AHA Scientific Statement

Primary Prevention of Cardiovascular Disease in Nursing Practice: Focus on Children and Youth

A Scientific Statement From the American Heart Association Committee on Atherosclerosis, Hypertension, and Obesity in Youth of the Council on Cardiovascular Disease in the Young, Council on Cardiovascular Nursing, Council on Epidemiology and Prevention, and Council on Nutrition, Physical Activity, and Metabolism

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Cardiovascular disease (CVD) is a leading cause of morbidity and premature mortality in women and men in the United States, most of the industrialized world, and many developing countries.[1] Data accumulated over the past 3 decades indicate that atherosclerotic-CVD processes begin early in childhood and are influenced over the life course by genetic and potentially modifiable risk factors and environmental exposures. Taken together, these data provide compelling evidence for primary prevention of CVD beginning early in childhood. Within the pediatric healthcare community, this evidence has prompted and informed the development of science-based guidelines with recommendations for individual/high-risk and population-based approaches to primary prevention of CVD in children and youth. The purpose of this statement is to provide an overview of the evidence and current science-based recommendations and to emphasize the role of advanced practice nurses in the implementation of strategies consistent with population-based and individual/high-risk approaches to CVD prevention in children and youth.

Evidence for CVD Prevention in Childhood

Evidence-based guidelines for primary and secondary prevention of CVD in adults are informed by the results of randomized controlled trials. The existing evidence (discussed below) argues convincingly for prevention of CVD beginning early in childhood. It is noteworthy that data from randomized controlled trials documenting the effect of risk reduction in childhood on the development of CVD in adulthood are nonexistent. Similarly, no long-term longitudinal studies have been conducted to determine the absolute levels of risk factors measured in childhood that predict CVD in adult life. However, evidence from laboratory, clinical, and epidemiological studies supports the need for primary prevention of CVD beginning early in life and has prompted and informed existing guidelines for children and adolescents.

Laboratory/Pathology and In Vivo/Clinical Studies

Autopsy studies conducted as part of the Bogalusa Heart Study[2,3] and the Pathobiological Determinants of Atherosclerosis in Youth (PDAY) Study[4,5] demonstrate significant positive associations between potentially modifiable CVD risk factors and the presence and extent of atherosclerotic lesions in the aorta and coronary arteries.[2–5] In the pathology component of the Bogalusa Heart Study, a long-term epidemiological study of risk factors for CVD in a biracial (black-white) population, risk factors were measured in free-living, healthy children and adolescents before death from non-CVD causes.[2,3] The PDAY study quantified risk factors by analyses of postmortem blood samples obtained at autopsy from ≈3000 persons 15 to 34 years of age who died from external causes, including accidents and homicides.[4,5]

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Findings from PDAY[4,5] and Bogalusa[2,3] confirmed the positive associations between modifiable risk factors, including hypertension, tobacco use, obesity, atherogenic lipids (non–high-density lipoprotein cholesterol [HDL-C]), and the presence and extent of arterial lesions and the negative association of cardioprotective HDL-C with these lesions.[2–5] More recently, noninvasive imaging has been used to examine the association of risk factors for CVD and vascular structure and function in childhood and adolescence and atherosclerosis in young adult life. Investigators from the Muscatine Study, a landmark longitudinal, observational study of CVD risk factors in children and youth, used carotid ultrasound in adults 33 to 42 years of age and found that carotid intima-media thickness was positively associated with levels of total serum cholesterol and body mass index (BMI) measured in childhood.[6] Similar results were observed in Bogalusa: childhood low-density lipoprotein cholesterol (LDL-C) level and BMI predicted increased carotid intima-media thickness in adulthood.[7] Results from the Young Finns Study reaffirm the link between risk factor exposures (including LDL-C, BMI, cigarette smoking, and systolic blood pressure [SBP]) in 12- to 18-year-old adolescents and preclinical atherosclerosis in adulthood.[8] Results from this population-based prospective cohort study of 2229 young adults 24 to 39 years of age are noteworthy because risk factors present in adolescence predicted adult common carotid intima-media thickness independently of contemporaneous risk factors.[8] Data from other noninvasive studies of adolescents and young adults are consistent with these results indicating that intraindividual clustering of multiple risk factors adversely affects carotid intima-media thickness during these developmental periods.[9,10]

Taken together, the results of laboratory/pathology studies and more recent noninvasive studies provide convincing evidence of the link between established potentially modifiable risk factors and accelerated atherosclerotic processes in adolescence and adulthood and support the need for primary prevention beginning early in life.

