Michigan Health System, Ann Arbor, Michigan

KEY WORDS: childhood obesity, diet, physical activity, cardiovascular risk factors, community health

ABBREVIATIONS: CI—confidence interval
HDL—high-density lipoprotein
LDL—low-density lipoprotein
OR—odds ratio
PHS—Project Healthy Schools
SES—socioeconomic status

Ms Govindan drafted the initial manuscript, carried out the initial analysis, and reviewed and revised the manuscript; Mrs Gurm carried out the statistical analysis and reviewed and revised the manuscript; Mr Mohan participated in data entry and reviewed the final manuscript; Mrs Kline-Rogers coordinated and supervised data collection and critically reviewed and revised the manuscript; Ms Corriveau reviewed and revised the manuscript; Dr Goldberg conceptualized and designed the study, coordinated and supervised data collection and critically reviewed and revised the manuscript; Ms DuRussel-Weston is responsible for the overall direction, growth, and sustainability of the program and reviewed the final manuscript; Dr Eagle conceptualized and designed the study, coordinated data collection, and critically reviewed and revised the manuscript; Dr Jackson conceptualized and designed the study and critically reviewed and revised the manuscript; and all authors approved the final manuscript as submitted.

(Continued on last page)
During the past 3 decades, the prevalence of obesity increased from 6.5% to 19.6% among 6- to 11-year-old children and from 5.0% to 18.1% among 12- to 19-year-old adolescents.\(^1\) Overweight youth are considerably more likely to be overweight or obese in adulthood.\(^2\) In addition, obesity in childhood is associated with cardiovascular risk factors in adulthood, including dyslipidemia, diabetes, and hypertension.\(^3,5\) Heart disease is the leading cause of death in the United States, with >600,000 victims annually.\(^4\) With the prevalence of obesity and its associated comorbidities continuing to rise, it has become more important than ever to find solutions to this national health crisis.

Previous studies have demonstrated differences between boys and girls in body composition, physical activity, and diet.\(^5-7\) Childhood body composition values, such as total body fat, body fat percentage, and fat-free mass, have been found to correlate with young adult body composition.\(^8\) While truncal obesity may more accurately predict future cardiovascular disease risk, BMI correlates well with total body fat and body fat percentage to reflect adiposity, particularly in the higher range of BMI.\(^9-11\)

Despite the limitations of BMI, the use of BMI cutoffs is appropriate in identifying children at risk for obesity.\(^11\)

The gender-specific effects of a school-based wellness program are not well understood. Project Healthy Schools (PHS), a school-based program, provides an opportunity to examine gender-related differences in risk factors for obesity among middle-school boys and girls.

**METHODS**

PHS is a program for sixth-graders at 20 participating middle schools in Ann Arbor, Detroit, Owosso, and Ypsilanti, Michigan. The program has 5 goals to reduce cardiovascular risk factors and promote life-long health: (1) eating more fruits and vegetables, (2) improving beverage choices, (3) reducing fast and fatty foods, (4) performing more physical activity, and (5) decreasing time spent in front of the computer and television. PHS features weekly activities that are taught in the advisory period, as well as monthly assemblies focused on healthy habits such as fitness and nutrition. PHS staff and volunteers present the program’s educational modules, as well as work with school administration to establish healthier lunch and vending machine options through a variety of actions, including increasing fruit and vegetable availability, adding whole grains, and replacing many of the fatty and high-sugar food items with healthier options. Full details of the PHS methodology, as well as its benefits on cardiovascular health, have been published elsewhere.\(^12,15\)

**Study Population**

Students enrolled in sixth grade (10–12 years old) at 20 schools, from 4 communities in southeastern Michigan, between 2004 and 2011 were eligible for participation in this study. Consent forms and descriptions of PHS were sent to the parents of each student. While all sixth-grade students enrolled in these schools received the educational component of PHS, data for analysis were collected only from students whose legal guardian(s) signed the consent forms. Students had the choice to opt out of the laboratory screening and physical assessment component of data collection, and only the written questionnaires were collected from these individuals. Only subjects who provided consent and from whom laboratory screening data were obtained were included in this study, and only those who had all variables completed were included in the logistic regression. The study was approved by the University of Michigan Institutional Review Board.

