Prevalence of Cardiovascular Disease Risk Factors Among US Adolescents, 1999−2008

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KEY WORDS

cardiovascular disease, obesity, risk factors, adolescent, clustering

ABBREVIATIONS

AAP—American Academy of Pediatrics
CVD—cardiovascular disease
DBP—diastolic blood pressure
HDL-C—high-density lipoprotein cholesterol
LDL-C—low-density lipoprotein cholesterol
SBP—systolic blood pressure

Dr May had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis; Study concept and design: Drs May, Kuklina, Yoon; Acquisition of data: Dr May; Analysis and interpretation of data: Drs May, Kuklina, and Yoon; Drafting of the manuscript: Dr May; Critical revision of the manuscript for important intellectual content: Drs May, Kuklina, and Yoon; Statistical analysis: Drs May and Kuklina; and Study supervision: Drs May, Kuklina, and Yoon.

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The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention.

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WHAT'S KNOWN ON THIS SUBJECT: Overweight and obese children have a higher prevalence of several cardiovascular disease (CVD) risk factors. There is growing evidence demonstrating that CVD risk factors present during childhood persist into adulthood.

WHAT THIS STUDY ADDS: US adolescents had no significant change in prehypertension/hypertension and borderline-high/ high low-density lipoprotein cholesterol prevalence from 1999–2000 to 2007–2008; however, prediabetes/diabetes increased by 14%.

abstract

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OBJECTIVE: Overweight and obesity during adolescence are associated with an increased risk for cardiovascular disease (CVD) risk factors. The objective of this study was to examine the recent trends in the prevalence of selected biological CVD risk factors and the prevalence of these risk factors by overweight/obesity status among US adolescents.

METHODS: The NHANES is a cross-sectional, stratified, multistage probability sample survey of the US civilian, noninstitutionalized population. The study sample included 3383 participants aged 12 to 19 years from the 1999 through 2008 NHANES.

RESULTS: Among the US adolescents aged 12 to 19 years, the overall prevalence was 14% for prehypertension/hypertension, 22% for borderline-high/high low-density lipoprotein cholesterol, 6% for low high-density lipoprotein cholesterol (<35 mg/dL), and 15% for prediabetes/diabetes during the survey period from 1999 to 2008. No significant change in the prevalence of prehypertension/hypertension (17% and 13%) and borderline-high/high low-density lipoprotein cholesterol (23% and 19%) was observed from 1999–2000 to 2007–2008, but the prevalence of prediabetes/diabetes increased from 9% to 23%. A consistent dose-response increase in the prevalence of each of these CVD risk factors was observed by weight categories: the estimated 37%, 49%, and 61% of the overweight, obese, and normal-weight adolescents, respectively, had at least 1 of these CVD risk factors during the 1999 through 2008 study period.

CONCLUSIONS: The results of this national study indicate that US adolescents carry a substantial burden of CVD risk factors, especially those youth who are overweight or obese. *Pediatrics* 2012;129:1035–1041

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Cardiovascular disease (CVD) is the leading cause of death among adults in the United States. Although its overt manifestations, such as heart attack and stroke, do not usually emerge until adulthood, CVD risk factors are often present during childhood and adolescence.[1] A recent report indicated that 8% of US adolescents aged 12 to 19 years had high low-density lipoprotein cholesterol (LDL-C) in 1999–2006; similarly, 8% had a low high-density lipoprotein cholesterol (HDL-C) level.[2] Seven percent and 14% of US adolescents in 2001–2006 had prehypertension/hypertension and elevated fasting glucose, respectively, in the nationally representative study.[3]

Currently, the most prevalent CVD risk factors observed among adolescents are overweight and obesity. In 2009−2010, an estimated 34% of US adolescents aged 12 to 19 years were overweight or obese.[4] Overweight and obesity have negative health consequences that extend beyond excess body fat and cosmetic concerns. Research indicates that being overweight or obese may place adolescents at increased risk for CVD risk factors such as hypertension,[5] abnormal lipid levels,[6] prediabetes/diabetes,[7] and increased C-reactive protein.[8,9] Because CVD risks present during this period may track into adulthood,[10] it is important to have an understanding of the problem among adolescents. However, no information on recent trends and prevalence of biological CVD risk factors by weight status is available among US adolescents.