Epidemiological Studies

Several sources, including the National Health and Nutrition Examination Surveys (NHANES),[11] the Centers for Disease Control and Prevention–Youth Risk Behavior Surveillance Surveys (CDC-YRBSS),[12] the National Heart, Lung, and Blood Institute (NHLBI),[13] and the American Heart Association (AHA),[1] provide nationally representative data on the distribution, prevalence and trends, and tracking of major risk factors and CVD-related health behaviors in children and youth. Data on potentially modifiable risk factors and behaviors, which are essential for the development of both individual and public health approaches to primary prevention, are presented below.

Lipids and Lipoproteins

Population-based data from the Lipid Research Clinics indicate that serum lipids and lipoproteins increase throughout the first 2 years of life and reach young adult levels by 2 years of age.[14] Partly on the basis of these observations of non-Hispanic white and black males and females, the National Cholesterol Education Program[15] issued the first guidelines for assessing the lipid profile and recommended selective screening for high-risk children (as defined by family history of premature CHD or parental dyslipidemia) after 2 years of age.

Population-based data from NHANES III (1988–1994) indicate that among children and adolescents (4 to 19 years old), the mean total cholesterol (TC) was 165 mg/dL. The mean age-specific values for TC peaked at 171 mg/dL just before puberty at 9 to 11 years of age and decreased thereafter.[11] Females had significantly higher mean TC and LDL-C than males. Children and adolescents classified as non-Hispanic black had higher LDL-C and cardioprotective HDL-C compared with those classified as non-Hispanic white or Mexican American.[11] Approximately 10% of adolescents (12 to 19 years old) had TC levels >200 mg/dL. An analysis of time trends for adolescents 12 to 17 years of age revealed a decline in mean TC of 7 mg/dL from 1966–1970 to the 1988–1994 survey.[11] A similar but greater decline has been observed in adults, providing evidence of a strong prevention effect in the United States from 1959 to 1994.[16] However, data from NHANES 1999–2000 indicate that mean levels of TC for children and adolescents (4 to 17 years old) have remained relatively unchanged since NHANES III.[17] The Figure illustrates trends in mean TC observed in adolescents (12 to 17 years old) in the NHANES surveys.

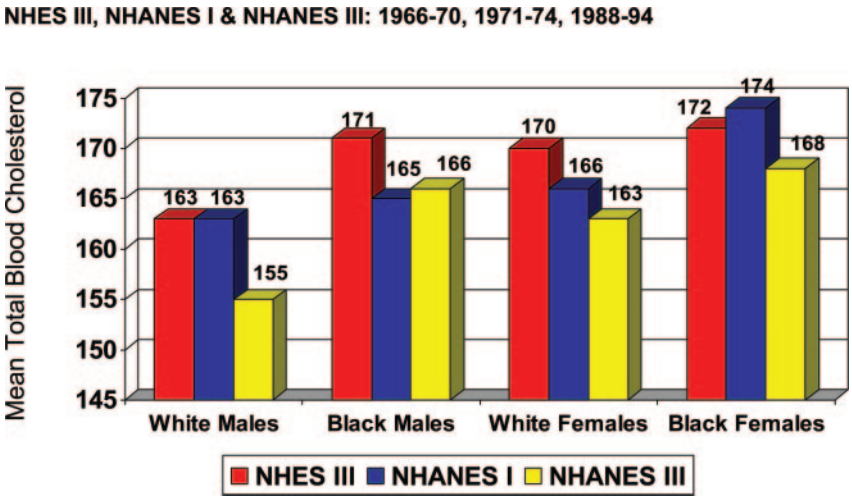

Figure. Trends in mean total blood cholesterol among adolescents 12 to 17 years of age by sex, race, and survey. NHES indicates National Health Examination Surveys.

