

# School Children Have Leading Risk Factors for Cardiovascular Disease and Diabetes: The Wausau SCHOOL Project

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## ABSTRACT

**Introduction:** Risk factors for cardiovascular disease and diabetes acquired in childhood commonly persist in later life and are particularly strong predictors of subclinical atherosclerosis in young adults. A rising tide of obesity and other lifestyle-related risk factors threatens to negate much of the success achieved in the prevention and treatment of these diseases. The SCHOOL project (School Children Have Leading Risk Factors for Cardiovascular Disease and Diabetes), was designed to measure the prevalence and magnitude of known risk factors in school-age children in Wausau, Wis.

**Methods:** Demographic data, anthropomorphic measures, family health history, diet and activity indices, and numerous laboratory measures were collected from a representative sample of students in grades 2, 5, 8, and 11.

**Results:** Clinically important disturbances of lipid metabolism were very common, even in the youngest participants. Of the children studied, 39% had at least 1 lipid abnormality and 22% had 2 or more. Abnormal blood pressure, overweight, and cigarette smoking were present in 29%, 16%, and 11% respectively. While elevated fasting glucose levels were uncommon, insulin resistance was noted in 25% of the sampled population and nearly 50% of sampled children with a body mass index greater than the 85th percentile in this survey. The number of children with

multiple risk factors rose dramatically with age. By 11th grade, 38% of those surveyed had 2 or more risk factors and 23% had 3 or more.

**Conclusions:** Using conservative definitions, significant abnormalities of lipid metabolism and other risk factors for cardiovascular disease and diabetes were common in our children. Risk profiles in older adolescents were worse than in the younger students and similar to what would be expected for adults with known coronary heart disease. In our community there is a growing consensus that we must take advantage of the multiple opportunities that exist to favorably alter the lifestyle patterns that put our children at risk.

## INTRODUCTION

Great strides have been made in the prevention and treatment of cardiovascular diseases in the last century, and yet they continue to be the leading cause of death in modern societies. Modifiable, lifestyle-related risk factors contribute to nearly the entire incidence of myocardial infarction in both sexes and in all regions of the world.<sup>1</sup> Longitudinal population-based studies that began in the 1970s clearly demonstrate that risk factors for the development of cardiovascular disease and diabetes, when acquired in childhood, persist in adult life and are predictive of future clinical disease.<sup>2,3</sup> Despite this information, unhealthy changes in lifestyles have occurred within the last 20 years that threaten to significantly increase the future burdens of cardiovascular disease and diabetes faced by children everywhere.<sup>4</sup> Worldwide, over 150 million school-aged children are overweight.<sup>5</sup> Within the European Union, 14 million school-aged children are overweight and that number is rising by 400,000 annually, 85,000 of whom are obese.<sup>5</sup> Children in the Americas lead the way, where more than 30% are either overweight or obese.<sup>6</sup> Best estimates are that a white child born in the United States in the year 2000 has a 1 in 3 chance of developing diabetes during his/

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her lifetime, and a 1 in 2 chance if he or she is black or Hispanic.<sup>7</sup>

If efforts to counter these trends are to succeed, they must be community-based and targeted to favorably alter lifestyle-related risk factors in the population at large.<sup>8,9</sup> A community-specific cardiovascular risk ‘report card’ in Olmstead County, Minn served to highlight local opportunities to reduce the incidence of cardiovascular disease and generate enthusiasm for an ongoing initiative (CardioVision 2020) to promote cardiovascular wellness in that community.<sup>10</sup> In a similar manner, the SCHOOL project was designed to measure the prevalence and magnitude of known risk factors for cardiovascular disease and diabetes mellitus, specifically in school-age children in Wausau, Wis. By providing our community with a measure of identifiable risk factors, as well as insights into changes that can improve that future, we anticipate the SCHOOL project will be a powerful motivation for local interventions.

## METHODS

### Sample

A representative sample of Wausau School District students enrolled in grades 2, 5, 8, and 11 was recruited from all 17 schools in the district, with a goal of 200 students per grade. Data collection occurred between November 2002 and June 2003. Approximately 480 students were randomly selected from each of the 4 grade levels, with about 40% of the students selected participating in some segment of data collection.