The current study focuses on CVD risk factors using nationally representative data to determine prevalence of biological CVD risk factors (prehypertension/hypertension, borderline-high/high LDL-C, low HDL-C, and prediabetes/diabetes) by weight status (normal weight, overweight, obese) and their trends among US adolescents aged 12 to 19 years. We also examine the clustering of these CVD risk factors among overweight and obese adolescents.

METHODS

Participants and Methods

The data used were from the NHANES, a nationally representative, continuous cross-sectional survey of the health and nutritional status of the US civilian, noninstitutionalized population. Annually, ~6000 persons are selected to participate by using a complex, multistage probability design. The survey oversamples non-Hispanic blacks and Mexican Americans. NHANES data are released in 2-year increments; this analysis was conducted with data from 5 cycles: 1999–2000, 2001–2002, 2003–2004, 2005–2006, and 2007−2008. Across all 5 cycles, 78% of those selected completed the physical examination component in an NHANES mobile examination center.

All participants in NHANES completed a standardized household interview and a detailed physical examination, including anthropometric and blood pressure measurements, and were invited to the mobile examination center. Those who were randomly assigned to the morning session, which required a fasting blood sample, were instructed to fast overnight for 8 to 24 hours. In the current study, only those who had fasted at least 8 hours before blood was taken were included in the fasting sample. Data for this group were weighted to account for the complex survey design and nonresponse. Participants 18 years and older provided written informed consent. For participants under 18 years, parents also provided written informed consent.

The initial combined sample for the 5 cycles included 10 397 adolescents who took part in home interviews and were examined at mobile examination centers. Of this group, 4174 were randomly selected to provide fasting blood samples for lipid and glucose testing. Those who reported being pregnant, had a positive urine pregnancy test (73), or were missing data (718) were excluded from the sample. The final analytical sample included 3383 adolescents (Table 1).

Measurement and Definitions of CVD Risk Factors

Weight Status

Using height and weight, which were obtained by trained interviewers during the physical examinations, and self-reported gender and age obtained during home interviews, adolescents were classified as being overweight or obese according to Centers for Disease Control age- and gender-specific percentiles for BMI.[11] Overweight was defined as having a BMI percentile of ≥85th and <95th percentile, and obesity was defined as being ≥95th percentile. Normal weight was defined as a BMI percentile ≥5th to <85th percentile. Underweight youth (BMI <5th percentile) were excluded from the analyses.

TABLE 1 Sample Demographic Characteristics, NHANES 1999–2008 (N = 3383)

Characteristic	*n*	%
Gender		
Male	1771	52
Female	1612	48
Current age, y		
12–13	903	24
14–15	814	25
16–17	874	27
18–19	792	24
Race/ethnicity		
Non-Hispanic White	936	64
Non-Hispanic Black	1041	14
Hispanic	1270	16
BMI[a]		
Normal wt	2142	66
Overweight	580	16
Obese	661	18

[a] Based on the 2000 Centers for Disease Control gender-specific growth charts for the United States. Available at www.cdc.gov/growthcharts. Overweight and obesity are defined as having a BMI within the 85th to <95th percentile or ≥95th percentile, respectively. Normal wt was defined as having an age- and gender-specific BMI >5th to <85th percentile.

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Prehypertension/Hypertension

Systolic (SBP) and diastolic (DBP) blood pressure were used to identify adolescents who were prehypertensive/hypertensive based on an average of up to 3 measurements that took place during the physical examination. For adolescents aged 12 to 17 years, guidelines established by the National Heart, Lung, and Blood Institute that were specific for age, gender, and height were used to define prehypertension and hypertension.[12] Prehypertension for this age group was defined as having a SBP or DBP reading that was ≥90th percentile to <95th percentile, and hypertension as having an SBP or DBP ≥95th percentile. Adolescents aged 18 to 19 years were classified as prehypertensive if they had an SBP ≥120 mm Hg to ≤139 mm Hg or a DBP ≥80 mm Hg to ≤89 mm Hg and hypertensive if they had a SBP ≥140 mm Hg or a DBP ≥90 mm Hg.

Abnormal Lipid Levels

Borderline-high, high LDL-C, and low HDL-C were defined with standards established by the National Cholesterol Education Program and the American Heart Association that were incorporated in the American Academy of Pediatrics (AAP) lipid screening guidelines for children and adolescents.[13] Adolescents were classified as having borderline-high or high LDL-C if their level was ≥110 to <129 mg/dL or ≥130 mg/dL, respectively. HDL-C levels <35 mg/dL were considered low.