**Data Collection**

Baseline data included demographic information (age, race, and gender), anthropometric measurements (height and weight), blood pressure, resting heart rate, and a blood sample from which lipid levels and glucose were measured. Height was measured by using a stadiometer with the student’s shoes removed, and weight was measured to the nearest 0.1 kg, by trained examiners. These measurement techniques were standardized across all project workers. All students measured for height and weight had BMI calculated. Overweight and obesity were defined as a BMI ≥85th percentile and ≥95th percentile, respectively, for gender and age, derived from the Centers for Disease Control and Prevention 2000 Growth Charts.\(^14\) Random glucose, total cholesterol, high-density lipoprotein (HDL) cholesterol, low-density lipoprotein (LDL) cholesterol, and triglycerides were measured by using finger-prick blood samples analyzed with a Cholestech LDX (Hayward, CA) machine, which has been validated for point-of-care use.\(^15\) Blood pressure was measured by using an automated blood pressure monitor (model 04-244-001; Mabis Health Care, Waukegan, IL) after the subject had been sitting quietly for 3 to 5 minutes. Measurements were taken 3 times, and the final 2 values were averaged and recorded as the mean systolic and diastolic blood pressures. Recovery heart rate (a measure of fitness) was determined by placing a stethoscope on the student’s upper sternum and counting the number of beats in 1 minute after the student completed a 3-minute step test. The step test consisted of the student stepping up and down on a bench, following a 96-beat per minute cadence, for 3 minutes under program supervision.

All the students completed an abbreviated version of the School Physical Activity and Nutrition questionnaire.\(^16\) The
questionnaire is a validated tool that queries topics such as the student’s level and frequency of physical activity and sedentary behaviors, in addition to dietary intake. Questions related to physical activity and sedentary behaviors included the number of days in the previous week the student had performed vigorous physical activity for at least 20 minutes, with a separate question for moderate activity of 30 minutes or longer. Additional questions were included to collect information on the number of physical education classes attended, participation in school-based team sports, and participation in sports or other physical activities outside the school. Sedentary behaviors were addressed with questions regarding the number of hours spent watching television, number of hours spent on the computer (outside of school), and the number of hours spent playing video games per day. For each of these questions, the frequency ranged from no time spent, <1 hour, 1 hour, and ≥6 hours.

Study site coordinators were trained and were provided a manual of operations and standardized data forms to ensure a high degree of accuracy in data collection. Data not within the set limit ranges, inconsistencies, and/or unrecorded fields were flagged and were clarified and corrected wherever possible. Approximately 10% of forms were randomly selected for verification with double entry of the data. As this is a community-based wellness program, students had the option to opt-out of certain portions of the questionnaire or health screening. Students with missing variables were included in the overall analysis but excluded from the logistic regression.

Statistical Analysis

Data were entered into a Microsoft Access database (Microsoft Corporation, Redmond, WA) at the Michigan Cardiovascular Research and Reporting Program. The Statistical Package for the Social Sciences (version 18.0; SPSS Inc, Chicago, IL) was used for statistical analysis. The cohort was divided into 4 groups: boys and girls characterized as obese and boys and girls characterized as nonobese.14 These groups were compared for differences in health behaviors and physiologic markers. For the univariate analysis, discreet variables were compared by using χ² tests and continuous variables by using t tests, with P value of <.05 considered significant. Covariates were selected for inclusion in multivariate analysis if they had a value of P ≤ .10 in the univariate analysis. Multivariate models were created by using logistic regression to examine independent predictors of obesity among boys and girls separately.

RESULTS

A total of 1714 middle-school children were included in the current study of whom 48.4% were boys (mean age 11.2 ± 0.44 years) and 51.6% were girls (mean age 11.56 ± 0.43 years) (Table 1). No statistically significant differences in the racial/ethnic composition were noted between the boys and girls. Boys were more likely to be overweight or obese than girls, with 19.4% of boys being overweight compared with 15.3% of girls and 18.4% of boys being obese compared with 15.8% of girls.

Gender-related differences were noted in physiologic parameters between obese and nonobese for both boys and girls (Table 2). Obese boys were more likely to have higher total cholesterol, LDL cholesterol, and triglycerides compared with nonobese boys. Obese boys also had lower HDL cholesterol than nonobese boys. In contrast, only triglyceride and HDL cholesterol levels differed between obese and nonobese girls. HDL cholesterol was lower and triglycerides were higher among obese girls compared with nonobese girls. Obese girls were noted to have higher random glucose levels than nonobese girls. No difference in random glucose levels were observed between obese and nonobese boys. Other physiologic measures were also noted to differ between nonobese and obese groups of both genders, including higher blood pressure (both systolic and diastolic), resting and recovery heart rate (a measure of fitness).