The Aspirus Wausau Hospital Institutional Review Committee and the Board of Education approved the study. Informed consent was obtained from parents and age-appropriate assent from students.

### Data Components

Data collection had 6 key components:

1. *Demographic data.* Date of birth, sex, race/ethnic identity, socioeconomic status, eligibility for Title 1 (federal program serving students with literacy and/or math needs), and disability status were collected via school records and parent surveys.
2. *Anthropomorphic measures.* Height and weight were measured and a standardized Body Mass Index (zBMI) was derived using Centers for Disease Control and Prevention (CDC) norms for each child, with normative information identified by sex and month of birth. Blood pressure was obtained using standard protocol.<sup>11</sup>
3. *Health history.* Parents were asked to complete an abbreviated health history form for their children

with special emphasis on prior diagnoses of cardiovascular disease, hypertension, or diabetes, as well as a similar family health history form.

4. *Dietary and activity recall.* Dietary information was collected using instruments adapted from Kristal et al and Murphy et al.<sup>12,13</sup> Activity habits were assessed using a modified version of the Self-Administered Physical Activity Checklist.<sup>14</sup>
5. *Health behaviors questionnaire.* An age appropriate questionnaire adapted from CATCH<sup>15</sup> was administered to gather information about current health behaviors, knowledge, and attitudes.
6. *Lab sampling.* Students were required to fast for 12 hours prior to blood draws. Lipids were measured using nuclear magnetic resonance technology.<sup>16,17</sup> This technique provides a standard lipid profile, as well as a measurement of the size and number of low-density lipoprotein cholesterol (LDL) and high-density lipoprotein (HDL) particles. Glucose measurements were made using the oxidation method.<sup>18</sup> Insulin measurements were completed for students in grades 2 and 11, allowing for pre- and post-pubertal comparisons. Plasma insulin levels were measured by Liposcience Inc., using a commercial chemiluminescent immunometric assay.<sup>19</sup> From the fasting glucose and insulin levels, an index of insulin resistance (homeostasis model of insulin resistance index: HOMA-IR) was calculated.<sup>20</sup>

### Definitions

Lipid abnormalities were defined as total cholesterol  $\geq 200$  mg/dL, non-HDL cholesterol  $\geq 160$  mg/dL, LDL cholesterol  $\geq 130$  mg/dL, HDL cholesterol  $\leq 35$  mg/dL, triglycerides  $\geq 150$  mg/dL, and Pattern B phenotype (average LDL particle size  $< 20.5$  nm).<sup>21</sup> Dyslipidemia was defined as the presence of 1 or more of these abnormalities. After adjustment for age and sex, subjects with a BMI higher than the 85th and 95th percentiles were designated as “at risk for overweight” and “overweight,” respectively.<sup>22</sup> Either a systolic blood pressure  $> 120$  mm Hg or a diastolic blood pressure  $> 80$  mm Hg were regarded as abnormal. This is consistent with recent guidelines for both children and adults.<sup>23</sup> A value of 100 mg/dL or greater was regarded as an impaired fasting serum glucose, based on recommendations of the Expert Committee on Diagnosis and Classification of Diabetes Mellitus.<sup>24</sup> Insulin resistance was considered present when HOMA-IR values exceeded the 85th percentile when compared with children in the same grade level who had “normal” BMI scores (defined as BMI below the 85th percentile).<sup>2</sup> Dyslipidemia, overweight, abnormal blood pressure,

**Table 1.** Key Demographics for Population and Sample

	All Students (Population)	Sample Participants with Physical Data	P*
Total N	2642	716	
<b>Sex</b>			
Male	1354 (51.2%)	348 (48.6%)	0.21
Female	1288 (48.8%)	368 (51.4%)	
<b>Ethnicity</b>			
Caucasian	1941 (73.5%)	624 (87.2%)	<0.001
Other	701 (26.5%)	92 (12.8%)	
<b>Lunch</b>			
Free	709 (26.8%)	112 (15.6%)	<0.001
Reduced	197 (7.5%)	54 (7.5%)	
No subsidy	1736 (65.7%)	550 (76.8%)	
<b>Title I†</b>			
Yes	81 (3.1%)	18 (2.5%)	0.44
<b>Disability</b>			
Yes	321 (12.1%)	76 (10.6%)	0.82

\*Chi square tests compared the particular sample subcomponent with the corresponding population frequencies.  
† Title I: federal program serving students with literacy and/or math needs.

smoking, and impaired fasting glucose were considered as separate risk factors for the future development of cardiovascular disease.