Prediabetes/Diabetes

Recommendations from the American Diabetes Association were used to classify adolescents with prediabetes/diabetes.[14] Those with a fasting plasma glucose level >99 mg/dL to <126 mg/dL were classified as adolescents with prediabetes, and those with a level ≥126 mg/dL were classified as adolescents with diabetes. Given changes in the equipment used to measure glucose levels in the NHANES in the 2003–2004 study cycle, a correction factor was applied to fasting glucose data for the 2005–2006 (fasting glucose × 0.9838) and 2007–2008 (fasting glucose = 0.9838 × [fasting glucose − 1.139]) cycles to allow for accurate estimation of trends in the prevalence of prediabetes and diabetes.[1] Youth who reported that they were diagnosed as being diabetic were also classified as adolescents with diabetes.

Demographic Characteristics

Demographic characteristics, including gender, age in years, and race/ethnicity, were self-reported during the home interview; classifications were non-Hispanic white, non-Hispanic black, Hispanic, Asian/Pacific Islander, or other (eg, multiple races). Adolescents of Asian descent and those self-classified as other are included in the overall analyses, but individual estimates for these 2 groups are not reported because of the small samples, unstable estimates, and within group diversity.

Data Analysis

First, we estimated the population prevalence and standard errors of the demographic characteristics and the prevalence of BMI categories (normal, overweight, and obesity) for the entire sample (Table 1). Second, the proportion of adolescents with 1 of 4 CVD risk factors (prehypertension/hypertension, borderline-high/high LDL, low HDL, prediabetes/diabetes) was examined for the entire sample and then stratified based on BMI category (Fig 1). Third, we tested for differences in the prevalence of each of the 4 CVD risk factors previously mentioned and of overweight and obesity across the 5 study cycles (1999–2000 referent year) by using χ^2 tests (Table 2). Significant differences in the number of these 4 CVD risk factors (0, 1, 2, or ≥3 risk factors) as a function of weight status and demographic factors were assessed by using χ^2 tests (Table 3). The Bonferroni method was used to account for multiple comparisons. Finally, we assessed combinations of ≥2 of these 4 CVD risk factors (11 total possible combinations) among overweight and obese youth by examining their prevalence and clustering (Table 4). Analyses were conducted by using SUDAAN statistical software to account for nonresponse and the complex sampling design of NHANES. Given limitations in the availability and continuity of data available between 1999 and 2008 for diet, physical activity, and smoking, these factors were not examined.

RESULTS

Among the 3383 adolescents in the study, there were slightly more boys than girls (Table 1; weighted data), and age was evenly distributed over the 2-year categories. Nearly two-thirds were non-Hispanic whites, and 34% of the study group was overweight or obese. The overall prevalence for each of the 4 risk factors was >10%, with the exception of low HDL-C (Fig 1). Borderline-high/high LDL-C was the most prevalent risk factor overall (22%), and a dose-response increase was observed between abnormal LDL-C (ie, borderline-high or high) and weight classification, as percentages were 18%, normal weight; 28%, overweight; and 32%, obese. Similarly, dose-response increase with weight category was observed for prehypertension/hypertension, low HDL-C, and prediabetes/diabetes. In addition, a dose-response increase was observed between weight category and having ≥2 CVD risk factors. There was no significant change in the prevalence of overweight, obesity, prehypertension, hypertension, borderline-high LDL-C, or high LDL-C (Table 2), but a significant decrease in low HDL-C (from 9% to 3%; $P < .05$) was observed when comparing the prevalence of each risk factor in