When wellness behaviors were examined, gender-related differences were also observed between nonobese and obese boys and girls (Table 3). For boys, those who were obese were less likely to report being physically active. In contrast, there were no significant differences between nonobese and obese girls for self-reported activity either 20 minutes of vigorous physical

<table>
<thead>
<tr>
<th>TABLE 1 Baseline Characteristics by Gender</th>
<th>Boys</th>
<th>Girls</th>
<th>P</th>
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<tbody>
<tr>
<td>Characteristic, n (%)</td>
<td></td>
<td></td>
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<tr>
<td>Age, y ± SD</td>
<td>11.62 ± 0.44</td>
<td>11.56 ± 0.43</td>
<td>.07</td>
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<tr>
<td>Race</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>White</td>
<td>808 (47.1%)</td>
<td>906 (52.8%)</td>
<td>.57</td>
</tr>
<tr>
<td>Black</td>
<td>155 (19.5%)</td>
<td>151 (16.8%)</td>
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</tr>
<tr>
<td>Asian</td>
<td>88 (11.1%)</td>
<td>87 (9.7%)</td>
<td></td>
</tr>
<tr>
<td>Hispanic</td>
<td>29 (3.9%)</td>
<td>38 (4.2%)</td>
<td></td>
</tr>
<tr>
<td>Native American</td>
<td>8 (1.0%)</td>
<td>12 (1.3%)</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>55 (6.9%)</td>
<td>64 (7.1%)</td>
<td></td>
</tr>
<tr>
<td>BMI category</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Underweight (&lt;5th percentile)</td>
<td>28 (3.5%)</td>
<td>27 (3.0%)</td>
<td>.02</td>
</tr>
<tr>
<td>Normal (5th to &lt;85th percentile)</td>
<td>474 (58.7%)</td>
<td>597 (65.9%)</td>
<td></td>
</tr>
<tr>
<td>Overweight (85th to &lt;95th percentile)</td>
<td>157 (19.4%)</td>
<td>139 (15.3%)</td>
<td></td>
</tr>
<tr>
<td>Obese (≥95th percentile)</td>
<td>149 (18.4%)</td>
<td>145 (15.8%)</td>
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</tbody>
</table>
activity ≥5 times per week or 30 minutes of moderate physical activity ≥5 times per week. Participation in
school sports also differed for the nonobese and obese boys, while no
difference was noted for the girls. When examining sedentary behaviors,
both obese boys and girls reported watching television ≥2 hours per day
more often than the nonobese boys or girls, although this difference appeared
to be more statistically significant in girls. Obese girls also reported using
a computer ≥2 hours per day more often than nonobese girls. However, there
was no reported difference in reported computer time for nonobese and obese
boys. We also observed no difference in reported video games (≥2 hours per
day) between nonobese and obese among both the boys and the girls.

Independent predictors were identified by using multivariate logistic regres-
sion models, with 1586 students included who had all variables completed
(Table 4). In both boys and girls, the report of consuming school lunches on
most of the days of the week and of television viewing for ≥2 hours of the
day were associated with obesity. Factors associated with a reduced risk of
obesity in boys included reporting ≥20 minutes of physical activity and partic-
ipation in ≥1 school sports team. For girls, consumption of milk was inversely
associated with obesity.

**DISCUSSION**

In this study, we observed that obese boys and girls have unfavorable cardio-
vascular profiles with lower HDL cholesterol, higher triglyceride levels,
higher blood pressure, and higher heart rate recovery (indicating a lower
level of fitness) compared with nonobese boys and girls. Predictors of
obesity included school lunch consumption and time spent watching
 television for both genders. However, other factors, such as physical activity
behaviors and milk consumption, differed by gender as related to obesity.

**Physiologic Markers**

In both genders, nonobese students exhibited significantly healthier physi-
ologic markers, including serum lipid levels, blood pressure, and heart rate
recovery, compared with their obese counterparts. These observations
are supported by findings from several other studies showing that obesity is
linked to increased cardiovascular risk factors. The Bogalusa Heart Study
noted lower HDL cholesterol and higher triglyceride levels were associ-
ated with increased weight. Cross-sectional data from the National
Heart, Lung, and Blood Institute’s Growth and Heart Study demonstrated
adverse lipid profiles (including increased total cholesterol, LDL, tri-
glyceride levels and lower HDL level) among white and black girls who were
obese compared with nonobese girls.19