### Statistics

The Statistical Package for the Social Sciences (SPSS) was used for all analyses. Frequency data for categorical variables were analyzed using Chi square. For continuous variables, t-tests were used to contrast 2 groups and ANOVA was used when making multiple comparisons (e.g. between 4 grade levels).

BMI is an index of obesity that is widely used with adults. To derive a more meaningful index of childhood obesity, we consulted CDC data files for males and females of all ages (by month) to use as our standard sample. Children were then compared against these "standard" values and their deviation from the normative value was translated into a z-score, or standardized score. Children who had the same weight as other children of their sex, age, and height were assigned a value of 0. On the other hand, children whose weight was 1 standard deviation above that of other children of their sex, age, and height were assigned a zBMI of +1.0. As with other z scores, zBMI scores roughly ranged from -3 to +3, and represent the number of standard deviations a child is above or below the normative group for his/her sex, age, and height.

## RESULTS

### Demographic Characteristics

Table 1 demonstrates the characteristics of the student population and our tested sample. When compared with the population, our sample did not differ from the population on sex, Title 1, or disability status. While minority students represent about 27% of the student population (with 89% of these students of Southeast Asian decent), only 13% of the actual participants were minority members. Although many efforts were made to encourage participation, this group was much less likely to consent to blood and physical data testing. While socioeconomic status was not directly assessed, students who were eligible for free or reduced lunch subsidy (34%) were somewhat under-represented in our sample. Because minority status and eligibility for lunch subsidy overlap considerably (17% of whites and 81% of minority students qualify for lunch subsidy), these differences primarily reflect the difficulties in recruiting students in the minority community.

Table 2 demonstrates the participation rates at each grade level for the various data elements collected. We obtained 586 blood samples and 716 anthropomorphic data sets. Younger students were somewhat more willing to consent to blood draws and a physical evaluation than were older students.

### Lipid Abnormalities

Clinically significant disturbances of lipid metabolism were very common. Abnormal values for total cholesterol, LDL cholesterol, non-HDL cholesterol, HDL cholesterol, triglycerides, and pattern B phenotype were seen in 18%, 27%, 12%, 10%, 8%, and 5% of study participants, respectively (Figure 1). Dyslipidemia, defined as the existence of at least 1 of these lipid abnormalities, was present in 39% of the sample, while 22% had 2 or more lipid abnormalities (Figure 2 and Table 3). Lipid values were compared across the 4 grade levels. Of greatest concern is that LDL levels were often abnormal, even in the youngest of children. Abnormalities of triglycerides ( $\chi^2=8.50$ ,  $P=0.037$ ) and HDL cholesterol ( $\chi^2=16.77$ ,  $P=0.001$ ) were found with increasing frequency at each subsequent grade level, while grade-related changes were not significant for the other lipid measures (Figure 1).

### Other Coronary Risk Factors

Table 3 demonstrates the frequency of cardiovascular risk factors at each grade level and for the entire study cohort. Abnormal blood pressure was identified in 29% of the children studied and was found with increasing

**Table 2.** Sample Distribution by Grade and Participation Level

	2nd Grade	5th Grade	8th Grade	11th Grade	All
Total no. students in population*	533 (20.2%)	662 (25.1%)	718 (27.2%)	729 (27.6%)	2642
No. consented for participation†	204 (38.3%)	213 (32.2%)	194 (27.0%)	142 (19.5%)	753 (28.5%)
No. students with blood data‡	137 (25.7%)	160 (24.2%)	163 (22.7%)	126 (17.3%)	586 (22.2%)
No. students with physical data‡	192 (36.0%)	198 (29.9%)	187 (26.0%)	139 (19.1%)	716 (27.1%)
Complete data (physical, blood, HBQ, activity, diet, & demographics)†	57 (10.7%)	107 (16.2%)	106 (14.8%)	100 (13.7%)	370 (14.0%)