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Although population-based prevention efforts aim to lower the distribution of TC and LDL-C for all children and adolescents, cut points for acceptable, borderline, and high levels have been established for assessment of individuals between the ages of 2 and 19 years as follows: acceptable (TC <170 mg/dL; LDL-C <110 mg/dL); borderline (TC 170 to 199 mg/dL; LDL-C 110 to 129 mg/dL); and high (TC ≥200 mg/dL; LDL-C ≥130 mg/dL).[15] Baseline data (collected in 1991) in the Child and Adolescent Trial for Cardiovascular Health (CATCH) indicated that 13.3% of children in the fourth grade in 4 geographic areas in the United States had TC levels ≥200 mg/dL, with a higher percentage of girls (15.6%) than boys (11.1%) at this high level. A higher prevalence of elevated TC was observed for African American (17.4%) than Anglo-American (12.5%) or Latino (13.2%) subjects.[18] A similar overall percentage (12.6%) was observed for 8- to 10-year-old subjects in the Cardiovascular Health in Children (CHIC) baseline study (conducted in the early 1990s) in North Carolina; however, gender differences were not pronounced. The CHIC study confirmed a higher percentage of African American children (18.7%) with high TC compared with Anglo-American children (11%) and others (11.8).[19]

Examining gender and ethnic/racial group differences in lipids and lipoproteins across broader age ranges is more complex. Longitudinal follow-up of children and adolescents in Project HeartBeat! in Texas demonstrated that development has a profound impact on TC values and that these developmental patterns are different for males and females.[20] Recent longitudinal evidence from 2 biracial cohort studies is consistent with these observations indicating that pubertal stage affects estimated prevalence of dyslipidemia as defined by current single cut points.[21] Age-gender patterns are further complicated by the fact that African American children have, on average, an earlier onset of sexual maturation than other racial/ethnic groups in the United States.[22]

Taken together, these observations underscore the need to reexamine current recommendations for assessment and management of the lipid profile in children and adolescents. Attention to the documented influences of gender, race/ethnicity, and sexual maturation on lipids and lipoproteins is likely to increase the sensitivity and specificity of screening and improve management of dyslipidemia as part of CVD risk reduction for children and youth.

Tracking of lipids and lipoproteins, particularly TC and LDL-C from childhood to young adulthood, has been observed in males and females from diverse racial/ethnic groups and is particularly evident in the upper and lower extremes of the distribution. In the Muscatine Study, 75% of children who were 5 to 18 years of age at baseline and had TC levels greater than the 90th percentile had elevated TC (≥200 mg/dL) at 20 to 25 years of age.[23,24] Bogalusa data indicate that ≈70% of children with elevated TC in childhood persisted with elevated levels in young adulthood.[25] Tracking, maintenance of percentile rank over time, is relevant to primary prevention because of the potential for identifying children at risk for future CVD.

Blood Pressure

Compared with NHANES III (1988–1994),[26] results from the most recent survey (1999–2000) of 5582 black, Hispanic, and white children 8 to 17 years of age indicate substantial increases in SBP and diastolic blood pressure (DBP) for all age, race/ethnic, and gender subgroups examined.[27] In NHANES III, children's mean SBP was 104.6 mm Hg, and mean DBP was 58.4 mm Hg.[26] In the most recent survey, children's mean SBP was 106 mm Hg, and mean DBP was 61.7 mm Hg.[27] Adjustment for the BMI distribution in 1988–1994 and 1999–2000 reduced the increases in SBP and DBP by 29% and 12%, respectively.[27] These results suggest that increases in BP in US children and youth are partially attributable to the increases in the prevalence of overweight. Other data underscore the clinical significance of these adverse trends indicating that, for each increment of 1 to 2 mm Hg in SBP, children have a 10% greater risk of developing hypertension in adulthood.[28] Additionally, modest elevations in BP levels in childhood have an adverse effect on vascular structure and function, with target organ damage (ie, left ventricular hypertrophy) documented in hypertensive children and adolescents.[29,30]

Although African American adults have significantly higher levels of blood pressure (BP) and higher prevalence and mortality from CVD, ethnic group differences in BP among children and adolescents are not evident in all studies and when present have produced conflicting results.[31] Detailed studies with ambulatory BP monitoring indicate that differences between African and European American adolescents in levels and diurnal patterns of BP are evident, but some of these differences are accounted for by other variables such as body size, sexual maturation, and socioeconomic status.[32,33] Few studies have included adequate numbers of Hispanic American children and adolescents to allow for subgroup analysis. An exception is a study of 7207 children 5 to 17 years of age that included Mexican American (58.2%), African American (13.2%), and non-Hispanic white children (28.3%).[34] There were no consistently significant differences in SBP or DBP across ethnic/racial groups.[34] Recent NHANES data, however, indicate slightly higher levels of BP among Mexican American youth (8 to 17 years of age) compared with their non-Hispanic white counterparts.[27] Analysis of pooled data from large national studies in the United States revealed an interaction between BMI and ethnic group; these interactions were different for SBP and DBP and not consistent across age and gender groups. In general, at lower levels of BMI, black youth had higher SBP and DBP, whereas at higher levels of BMI, white youths had higher SBP and DBP.[31]