<table>
<thead>
<tr>
<th>TABLE 3</th>
<th>Self-Reported Activities: Nonobese versus Obese Stratified by Gender</th>
</tr>
</thead>
<tbody>
<tr>
<td>Behavior, n (%)</td>
<td>Boys</td>
</tr>
<tr>
<td></td>
<td>Nonobese (n = 610)</td>
</tr>
<tr>
<td>Physical activities</td>
<td></td>
</tr>
<tr>
<td>20 min vigorous ≥5 times/wk</td>
<td>339 (55.9%)</td>
</tr>
<tr>
<td>30 min moderate ≥5 times/wk</td>
<td>228 (37.8%)</td>
</tr>
<tr>
<td>≥1 school sports team</td>
<td>375 (61.5%)</td>
</tr>
<tr>
<td>Sedentary activities</td>
<td></td>
</tr>
<tr>
<td>Television ≥2 h/d</td>
<td>293 (48.3%)</td>
</tr>
<tr>
<td>Computer ≥2 h/d</td>
<td>135 (22.2%)</td>
</tr>
<tr>
<td>Video games ≥2 h/d</td>
<td>174 (28.5%)</td>
</tr>
</tbody>
</table>

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<tr>
<th>TABLE 2</th>
<th>Physiologic Parameters: Nonobese versus Obese Stratified by Gender</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Boys</td>
</tr>
<tr>
<td></td>
<td>Nonobese (n = 659)</td>
</tr>
<tr>
<td>Lipids, mean ± SD mg/dL</td>
<td></td>
</tr>
<tr>
<td>Total cholesterol</td>
<td>161.34 ± 28.50</td>
</tr>
<tr>
<td>LDL cholesterol</td>
<td>85.77 ± 23.33</td>
</tr>
<tr>
<td>HDL cholesterol</td>
<td>55.03 ± 12.91</td>
</tr>
<tr>
<td>Triglycerides</td>
<td>108.88 ± 68.37</td>
</tr>
<tr>
<td>Random glucose, mean ± SD mg/dL</td>
<td>98.36 ± 14.64</td>
</tr>
<tr>
<td>Blood pressure, mean ± SD mm Hg</td>
<td></td>
</tr>
<tr>
<td>Systolic</td>
<td>107.37 ± 11.48</td>
</tr>
<tr>
<td>Diastolic</td>
<td>63.63 ± 8.38</td>
</tr>
<tr>
<td>Resting heart rate, mean ± SD beats per minute</td>
<td>79.83 ± 10.63</td>
</tr>
<tr>
<td>Heart rate recovery, mean ± SD beats per minute</td>
<td>99.72 ± 15.90</td>
</tr>
</tbody>
</table>
We observed no significant differences in total cholesterol and LDL between nonobese and obese girls but did see increases in total cholesterol and LDL among obese boys compared with nonobese boys. It is important to note that the serum lipid measurements in our study represent nonfasting values.

**Physical Activity and Sedentary Behaviors**

We also observed differences in physical activity and sedentary behaviors between obese and nonobese students. Nonobese boys reported performing more moderate and vigorous physical activity than their obese peers. Girls in general were less likely to report being physically active, although obese boys had the lowest prevalence of vigorous activity. Other studies have observed lower levels of physical activity among girls compared with boys.20,21 The major difference we observed was the significantly lower prevalence of all three measures of activity (vigorous activity, moderate activity, and participation in team sports) among obese boys compared with nonobese boys, which was not observed among girls (obese compared with nonobese). One possible explanation for this is the potential for activities such as dance or cheerleading not considered by children to be a sport or an activity and thus not reported. Such activities are likely to be more prevalent among girls. Several studies have noted girls to report lower-intensity activities rather than vigorous activities and to be, on average, less active than boys.20,21 In a study of 2389 adolescents, physical activity was associated with lower likelihood of obesity in boys but not in girls. Thus, study authors hypothesized that a fewer number of girls who report physical activity, in particular vigorous activity, may reduce the power to detect significant associations between physical activity and BMI.20

For both boys and girls, we observed that children had higher levels of heart rate recovery, suggesting poor levels of fitness among obese boys and girls compared with nonobese boys and girls. This has also been observed in other studies.22,23 The lower level of fitness among girls compared with boys is consistent with our findings of lower levels of physical activity among the girls compared with the boys. The implications of fitness are significant, as several studies have observed associations between level of fitness and cardiovascular risk factors, including hypertension, diabetes, and hypercholesterolemia.24,25 In addition, the associations between fitness and BMI among the girls suggest that heart rate recovery may be a better indicator of risk for obesity among girls as opposed to reported physical activity behaviors.