HBQ=Health Behavior Questionnaire

\* Percent of 2642 (total population)

† Percent of no. of students in specified grade level

**Table 3.** Frequency of Individual and Multiple Risk Factors by Grade Level

	2nd Grade	5th Grade	8th Grade	11th Grade	All
N available for these contrasts	122	139	152	122	535
Dyslipidemia*	41 (33.6%)	55 (39.6%)	55 (36.2%)	56 (45.9%)	207 (38.7%)
Abnormal Blood Pressure†	14 (11.5%)	38 (27.3%)	53 (34.9%)	51 (41.8%)	156 (29.2%)
Ever Smoked	2 (1.6%)	6 (4.3%)	19 (12.5%)	32 (26.2%)	59 (11.0%)
Overweight‡	18 (14.8%)	23 (16.5%)	27 (17.8%)	18 (14.8%)	86 (16.1%)
Impaired Fasting Glucose§	0 (0%)	5 (3.6%)	14 (9.2%)	0 (0%)	19 (3.6%)
Multiple risk factors	14 (11.5%)	33 (23.7%)	48 (31.6%)	46 (37.7%)	141 (26.4%)

\*Dyslipidemia = Total cholesterol >200mg/dl, LDL >130mg/dl, HDL <35mg/dl, Triglycerides >150mg/dl, nonHDL >160mg/dl or pattern B LDL phenotype

† Abnormal Blood Pressure >120 mmHg systolic or >80 mmHg diastolic

‡ Overweight = BMI (corrected for age and sex) >95th percentile

§ Impaired Fasting Glucose >100mg/dl

frequency in older students (e.g., 42% of 11th graders). Self-reported cigarette smoking, defined as ever having smoked any amount at any time, was acknowledged by 11% of the entire study population and 26% of those in grade 11. Regarding body weight, 5% of the children were anticipated to be above the 95th CDC percentile; however our sample found that 16% were in this “overweight” category. Further, we anticipated that 15% of the children would be above the 85th CDC centile, but found 30% were “at risk of being overweight” (Figure 3). Impaired fasting glucose was noted in 4% of those surveyed. Approximately 25% of the total population and 50% of those whose BMI exceeded the 85th percentile had insulin resistance, as estimated by the HOMA-IR method.

#### *Additional Observations*

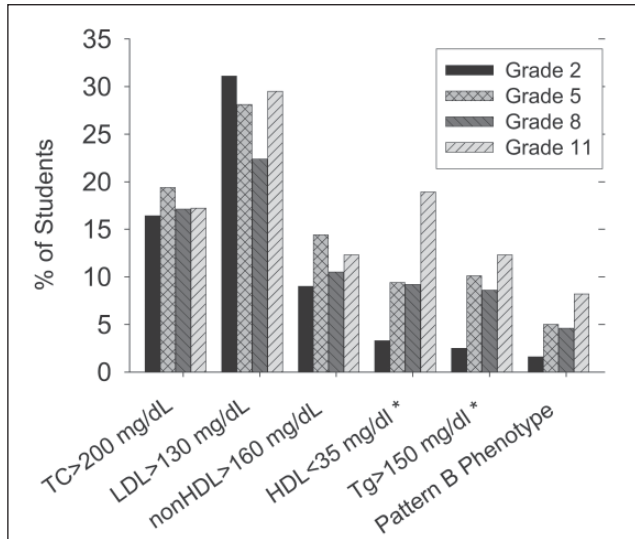
Activity and dietary inventories help provide insight into these findings. Children at all grade levels report consuming roughly half the daily number of servings of fruits and vegetables recommended by the CDC. Weekly consumption of soda nearly tripled between grades 2 and 11. On average, these children reported spending fewer than 50 minutes a day in all forms of physical activity

and more than 3 hours daily in sedentary activities such as television viewing and computer usage. These patterns were similar in boys and girls (Figure 4).