Tracking of BP during childhood and adolescence and from childhood to adulthood tends to be weaker and more disparate for BP than for other risk factors for CVD, largely because of the inherent variability of BP. Nevertheless, elevated BP in childhood predicted hypertension in young adulthood for participants in the Bogalusa Heart Study.[35] Similarly, with the use of data from an East Boston cohort and by averaging BP measurements over several years during childhood, tracking correlations for SBP were 0.55 in boys

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TABLE 1. Percentage of Children and Adolescents Who Are Overweight*

		NHANES Examination Year				
Age, y	Race/Ethnicity	1971–1974	1976–1980	1988–1994	1999–2002†	2003–2004†
6–11	Non-Hispanic white	4%	6%	11%	13%	18%
	Non-Hispanic black	4%	9%	15%	20%	22%
	Mexican American	6%	11%	17%	22%	22%
12–17‡	Non-Hispanic white	6%	4%	11%	13%	17%
	Non-Hispanic black	8%	8%	13%	22%	22%
	Mexican American	9%	8%	14%	25%	16%

*Overweight is defined as a BMI for age and sex greater than or equal to the 95th percentile. For all years except 2003–2004, adolescents were also coded as overweight if their BMI was ≥30 kg/m^2, even if it was below the 95th percentile.

†Data derived with permission from Ogden et al.[49]

‡Age range is 12–19 years for 2003–2004.

and 0.66 in girls, and for DBP, were 0.47 for boys and 0.57 for girls.[36]

Although not common in children, primary hypertension has been observed, is usually characterized by mild or stage 1 hypertension, and is often associated with family history of this risk factor and/or CVD.[29,37] As documented in the most recent NHANES,[27] overweight and obesity are positively associated with elevated BP levels in childhood and adolescence. Data from school health screening programs indicate a progressive increase in the prevalence of hypertension with increases in BMI.[38] Intraindividual clustering of CVD risk factors, including low HDL-C, elevated triglycerides, hyperinsulinemia, and truncal obesity, has been observed in children with elevated BP.[39–42]

Collectively, these results have informed recent guidelines for clinical practice that place emphasis on comprehensive assessment of the CVD risk factor profile in children and youth with elevated levels of SBP and/or DBP.[42] These guidelines, the Fourth Report on the Diagnosis, Evaluation, and Treatment of High Blood Pressure in Children and Adolescents, were published in 2004.[42] They also recommend that children ≥3 years of age have their BP measured when seen in a medical setting. Correct methods of measurement are described in this report along with recommended dimensions for BP cuff bladders.[42] Assessing whether a BP level of a child is elevated is difficult in that the standards for SBP and DBP are specific for age, gender, and percentile of height. Interpretation is facilitated by free software available from the NHLBI, which can be downloaded to a personal digital device.[43] Assessment of BP in children is further complicated by the necessity of confirming an elevated BP on multiple occasions before characterizing a child as having hypertension.[42]

BMI, Adiposity, and Related Comorbidities

For children in the United States, the CDC age- and gender-specific nomograms are used to monitor patterns of growth and define overweight and obesity.[44] On the basis of cross-sectional data from sequential measurements of representative samples of US children, cut points (by age and gender) are defined as follows: normal weight (BMI percentile >5th and <85th); at risk for overweight (BMI percentile between 85th and 95th); and overweight (BMI percentile ≥95th).[44,45] It is noteworthy that some recent reports, including a report issued by the Institute of Medicine, classify children with BMI ≥95th percentile as obese.[46]

Recognized as a major risk factor for CVD in adulthood, overweight and obesity in children and adolescents in the United States (and globally) have become major public health challenges.[47–49] With overweight defined as a BMI for age and gender ≥95th percentile, data from the most recent NHANES (2003–2004) indicate that 17.4% of adolescents (12 to 19 years old) and 18.8% of children (6 to 11 years old) are overweight.[49] During 1999–2004, significant time trends were also observed for male and female children and adolescents, with increases in overweight prevalence from 13.8% to 16.0% and from 14.0% to 18.2% in female and male children and adolescents, respectively. As illustrated in Table 1, across the past 3 NHANES reports and consistent with other data, higher prevalence of excess BMI has been observed in non-Hispanic black and Mexican American children and adolescents compared with their non-Hispanic white counterparts.[49]