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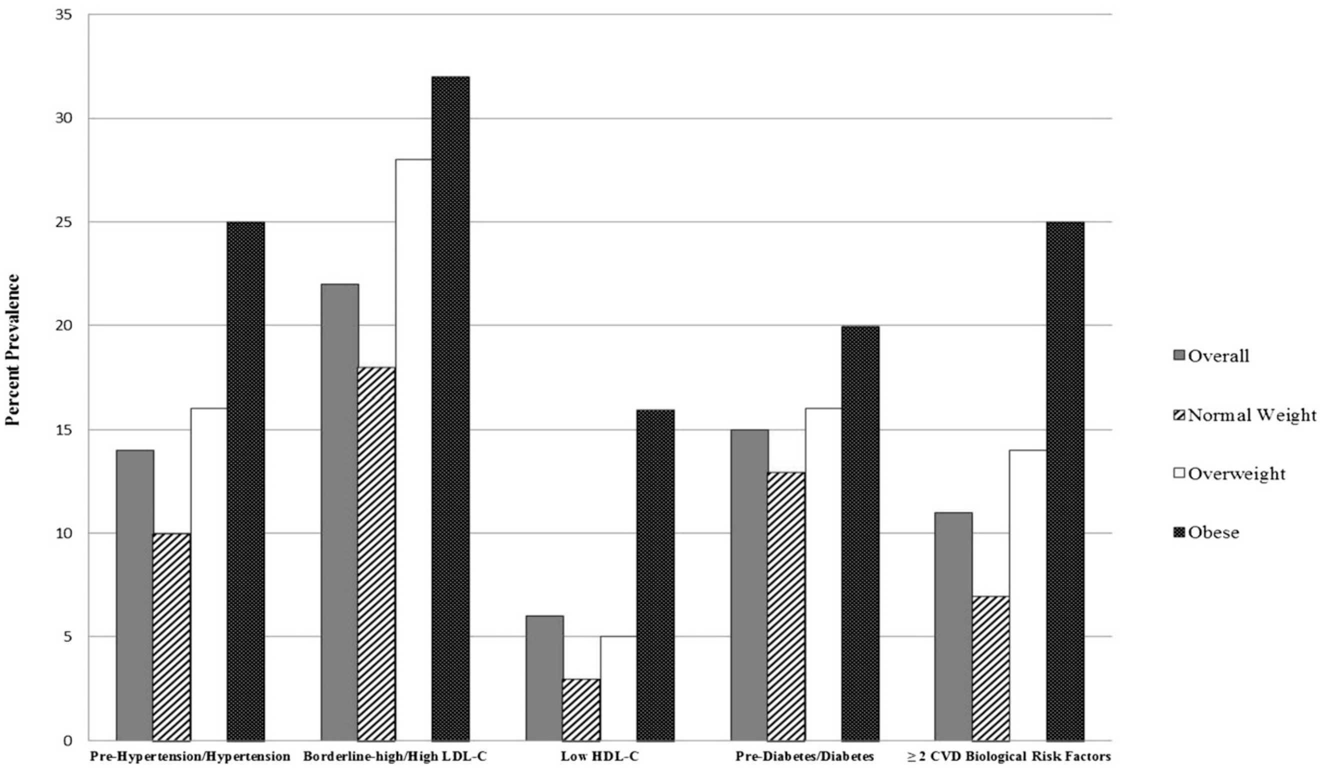

FIGURE 1
Prevalence of CVD risk factors among US adolescents, NHANES 1999–2008 (N = 3383). Based on the 2000 Centers for Disease Control gender-specific growth charts for the United States. Available at: www.cdc.gov/growthcharts. Overweight and obesity are defined as having a BMI within the 85th to <95th percentile or ≥95th percentile, respectively. Normal weight was defined as having an age- and gender-specific BMI >5th to <85th percentile.

TABLE 2 Distribution of BMI and Selected CVD Risk Factors Over Time Among US Adolescents, NHANES 1999–2008 (N = 3383)

Risk Factor	1999–2000 n = 788 % (SE)	2001–2002 n = 797 % (SE)	2003–2004 n = 744 % (SE)	2005–2006 n = 692 % (SE)	2007–2008 n = 362 % (SE)
BMI[a]					
Overweight	15 (1.54)	14 (1.78)	17 (2.02)	16 (1.69)	15 (2.81)
Obese	18 (2.66)	16 (1.21)	19 (3.01)	19 (3.09)	20 (2.99)
Blood pressure[b]					
Prehypertensive	12 (1.53)	11 (1.64)	10 (1.35)	12 (1.71)	10 (1.82)
Hypertensive	5 (0.89)	4 (0.97)	3 (0.74)	4 (1.38)	3 (0.91)
LDL-C[c]					
Borderline-high	14 (2.44)	18 (2.34)	13 (1.43)	15 (2.03)	13 (2.58)
High	9 (1.67)	9 (2.13)	6 (1.06)	7 (1.48)	6 (1.26)
HDL-C[d]					
Low	9 (1.47)	8 (0.94)	6 (1.42)	3 (1.41)*	3 (0.79)*
Fasting blood glucose[e]					
Prediabetes and Diabetes	9 (1.79)	15 (1.83)*	13 (1.99)	16 (1.87)*	23 (2.56)*