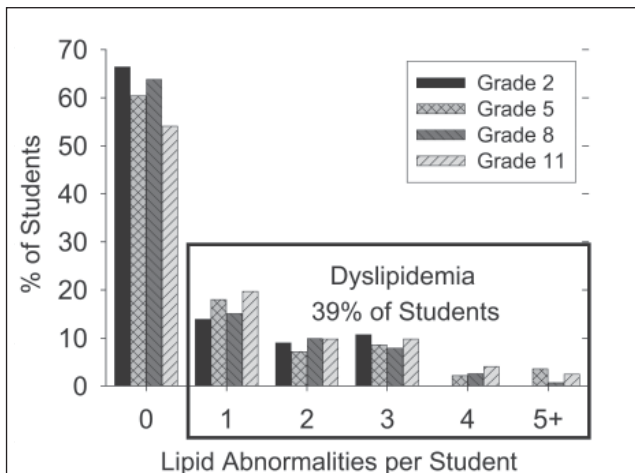
The number of children with risk factors rose dramatically with age. In grade 2, 55% of the students had at least 1 risk factor. By grade 11, that figure rose to 75%. Of those surveyed at grade 11, 38% had 2 or more risk factors (Table 3). In general, risk profiles were worse in older adolescents and similar to patterns seen in adults with established coronary artery disease. We present in Figure 5 a report card for cardiovascular wellness at grade 11 based on our findings.

## **DISCUSSION**

The findings reported here reinforce much of the concern currently voiced in the public media regarding a looming health crisis. In this cross sectional survey of children and adolescents in the Wausau School District we found a striking frequency of risk factors for the future development of cardiovascular disease and diabetes. Dyslipidemia, abnormal blood pressure, overweight, smoking, and impaired fasting glucose were respectively present in 39%, 29%, 16%, 11%, and 4% of the overall



**Figure 1.** Prevalence of specific lipid abnormalities by grade level.\* Significant differences between grade levels. TC=total cholesterol; Tg=triglycerides.



Note: Lipid abnormalities defined as TC > 200 mg/dl, LDL > 130 mg/dl, HDL < 35 mg/dl, Tg > 150 mg/dl, nonHDL > 160 mg/dl, or pattern B LDL phenotype.

**Figure 2.** Number of lipid abnormalities per student by grade level.

study group, and in 46%, 42%, 15%, 26%, and 0% of grade 11 participants. In general, our definitions for risk factors were conservative, as were the methods used to tally them. For example, multiple separate lipid abnormalities were commonly present in study participants with dyslipidemia, but were only counted as 1 risk factor for that individual. Insulin resistance was present in 25% of participants, but was not considered an independent risk factor. Our results also suggest that the future risk of diabetes and cardiovascular disease would be better estimated using a BMI cut-point greater than

the 85th percentile (rather than the 95th percentile used in this analysis), since insulin resistance was present in 50% of participants who had a BMI above the 85th percentile. For these reasons, the actual future risk of clinical disease in this population could be underestimated by our statistics.

Multiple risk factors in the same individual are known to exponentially increase the probability of cardiovascular events in adults.<sup>1</sup> Similarly, multiple coronary risk factors, when measured in childhood and adolescence, were associated with an exponential increase in the frequency of fibrous coronary artery plaques at later autopsy in a cohort of 93 young adults in the longitudinal Bogalusa Heart Study.<sup>26</sup> In that study, 3 or more risk factors were a threshold associated with a dramatic increase in coronary atherosclerosis. A quarter of the participants in the SCHOOL project had more than 1 risk factor, and by grade 11, 23% had 3 or more.

There is considerable evidence suggesting a ‘clustering’ of other risk factors in association with obesity.<sup>6,27</sup> In the National Health and Nutrition Examination Survey for 1999-2002, the prevalence of at risk for overweight (31%) and overweight (16%) for children and adolescents throughout the United States were greater than in previous surveys and virtually identical to the rates in our community.<sup>28</sup> While our behavioral measures are self-reported, and therefore subject to some distortion, the findings are consonant with physical measures and clearly identify opportunities for intervention. Diets were typically deficient in fruit and vegetables and high in fat and carbohydrates. Most children engaged in very little exercise or physical activity, while sedentary activities involving television, music, and computers were predominant.