Particularly important from a CVD prevention perspective are the documented comorbidities associated with overweight in children, including atherogenic dyslipidemia, hypertension, left ventricular hypertrophy, insulin resistance, and the clustering and tracking of risk factors recognized as metabolic syndrome in adults.[50–56] Although controversy exists regarding the specific components, cut points, and clinical utility of defining metabolic syndrome in children and youth, studies have estimated prevalence rates using Adult Treatment Panel III criteria adapted for pediatric populations. Accordingly, a report from NHANES III estimated that 1 million US adolescents meet the criteria for metabolic syndrome, with an estimated population prevalence of 4%.[52] In overweight children and youth, prevalence estimates range from 30% to 50%.[52,53,55]

With the use of the Adult Treatment Panel III criteria, a recent longitudinal assessment of predictors of metabolic syndrome in black and white females (18 to 19 years old) from the NHLBI Growth and Health Study indicated a prevalence of 3.5% and 2.4% in black and white females, respectively, in adolescence.[57] Results of multivariate analysis indicated that central adiposity, as measured by waist circumference at baseline (9 to 10 years of age), was a significant predictor of metabolic syndrome. Racial differ-

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ences in prevalence of components of metabolic syndrome were observed; increases in body size, central adiposity, and SBP and DBP in black females exceeded those observed in white females.[57] However, the increase in insulin sensitivity (as defined by homeostasis model assessment–insulin resistance scores), consistent with completion of puberty, reduced the risk of metabolic syndrome. Racial differences in triglyceride levels were observed, with considerable increases from baseline noted in white females only. The contribution of adverse levels of triglycerides as a defining component of metabolic syndrome was less in black females than in their white counterparts. Patterns observed in adiposity-triglyceride associations at follow-up (18 to 19 years of age) suggest racial differences in triglyceride metabolism and warrant further research.[57]

Paralleling the increases observed in the prevalence of overweight/obesity is the increase in type 2 diabetes mellitus in youth. A recent report that combined results from population-based studies and clinical case series conducted in North America, Europe, and the Asian-Pacific region documents a global spread of type 2 diabetes mellitus.[58] Although type 2 diabetes mellitus accounted for ≈3% of incident cases of diabetes in youth in 1990, combined results from this report indicate that 45% of new cases of diabetes in youth are type 2 diabetes mellitus.[58] The patterns and trends observed (by geographic region, ethnicity, and culture) suggest that attention to the epidemiology of this chronic condition in adults may assist in predicting incident type 2 diabetes mellitus in youth. Limitations in differential diagnosis and classification (type 1 versus type 2 diabetes mellitus) notwithstanding,[58] results are consistent with obesity–type 2 diabetes mellitus associations documented in other clinical and population-based studies.[59,60]

Taken together, these results suggest the potential for manifest CVD earlier in adult life for our current generation of children and youth and underscore the critical importance of primary prevention of overweight/obesity as part of a comprehensive profile approach to cardiovascular health and CVD risk reduction in childhood. They also suggest the need for increased attention to ethnic, cultural, and gender-related factors and issues in tailoring individual approaches to preventive interventions.

Health Behaviors

The cornerstone of cardiovascular health promotion and risk reduction in childhood and adolescence is healthy lifestyle behaviors and therapeutic lifestyle change. Recent population-based prevalence and trend data on health behaviors central to current recommendations, however, provide cause for concern. Although some positive trends have been observed in tobacco use, a recent (2006) report from the Office of National Drug Control Policy indicated that 730 000 adolescent girls and 565 000 adolescent boys in the United States initiated cigarette smoking in 2004.[61] Early adolescence is recognized as a critical period for smoking initiation; ≈80% of persons who use tobacco begin before the age of 18 years.[61,62]

Data from CDC-YRBSS for 2003 indicate that 30.3% of male high school students and 24.6% of female students use tobacco.[63] A very recent report from CDC-YRBSS indicates that the prevalence of lifetime, current, and frequent cigarette use among high school students remains basically unchanged from 2003 to 2005.[64,65] Several surveys of adolescents in the United States indicate racial/ethnic and gender differences in patterns of tobacco use. A consistent observation across recent CDC and NHANES surveys is higher prevalence of tobacco use for non-Hispanic whites compared with their non-Hispanic black and Hispanic counterparts.[63–65] Among high school students, CDC data indicate a higher percentage of current cigarette use among black males (19.3%) than black females (10.8%).[63] This survey, based on 2003 data, also indicated high prevalence (26.6%) of current smoking in non-Hispanic white females.[63] Data from the most recent survey indicate persistence in gender and ethnic differences in current cigarette use, with no significant changes observed except for black males, whose current use declined from 19.3% to 14.0%.[65] Socioeconomic status emerged as an important predictor of tobacco use in the analysis of Winkleby et al[66] of NHANES data, with higher prevalence observed among youth of lower socioeconomic status.

