Original article

Trends and Clustering of Cardiovascular Health Metrics Among U.S. Adolescents 1988–2010 ☆

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A B S T R A C T

Purpose: American Heart Association recently published a set of seven cardiovascular (CV) health metrics for adults and children, emphasizing importance of preventing CV risk factors. Although CV disease risk factors have generally improved in adults, there is concern that this has not been true among adolescents. The present study examined trends and disparities of CV health metrics among U.S. adolescents.
Methods: We used data from a series of National Health and Nutrition Examination Survey (1988–1994, 1999–2004, and 2005–2010) including 11,233 adolescents aged 12–17 years. We estimated prevalence and mean score of CV health metrics and examined the disparities in mean score by sex, race/ethnicity, educational attainment, and poverty-income ratio.
Results: The prevalence of nonsmoking and healthy diet increased from 1988 through 2010, while the prevalence of normal body mass index and physical activity decreased, resulting in an unchanged distribution of overall CV health scores since 1988. The prevalence of adolescents meeting all seven CV health metrics was low, 3.5% (95% confidence interval [CI] 2.2–5.4), 4.0% (95% CI 3.3–4.8), and 4.0% (95% CI 2.9–5.3) in National Health and Nutrition Examination Survey 1988–1994, 1999–2004, and 2005–2010, respectively. The disparities in adjusted mean scores persisted between non-Hispanic whites and non-Hispanic blacks, families/households with >12 versus <12 years of education, and poverty-income ratio of >3 versus <3 ($p < .05$).
Conclusions: The proportion of adolescents achieving all seven CV health metrics was low and remained unchanged during 1988–2010. The disparities in mean CV health score persisted among adolescents.

Published by Elsevier Inc. on behalf of Society for Adolescent Health and Medicine.

IMPLICATIONS AND CONTRIBUTION

Despite improvements in some cardiovascular health metrics, the prevalence of adolescents who achieve all metrics has remained low since the 1980s. To improve adolescents' cardiovascular health, public health efforts should focus on promoting healthy dietary habits, increasing physical activity, and identifying cardiovascular health risks early.

Cardiovascular disease (CVD) is the leading cause of death in the United States and accounts for estimated annual direct and overall costs of $192.1 billion and $312.6 billion, respectively [1]. CVD risk factors in youth—smoking, obesity, elevated blood pressure, undesirable lipid profiles, and metabolic syndrome—have been associated with accelerated atherosclerosis in youth [2] and often continue into adulthood [3–5]. The American Academy of Pediatrics recently updated its guidelines for CV health and risk reduction in children and adolescents and emphasized the importance of early, or primordial, prevention of CVD risk factors

through various strategies, including promoting a healthy diet, greater participation in physical activity, and effective management of risk factors in children and adolescents [5]. In 2010, the American Heart Association (AHA) published recommendations aimed at improving CV health in United States by encouraging seven ideal CV health behaviors or factors (i.e., not smoking; being physically active; having normal weight, blood pressure, blood glucose, and total cholesterol levels; and eating a healthy diet) [6]. Several studies have examined the prevalence and trends in CV health metrics in adolescents and adult population [7–9], but recent information on trends in CV health metrics in adolescents is lacking. For the present study, we examined trends and disparities of CV health metrics among adolescents aged 12–17 years who participated in the National Health and Nutrition Examination Surveys (NHANESs) from 1988 through 2010.

Methods

National Health and Nutritional Examination Survey

NHANES consists of nationally representative sample surveys of the civilian, noninstitutionalized U.S. population. Data for NHANES were collected via household interviews and physical examinations. Detailed information is available elsewhere [10]. Before 1999, NHANESs were conducted on a periodic basis, but, beginning that year, the survey became continuous surveys. For the present study, we selected adolescents aged 12–17 years from NHANES 1988–1994, 1999–2004, and 2005–2010. Our analyses included 2,447 (1988–1994), 5,242 (1999–2004), and 3,544 (2005–2010) adolescents who were surveyed in Mobile Examination Centers (MECs), and for whom information was available on CV health metrics. In calculating CV health scores, we included all adolescents with complete information on all seven metrics (1,583 [1988–1994], 4,402 [1999–2004], and 2,892 [2005–2010], respectively). Figure 1 showed the flowchart of missing pattern for each CV health metric and selection of adolescents in the analysis. Adolescents who were excluded because of missing covariates for all seven metrics score analysis were in general similar to those included in the study in terms of age, sex, race/ethnicity, education, and poverty-income ratio (PIR; Supplementary Table 1). However, in NHANES III, a lower percentage of non-Hispanic white and adolescents with household head >12 years education was excluded, and in NHANES 2005–2010, a higher percentage of non-Hispanic black and a lower percentage of Mexican American were excluded from the study ($p < .05$).