The SCHOOL project is a comprehensive and contemporary assessment of multiple measures of cardiovascular wellness in school-age children. As a small cross-sectional survey it does not have the power of several large recent prospective longitudinal studies of behaviors and risk factors in childhood and the subsequent consequences in adult life. For example, television viewing of more than 1 hour a weekday during childhood and adolescence was recently correlated, in a dose dependent way, with overweight, poor cardio-respiratory fitness, hypercholesterolemia, and smoking in early adulthood.<sup>29</sup> Similarly, the particularly steep decline in physical activity levels during adolescence in girls is associated with a doubling of the rate of overweight and obesity between the ages of 9 and 19.<sup>30</sup> Despite these limitations, the SCHOOL project

is proving to be powerful motivation for change in our school system and the community at large.<sup>31,32</sup>

A great deal is known about the predictive value of risk factors for the purpose of primary prevention of cardiovascular disease and type II diabetes in adults. Are abnormalities of these risk factors in children really linked to diseases that will not manifest until midlife or later? At one time “the idea that lifestyles in youth could affect a process with deadly consequences in middle-age seemed farfetched.”<sup>33</sup> The unexpected and frequent finding of advanced coronary artery disease in young soldiers killed in the Korean War helped to change this thinking.<sup>34</sup> Since then, prospective longitudinal epidemiologic studies have consistently demonstrated that children with risk factors for cardiovascular disease become young adults with risk factors and subclinical atherosclerosis.<sup>26,35-38</sup> For example, carotid intima-media thickness and coronary artery calcification in young adults are associated with measures of LDL cholesterol and BMI from childhood in the same individuals.<sup>38</sup> As the participants in these longitudinal studies age, the strength of the link between childhood lifestyle patterns and overt disease in adult life may become even more apparent.

Our study does have several potential limitations. Despite special enrollment efforts, ethnic minorities were under-represented. Also, we used a history of ever smoking as our estimate of cigarette smoking. This differs from the 2004 National Youth Tobacco Survey where the CDC used 81 separate questions to gauge adolescent smoking habits.<sup>39</sup> In the SCHOOL project, 26% of students in grade 11 reported ever smoking, a value similar to the most recent estimate for current smoking (23%) among middle and high school students nationwide.<sup>40</sup> We did not account for environmental tobacco exposure in the home.

The results of the SCHOOL project indicate that the future burden of cardiovascular disease and diabetes our children face could be severe without intervention. Guidelines from the American Heart Association speak specifically to goals and therapeutic interventions for physicians and parents as they interact with individual children.<sup>41</sup> Interventions can be targeted to high-risk subgroups such as adolescent girls or children with a BMI >85th percentile. Many opportunities exist for intervention in our community and could provide great benefit for those who choose to participate. Potential future opportunities could include daily physical education classes at all grade levels, an emphasis on life sports, promotion of nutritious foods in our schools and res-

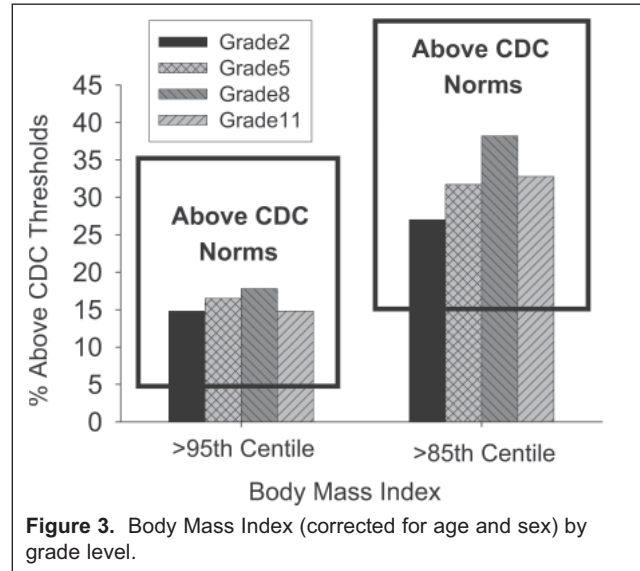


Figure 3. Body Mass Index (corrected for age and sex) by grade level.