Although the determinants of smoking initiation in youth are multifaceted and include individual and familial factors, the role of broader socioecological influences and multilevel policies cannot be overemphasized. For example, statewide tobacco control programs have been instrumental in preventing smoking initiation. In California, where intense tobacco control and prevention programs were implemented in 1990, the proportion of 12- to 17-year-old persons who reported never smoking increased from 60% of males and 66% of females in 1990 to 70% of both males and females in 1999. From 2002 to 2004, however, overall statewide spending on tobacco prevention and control programs declined by 28% in the United States.[67] Program cuts exceeded 75% in some states, including Minnesota, where reductions were associated with decreased awareness of the antitobacco campaign and a substantial increase in smoking susceptibility in youth.[68]

As emphasized in pediatric guidelines for cardiovascular health and CVD risk reduction, patterns of dietary intake and physical activity for a majority of children and adolescents are not meeting current recommendations.[65,69–71] Data indicate adverse trends in food consumption, particularly among older school-aged children and adolescents.[65,72–74] These trends include reduction of high-fiber fruits and vegetables and dairy products consumed and increased consumption of nutrient-poor foods and sweetened beverages and increased percentage of total calories from snacks.[65,72–74] In adolescents, these changes in dietary patterns have resulted in median intakes below the recommended values of several micronutrients, including calcium and potassium, and sodium intakes that are well above recommended levels.[63,65,74] Data from the US Department of Agriculture (2005) also document dietary deficiencies (in male and female children and adolescents) in micronutrients necessary for healthy immune and metabolic functions, including magnesium, iron, zinc, and vitamins B_6, C, D, and E.[71]

Similarly, adverse trends in physical education and patterns of leisure-time physical activity have been documented,

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particularly among adolescent girls. Recent (2005) data from the CDC indicate that only 54.2% of students nationwide are enrolled in physical education classes on 1 or more days of an average school week, and 33.0% are enrolled in daily physical education.[65] Nationwide, 35.8% of students reported the recommended levels of moderate to vigorous physical activity of at least 60 minutes per day on at least 5 days per week.[65] The prevalence of meeting this recommendation was higher among male (43.8%) than female (27.8%) students and lowest in black females (21.3%).[65] Consistent with results from the CDC,[65] a population-based study of black and white girls documented substantial declines in leisure-time physical activity throughout adolescence; by age 18 or 19 years, 56% of black girls and 31% of white girls reported no habitual recreational activity.[75]

Sedentary behaviors such as television viewing are considered risk factors for obesity in children and adolescents. On the basis of data linking these sedentary behaviors with overweight in childhood and adolescence and data indicating that reduction in viewing time can be an effective strategy for improving weight status,[76–78] current recommendations limit television viewing (and other sedentary behaviors) to <2 hours per day.[79] Current national estimates, however, indicate that 37.2% of students watched television at least 3 hours per day on an average school day.[65] The prevalence of this behavior was higher among black (64.1%) than white (29.2%) and Hispanic students (45.8%).[65] As discussed below, these health behavior data support the need for population-based as well as individual approaches to cardiovascular health promotion and CVD risk reduction in children and adolescents.

Promoting Cardiovascular Health and Reducing Risk for CVD in Children and Youth

Background

Primary prevention of CVD beginning in childhood includes and encompasses both cardiovascular health promotion and reduction of established, modifiable risk factors for CVD.[79] Primordial prevention goes beyond prevention of risk factor development in children and refers to "preserving risk-factor free societies from the penetration of risk factor epidemics."[80] This level of prevention addresses the societal and environmental conditions that foster risk factor development. Two main strategies are recommended for prevention of CVD across the life course, including children and adolescents. Population-based (or public health) approaches are designed to move the population distribution of risk factors to lower, more desirable levels. The rationale supporting this approach is that the vast majority of cases of CVD arise from the broad middle range of the distribution of risk factors. Thus, concentrating only on those with extreme values may prevent or delay disease in a relatively small segment of those at risk.[81] Individually oriented approaches are designed to identify and manage children and youth at highest risk for atherosclerotic disease. These strategies are complementary in CVD prevention and are frequently implemented in tandem in pediatric clinical (and community-based) settings. Central to the population approach and a major cornerstone of CVD risk reduction for children and adolescents with identified risk factors is adoption of healthy lifestyle behaviors. As reflected in guidelines and statements issued by the AHA,[79,82,83] the American Academy of Pediatrics,[84] and numerous expert panels, emphasis is placed on healthy lifestyle training to promote cardiovascular health in childhood; to normalize levels of identified, modifiable risk factors; and to reduce the risk and burden of CVD in adult life. As discussed below, nurses, including advanced practice nurses and nurse practitioners, equipped with the evidence base in prevention, developmental life course, and behavioral science and the respective skill sets and competencies are well prepared to implement strategies consistent with both individual and population-based approaches to CVD prevention in children and youth.