[a] Based on the 2000 Centers for Disease Control gender-specific growth charts for the United States. Available at www.cdc.gov/growthcharts. Overweight and obesity are defined as having a BMI >85th to <95th percentile or >95th percentile, respectively. Normal wt was defined as having an age- and gender-specific BMI >5th to <85th percentile.
[b] Blood pressure (for ages 12–17 y prehypertensive = systolic blood pressure (SBP) or diastolic (DBP) blood pressure ≥90th percentile to <95th percentile, and hypertensive = SBP or DBP ≥95th percentile; for ages 18 to 19 y prehypertension = SBP ≥120 mm Hg to ≤139 mm Hg or DBP ≥80 mm Hg to ≤89 mm Hg and hypertensive = SBP ≥140 mm Hg or DBP ≥90 mm Hg).
[c] Low-density lipoprotein cholesterol (high = LDL-C ≥130 mg/dL).
[d] High-density lipoprotein cholesterol (low = HDL-C <35 mg/dL).
[e] Fasting blood glucose >99 mg/dL or reported physician diagnosis as a patient with diabetes.
* $P < .05$.

1999–2000 to the prevalence of subsequent study cycles. During the same period, the prevalence of prediabetes/diabetes (combined given the small number of adolescents with diabetes) increased significantly (from 9% to 23%; $P < .05$). No other significant differences were found in the prevalence of each of 4 CVD risk factors within each combination of 2 study cycles (1999–2000 vs 2003–2004, 2001–2002 vs 2003–2004, etc). In all, 43% of adolescents had at least 1 biological CVD risk factor (Table 3). Significant differences were observed by demographic characteristics in the distribution of the number risk factors by adolescent gender, age, and BMI. Boys were more likely than girls to have 1, 2, or ≥3 risk factors. In addition, a higher percentage of older adolescents (18−19 years) had ≥2 risk factors than did the youngest adolescents (12−13 years). A consistent dose-response increase in the prevalence

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TABLE 3 Number of CVD Risk Factors Distributed Across Demographic Characteristics Among US Adolescents, NHANES 1999–2008 (N = 3383)

Demographic Characteristic	No. of CVD Risk Factors (Prehypertension/Hypertension, Borderline-High/High LDL-C, Low HDL-C, or Prediabetes/Diabetes)			
	0 (n = 1921) 57% % (SE)	1 (n = 1085) 32% % (SE)	2 (n = 299) 9% % (SE)	≥3 (n=78) 2% % (SE)
Gender				
Male (reference)	50 (1.87)	36 (1.40)	10 (0.88)	4 (0.75)
Female	65 (1.81)*	28 (1.64)*	7 (0.92)*	0.8 (0.34)*
Race				
Non-Hispanic white (reference)	57 (2.13)	32 (1.68)	9 (0.85)	3 (0.69)
Non-Hispanic black	55 (2.12)	33 (1.91)	10 (1.12)	2 (0.49)
Hispanic	58 (1.86)	32 (1.77)	8 (0.77)	2 (0.62)
Current age, y				
12–13 (reference)	55 (2.56)	34 (2.31)	9 (1.35)	2 (1.04)[a]
14–15	61 (2.68)	31 (2.66)	6 (1.27)	2 (0.82)
16–17	64 (1.96)*	28 (1.92)	7 (1.21)	0.9 (0.41)
18–19	46 (2.71)*	35 (2.40)	14 (1.21)*	5 (0.91)*
BMI[b]				
Normal wt (reference)	63 (1.54)	30 (1.33)	6 (0.75)	1 (0.28)
Overweight	51 (4.24)*	35 (3.48)	13 (1.93)*	2 (1.00)
Obese	39 (3.30)*	35 (2.95)	17 (1.83)*	8 (1.87)*

* $P < .05$.

[a] Relative SE estimate >50, estimate may be unreliable.

[b] Based on the 2000 Centers for Disease Control gender-specific growth charts for the United States. Available at www.cdc.gov/growthcharts. Overweight and obesity are defined as having a BMI within the 85th to <95th percentile or ≥95th percentile, respectively. Normal wt was defined as having an age- and gender-specific BMI >5th to <85th percentile.