Definitions of cardiovascular health metrics

We used the modified AHA definitions of ideal, intermediate, and poor CV metrics because of changes in the questionnaires across NHANESs or lack of information for some metrics. Supplementary Table 2 provided the detailed information and explanation of the CV health metrics used in the present study.

Smoking status. For adolescents aged ≥12 years, the questionnaires about smoking status changed substantially across the NHANESs; therefore, we used the gender- and race/ethnicity-specific cutoff points of cotinine concentrations to classify adolescents as noncurrent smokers versus nonsmokers [11]. For male adolescents, the cutoff points of cotinine concentrations were 8.78, 6.01, and 1.18 for non-Hispanic white, non-Hispanic black, and Mexican American, respectively. The corresponding

cutoffs for female adolescents were 2.95, 2.81, and .66, respectively. The overall sensitivity of using cotinine to classify smoking status was 86.5% and specificity 93.1%.

Physical activity. Physical activity questionnaires varied in collection of participation, frequency, and duration of physical activity across NHANES cycles. Questionnaires to assess the AHA recommended physical activity levels were not available; thus, physical activity was assessed at its most basic level: those reporting no activity (i.e., inactive) versus those reporting some activity over the assessed period. In NHANES 1988–1994, those with <1 time per week were categorized as inactive. In NHANES 1999–2006 and 2007–2010, the recall period varied, but information on participation, intensity, frequency, and duration of physical activity was available. Those reporting no physical activity or physical activity below minimum thresholds (<10 minutes in a typical week; <40 minutes in past 30 days) were categorized as inactive. We conducted additional sensitivity analyses across NHANES cycles, both with consistent physical activity assessment (1999–2004 and 2005–2006) and with physical activity removed from CV health metrics categories. The results are listed in Supplementary Table 3.

Body mass index. Body mass index (BMI) was calculated as weight (kg)/height (m^2). To account for variability by age and sex, we compared BMI in adolescents with age- and sex-specific reference values from the 2000 Centers for Disease Control and Prevention (CDC) growth charts [12]. BMI for age of ≥85th to <95th percentiles was defined as overweight, and ≥95% percentile as obese, and <85th percentile as ideal BMI.

Healthy diet score. The AHA healthy diet score includes the following five components: consumption of fruits and vegetables (≥4.5 cups/day), fish (≥2 3.5-oz servings/week), fiber-rich whole grains (≥3 1-oz equivalent servings/day), sodium (<1,500 mg/d), and sugar-sweetened beverages (<36-oz/week). The NHANES Food Frequency Questionnaire, used to estimate the recommended healthy diet score, was not administered in NHANES 2007–2008 and 2009–2010. Therefore, we used the Healthy Eating Index-2010 (HEI-2010) that was designed to assess multiple aspects of diet quality as described by key recommendations of the *2010 Dietary Guidelines for Americans* [13]. The HEI-2010 has 12 components representing all major food groups, including fruits, vegetables, grains, milk, meat and beans, oils, saturated fat, sodium, and calories from solid fats, alcoholic beverages, and added sugars. Food components are given maximum and minimum points per 1,000 calories, and the total score ranges from 0 to 100, a higher score indicating a more healthy diet. A detailed description of the HEI-2010 has been published previously [14]. We merged the NHANES 1988–1994 and 1999–2002 individual food files with the MyPyramid Equivalents Database (MPED) version 1 and NHANES 2003–2004 and 2005–2010 files with MPED version 2 to calculate HEI-2010 [15,16]. Of 5,440 unique United States Department of Agriculture (USDA) food codes in NHANES 2005–2010, 5,030 were also in MPED version 2. We matched the remaining 410 foods to the most similar foods. For example, the food code 21501350 (ground beef, 90%–94% lean, cooked) was matched to the nearest food code 21501300 (ground beef, 80%–84% lean, cooked). Dietary information was obtained from in-person 24-hour dietary recalls, and nutrient intake was estimated using the corresponding Food and Nutrient Databases for Dietary Studies from the USDA [17]. Twenty-four–hour dietary recalls are considered among the most precise