Population-Based Approaches to CVD Prevention

Population-based or public health approaches normally involve interventions at the community level, such as the CVD prevention trials implemented in the United States and Sweden during the 1970s.[85] Schools, preschools, and other community-based settings in which child care is provided are important venues for implementing population-based strategies in children and adolescents. As detailed in integrative reviews,[86–89] school-based interventions have been effective in conveying knowledge and improving attitudes and CVD-related health behaviors; however, the influence of multicomponent interventions on physiological risk factors for CVD, including dyslipidemia and obesity, has been less than optimal and variable across studies.[86–89] Lessons learned from methodologically rigorous and resource-intensive randomized controlled trials clearly indicate the importance of developmentally appropriate, culturally sensitive individual (student-level) interventions combined with modifications of the school food and physical activity environments.[90] Additional research is needed, however, to define the duration, intensity, and specific intervention elements relevant to physical activity and dietary modification necessary to reduce physiological risk factors (ie, overweight) as part of school-based interventions. In addition, as currently emphasized in social-ecological models of health, attention to the multiple levels of environmental influences (including regulatory policies) will be necessary to promote and sustain healthy patterns of behavior across the life course of individuals and diverse populations.[46,91] The epidemic of childhood obesity exemplifies the importance of an ecological approach and has called attention to the potential impact of school communities (including the built environment), the food industry, and the media in primordial prevention of overweight in childhood. The AHA, American Academy of Pediatrics, Institute of Medicine, and National Association of Pediatric Nurse Practitioners and Associates advocate prevention approaches that address these levels of influence as well as individual- and family-level factors.[45,46,84,92]

Numerous opportunities exist for nurses and advanced practice nurses/nurse practitioners in implementing population-based approaches to CVD prevention. The *American Heart Association Guide for Improving Cardiovascular Health at the Community Level* provides examples and

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evidence-based recommendations for cardiovascular health promotion at the community level.[93] The recommendations included in this guide are consistent with those recently issued by the CDC[94] and the Task Force on Community Preventive Services.[95] The AHA's Scientific Statement *Cardiovascular Health Promotion in the Schools*[88] is particularly applicable for population-based primordial and primary prevention focused on children and youth. This statement builds on the community guide and endorses the school environment (including preschools and after-school programs) as an integral part of population-based strategies designed to promote cardiovascular health for all US children and youth.[88] Consistent with the population approach outlined in the AHA's guidelines for primary prevention,[79] the goals and recommendations emphasize heart health education and behavioral skill training, school policies, and school and community linkages necessary to optimize the capacity of school environments in shaping health behaviors, including patterns of dietary intake and physical activity.[88]

School nurses are particularly well positioned to assume leadership roles relevant to several major recommendations issued in this statement and in those offered by the National Association of Pediatric Nurse Practitioners and Associates for nurses and nurse practitioners in school and community-based settings: (1) advocating for and conducting evidence-based, comprehensive, age-appropriate heart health education; (2) implementing age-appropriate and culturally sensitive curricula on changing students' patterns of dietary intake, physical activity, and smoking behaviors; (3) screening and referral of children identified as at risk for CVD; and (4) establishing links with community resources and infrastructures necessary to support the school environment in promoting the cardiovascular health of children and youth at the district, school, and individual levels.[88,92] Consistent with recommendations 1 and 2 (above) are the implications for school nurses resulting from the Child Nutrition and Women, Infants, and Children Reauthorization Act of 2004.[96] Specifically, this mandate requires all school districts with federally funded meal programs to develop and implement wellness policies by the start of the 2006–2007 school year. Schools are required to (1) set goals for nutrition education, physical activity, and other school-based initiatives designed to promote wellness; (2) establish nutrition standards for all foods that are available on each school campus during the school day; (3) monitor the implementation of the wellness policy; and (4) involve a broad group of individuals in its development.[96] The expertise of the school nurse can be a valuable addition to the educational team in establishing goals relevant to school wellness, including curricular development and revision aimed at improving health behaviors and reducing CVD risk. As recognized experts on children's health, school nurses are well positioned to advocate (on multiple levels) for policy changes necessary for the actual implementation of age-appropriate heart health education, behavioral skill training, and policy changes necessary for increasing physical education in the school curriculum and increasing nutritious foods as part of meals served, à la carte, and vending machine menus.[97] School nurses can also be instrumental in advocating for alternative nonfood rewards and promoting inclusion of nutritious and culturally appropriate foods for holiday parties and school functions.