TABLE 4 Patterns of CVD Risk Factors Among Overweight and Obese US Adolescents, NHANES 1999–2008 (n = 231)

Pattern	%	SE
BP[a]/LDL-C[b]	26	4.00
LDL-C/Diabetes[c]	18	3.72
BP/ Diabetes	13	3.26
LDL-C/HDL-C	11	3.05
BP/LDL-C/Diabetes	7	1.90
LDL/HDL-C/Diabetes	5	2.52
BP/LDL-C/HDL-C	5	2.24
BP/HDL-C	4	1.49
BP/HDL-C/Diabetes	4	1.68
BP/LDL-C/HDL-C/Diabetes	4	1.91
HDL-C/Diabetes	2	1.20[d]

From NHANES, 2005–2006 Data Documentation, Codebook, and Frequencies, www.cdc.gov/nchs/nhanes/nhanes2005-2006/GLU_D.htm. Accessed October 2010.

[a] BP (blood pressure) includes prehypertension and hypertension.

[b] LDL-C includes borderline-high and high LDL-C.

[c] Diabetes includes prediabetes and diabetes.

[d] Relative SE estimate >50, estimate may be unreliable.

of each of these CVD risk factors was observed by weight categories: the estimated 37%, 49%, and 61% of the overweight, obese, and normal-weight adolescents, respectively, had at least 1 of these CVD risk factors during the 1999–2008 period of study. A significantly greater proportion of overweight and obese adolescents (vs those of normal weight) had 2 risk factors, and obese youth but not their overweight peers were more likely to have ≥3 risk factors than were those of normal weight. There were no significant differences in the prevalence of various numbers of CVD biological risk factors based on race/ethnicity.

Of the 11 possible combinations of CVD risk factors examined among overweight and obese adolescents, the most common, prehypertension/hypertension (BP in table) and borderline-high/high LDL-C, accounted for just over one-fourth (Table 4). Other common combinations in this population included borderline-high/high LDL-C and prediabetes/diabetes, prehypertension/hypertension and prediabetes/diabetes, and borderline-high/high LDL-C and low HDL-C.

DISCUSSION

The results of this study indicate that US adolescents bear a substantial burden of risk factors for CVD. In our nationally representative study, 49% of the overweight and 61% of the obese adolescents had ≥1 CVD risk factors in addition to their weight status during the 1999–2008 period of study. We found that the prevalence of CVD risk factors among normal-weight adolescents was lower than among those who were overweight or obese, an estimated 37% of normal-weight adolescents had at least 1 CVD risk factor. Thus, the results presented here indicate that from a population level, a large proportion of adolescents, regardless of weight status, would benefit from interventions such as Let's Move[15,16] and programs that promote overall healthy lifestyles, including physical activity, healthy diet, and healthy weight maintenance.

Our findings are concerning given growing evidence demonstrating that CVD risk factors present during childhood may persist into adulthood.[10] Moreover, atherosclerosis, a complex, multifactorial disease that affects millions of adults, may be first observed in childhood as atherosclerotic changes on the arterial wall.[17] Carotid intima-media thickness, a measure of subclinical atherosclerosis, was found to be increased in children with CVD risk factors, especially if multiple risk factors were present.[18] However, the adoption of healthy lifestyle behaviors appears to be promising as a counteractive force. For example, results from the Cardiovascular Risk in Young Finns cohort, which consisted of 1809 subjects who were followed up for 27 years since baseline (1980, age 3–18 years), found that frequent fruit consumption plus high physical activity in childhood was associated with an increase in the HDL/LDL cholesterol ratio, a decrease in BMI from childhood to adulthood, and reduced progression of intima-media thickness.[19]

Our results indicating that the prevalence of prehypertension/hypertension and borderline-high/high LDL-C did not change from 1999–2000 to 2007–2008

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are encouraging. In contrast, we found that the prevalence of prediabetes/diabetes increased during this period, but this result should be interpreted with caution, given the approach used. We identified prediabetes/diabetes by using a single fasting blood glucose value, which may be a relatively unreliable measure in children.[20] Furthermore, a decrease in the prevalence of low HDL-C was observed, but whether this was a true decline is not known. The decrease may have been related to changes in the protocol used to determine HDL-C in NHANES.[21]