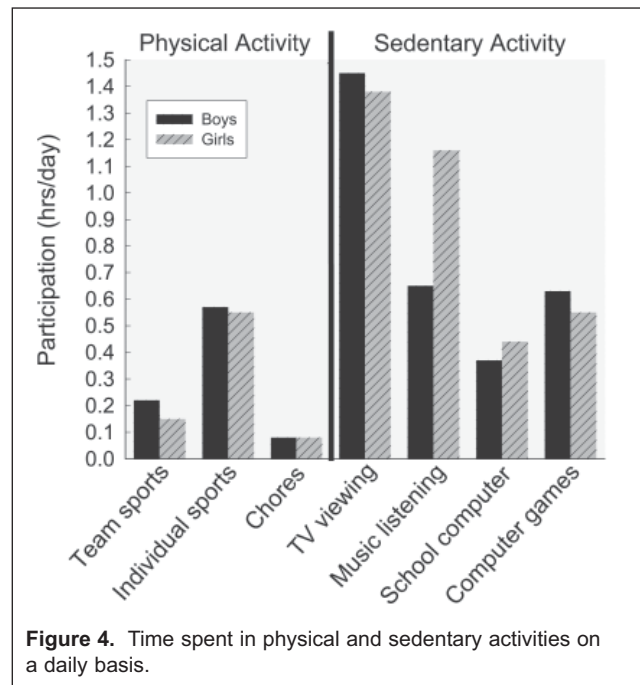
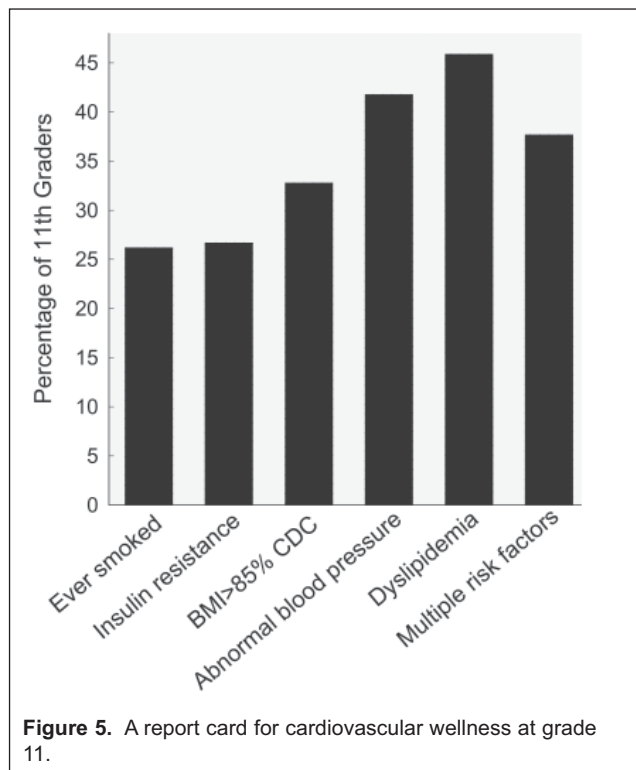


Figure 4. Time spent in physical and sedentary activities on a daily basis.

taurants, freedom from environmental tobacco exposure in public places throughout the community, and widespread, actively promoted, year-round opportunities for physical activity regardless of socioeconomic status.

Primary prevention of atherosclerotic cardiovascular disease must begin in childhood. At an early age, children will find it easier to learn and adopt healthier lifestyles if the encouragement they receive from parents, teachers, and society is reinforced by example and actions. Future research in this area should focus on identifying interventions with large anticipated benefits



**Figure 5.** A report card for cardiovascular wellness at grade 11.

as well as successful systems and strategies to fund and implement them.

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