We observed that increased time spent watching television was significantly associated with obesity for both boys and girls. This relationship has been widely recognized and likely mediated by corresponding decreased physical activity.21,26 Interventions to reduce sedentary behaviors may be an important component of reducing childhood obesity. A randomized controlled trial in elementary school children found that a school-based intervention to reduce television viewing time resulted in a decrease in BMI compared with controls.27

When asked about computer use, obese girls were more likely to use a computer than any of the other groups. In regard to other types of sedentary activities, obese boys reported playing video games more often than nonobese boys, while both obese and nonobese girls were much less likely to report playing video games than were boys. We did not find a significant association between time spent playing video games and obesity among boys, which has been observed in other studies.20 Although we observed a similar trend, the lack of statistical significance may be due to smaller sample size in our study compared with others. Our data would seem to support the findings in other investigations where interventions to reduce screen time of any type (television, computer, or video games) would be protective against obesity among children and adolescents. The gender-related differences in reported computer time versus video games that we observed suggest the potential for targeting specific screen behaviors by gender to improve the effectiveness of interventions to reduce screen time.

**Dietary Factors**

For both boys and girls, regularly eating school lunch was a predictor of obesity. Other studies have also reported an association between school lunch consumption and increased weight,29,30 while another study did not.30 A major issue with such studies is the potential for confounding by socioeconomic status (SES), given that many children with lower SES will be eligible for free or reduced school lunches. Lower SES has been linked with obesity.31–35 Although we were not able to examine

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**TABLE 4: Independent Predictors of Obesity by Gender**

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<thead>
<tr>
<th></th>
<th>OR</th>
<th>95% CI</th>
<th>P</th>
</tr>
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<tbody>
<tr>
<td>Boys (n = 738)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>School lunch consumption (almost always or always)</td>
<td>1.29</td>
<td>1.01–1.64</td>
<td>.04</td>
</tr>
<tr>
<td>Television viewing (≥2 h/d)</td>
<td>1.19</td>
<td>1.07–1.32</td>
<td>&lt;.01</td>
</tr>
<tr>
<td>Physical activity (20 min vigorous activity ≥5 times/wk)</td>
<td>0.90</td>
<td>0.82–0.98</td>
<td>.02</td>
</tr>
<tr>
<td>School sports participation (≥1 team)</td>
<td>0.77</td>
<td>0.64–0.94</td>
<td>.01</td>
</tr>
<tr>
<td>Girls (n = 848)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>School lunch consumption (almost always or always)</td>
<td>1.27</td>
<td>1.00–1.62</td>
<td>.05</td>
</tr>
<tr>
<td>Television viewing (≥2 h/d)</td>
<td>1.19</td>
<td>1.06–1.34</td>
<td>&lt;.01</td>
</tr>
<tr>
<td>Milk consumption (any type, ≥2 servings in previous 24 h)</td>
<td>0.81</td>
<td>0.67–0.98</td>
<td>.03</td>
</tr>
</tbody>
</table>
the specific nutritional content of school lunches in our study, previous research suggests the nutritional value of lunches being consumed in schools is not optimal, consisting of nutrient-poor, calorie-rich foods. For example, Crepinsek et al found less than one third of school lunches met current recommendations for saturated fat intake.36

We also observed that nonobese girls were more likely to consume ≥2 servings of milk than their obese peers, suggesting that milk consumption may be protective against obesity. We suggesting that milk consumption might improve health among middle-school children.

REFERENCES


Study Limitations

PHS is a school-based intervention; as such, this is a real-world observational study as opposed to a randomized trial. Such data provide information on a heterogeneous population without exclusion of specific subgroups. Nevertheless, as an observational study, these data are subject to inherent limitations and potential biases. Limitations of self-reported information on lifestyle behaviors including diet and physical activity are subject to measurement error and recall biases, which may influence our results. We included only those children who provided individual and parental consent; therefore, participation was not 100% of the students at each school. Future directions would include measurement of waist and hip circumference to assess for truncal obesity, which better correlates with cardiovascular disease risk.9 Normal maturation is associated with changes in physiologic parameters, such as LDL level.39 This study did not evaluate for pubertal maturation. However, these results do provide a foundation for collection of long-term data and development of interventions that may prevent or reduce obesity and improve health among middle-school children.

CONCLUSIONS

We observed among a cohort of middle-school children that both consuming frequent school lunches and watching ≥2 hours of television were associated with obesity for both genders. Gender differences were observed in the risk of obesity associated with physical activity, school sports participation and milk intake. Exploring such gender-related differences in a larger cohort may assist in refining interventions to promote weight loss and/or prevent obesity among middle-school children.


(Continued from first page)

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Address correspondence to Elizabeth A. Jackson, MD, MPH, Department of Internal Medicine, Division of Cardiovascular Medicine, University of Michigan Health System, 24 Frank Lloyd Wright Dr, Ann Arbor, MI 48108-0363. E-mail: lisjacks@umich.edu

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474 GUVINDAN et al

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