The plateauing of the prevalence of several CVD risk factors is not surprising when one considers that the prevalence of obesity, a frequent precursor to the risk factors examined here, did not increase significantly for most youth in our or another NHANES study.[4] Another state-level report has also indicated small declines in the prevalence of obesity among youth.[22] Results suggesting a leveling off or decline in obesity may be related to increased attention to and awareness of obesity in the general population. Obesity prevention efforts focusing on individual and environmental changes may have been beneficial in helping to control CVD risk factors among US adolescents. In a recommendation issued in 2010, the US Preventive Services Task Force proposed to screen children aged ≥6 years for obesity and offer/refer them to comprehensive, moderate to intense behavioral interventions for weight control.[23] In 2011, the AAP issued Expert Panel on Integrated Guidelines for Cardiovascular Health and Risk Reduction in Children and Adolescents.[10] The guidelines recommend classifying children's weight starting at age 2 years. Intensified diet and physical activity for 8 months is suggested for children aged ≥5 years with BMI percentiles ≥85.[10] Screening for diabetes is also recommended among all children 10 years and older with BMI percentiles ≥85, weight for height, or weight >120% of ideal for height by using fasting blood glucose.[10] Both guidelines, however, recommend using BMI percentiles[11] for screening overweight/obesity. Still, concern has been expressed that obesity is underrecognized and undertreated by pediatricians in primary care. According to a nationally representative survey, although 99% of respondents reported measuring height and weight at well visits, only 52% of them used BMI percentiles for children aged >2 years. Pediatricians in large practices and those with recent obesity training were more likely to screen for obesity by using BMI percentiles.[24]

Previous studies indicate that obese children are more likely than their peers to be screened for certain CVD risk factors,[25] but prehypertension/hypertension are often underdiagnosed.[26] This is disconcerting, given the recommendation by the National High Blood Pressure Education Program and the AAP that children >3 years have their blood pressure measured as part of any health care visit.[10,12] These guidelines also suggest differentiating between primary and secondary hypertension in all children with diagnosed hypertension through a comprehensive diagnostic panel. The limited availability of data in the NHANES study precluded us from distinguishing these 2 types of hypertension. However, a retrospective study using a different population found that primary hypertension was the most prevalent type of hypertension in children aged 8 to 18 years and that it often coexisted with a positive family history for hypertension, an elevated BMI, and hypercholesterolemia.[27] In our study, having a borderline-high/high LDL-C level was the most prevalent CVD biological risk factor for adolescents. The AAP expert panel recommends universal lipid screening for all children aged 9 to 11 years and adolescents 17 to 21 years using nonfasting or fasting blood samples.[10] For children 2 to 8 years and adolescents 12 to 16 years, lipid screening is suggested if there is a family history of premature CVD, high cholesterol, high BMI, diabetes, hypertension, or if youth smoke or have conditions predisposing to accelerated atherosclerosis and early CVD.[10] Thus, these recommendations addressed several concerns that have been raised previously regarding lipid screening in the pediatric population, including the low sensitivity of BMI or known family history as a criterion for cholesterol screening, changes in lipid concentrations during puberty, and using a nonfasting lipid profile for screening.[28] The US Preventive Services Task Force has recognized that the benefits and potential long-term harms of lipid screening, low-fat diets, and lipid-lowering medications among children have not been studied adequately. Accordingly, the Task Force has not made any recommendation for or against lipid screening among children and adolescents.[29]

Several limitations of this report should be considered. First, our examination of CVD risk factors was not exhaustive; we focused on biological risk factors only. The emergence of CVD is multifactorial and determined in part by biological risk factors; other factors such as family history and behaviors (eg, diet, physical activity, smoking) are also important but were not examined in this study because these behavioral risks were not available in this dataset for this time period. BMI percentiles and the other biological risk factors examined in this study lend themselves to easy, quick, and objective measurement of CVD risk in the clinical setting. The measurements of height and weight that we used to calculate BMI were standardized in our study, and BMI is highly correlated with fatness.

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However, there are other measures that may be better than BMI in predicting CVD risk factors in children and adolescents; specifically, measures of central obesity, including waist circumference and waist-to-height ratio, may be superior.[30] Finally, given the limited number of nationally representative studies reporting the prevalence of CVD risk factors stratified by adolescent weight status and variability in definitions and/or range of ages included, it is difficult to compare the results of this study regarding secular trends with previous research. This highlights the need for initiating surveillance of CVD risk factors among adolescents.

The results of this national study indicate that US adolescents carry a substantial burden of CVD risk factors, especially those youth who are overweight or obese. Adolescence represents a window of opportunity for assessment of CVD risk factors and the promotion of lifestyles that will affect the development and progression of CVD.

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