Not all children receive regular physical examinations or well-child care outside of that provided in the school environment. Assessment and identification of risk factors for CVD are key components of primary prevention; thus, incorporating CVD risk factor screening with school-based (and preschool) health assessments would assist in early identification of children at risk.[98] School-based screening for overweight and other risk factors often stretches the limits of time available to school nurses in view of the increasing health needs of school-age children. University–school district partnerships are one approach to expanding opportunities for CVD risk factor screening in schools.[99] As experts on resources in their communities, school nurses are well positioned to provide appropriate referrals for children and their families once identification of a risk factor has been established.

It is noteworthy that other pediatric agencies and expert groups have also suggested schools as viable settings for population-based approaches to CVD prevention in children and adolescents and have issued recommendations consistent with those of the AHA.[46,92] Thus, with authority and empowerment to implement the strategies suggested herein, school nurses could have a pivotal role in optimizing population-based approaches to cardiovascular health in children and youth.

Individual/High-Risk Approaches to CVD Prevention

Across healthcare settings, individual approaches begin with a comprehensive assessment of the total CVD risk profile. As emphasized in child health guidelines and recommendations.[42,45,79,82,83] CVD-related health behaviors, the cornerstone of cardiovascular health promotion and disease prevention (interventions designed to normalize levels of risk factors and deter atherosclerotic disease processes), are assessed and monitored at each well-child visit. The AHA recommends a developmental, profile approach to the assessment and management of tobacco use, physical activity, dietary intake, family history of CVD, and physiological risk factors.[79,82] For young children (<2 years old), assessment of parents'/caregivers' health behaviors is recommended, including patterns of household smoking. An important part of individual/high-risk assessment approaches is a multigenerational family history of CVD (including age of onset) and diagnostic and treatment history of attendant risk factors and comorbidities (ie, hypertension, dyslipidemia, obesity, diabetes). The family health history/portrait should be updated at visits throughout childhood and adolescence. Consistent with recommendations advanced by the National Cholesterol Education Program,[15] the AHA emphasizes early identification and follow-up of children with a family history of premature CVD (age of onset ≤55 years in males and ≤65 years in females).[79]

Levels of concern for CVD risk factors and behaviors (Table 2) and recommendations for follow-up (Table 3) are based on currently available data. Although cut points are provided to assist clinicians in identifying children at risk and in guiding treatment decisions, it is important to emphasize

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that no long-term longitudinal studies have been conducted to determine the absolute levels in childhood and adolescence that accelerate atherosclerotic processes and predict CVD in adult life. In addition, the relationship between established risk factors (eg, LDL-C, hypertension) and CVD is continuous and graded. Thus, these are important factors for consideration in clinical decision making regarding both identification of risk status and management/treatment of risk factors.

As illustrated in Table 3, lifestyle modification (therapeutic lifestyle change) with emphasis on normalization of body weight and healthy patterns of dietary intake and physical activity is essential for treatment of children identified with CVD risk factors. Central to therapeutic lifestyle change are effective strategies for behavioral change.[100] Table 4 includes evidence-based strategies that have been effective in modifying CVD-related health behaviors in children and families.[100–102]

Prescriptions for an adequate trial of therapeutic lifestyle change consider the specific risk factor(s) identified, severity of risk (ie, overweight versus morbidly obese), child's age, developmental level, and presence of comorbidities. For example, the recommended treatment plan for a 10-year-old male who presents with dyslipidemia (LDL-C of 145 mg/dL measured in a fasting state on 2 occasions), BMI at the 85th age- and gender-specific percentile, no other comorbidities, and a negative multigenerational family history would have a diet and physical activity prescription as outlined in Table 3. An adequate trial (ie, 6 to 12 months) of therapeutic lifestyle change is recommended, with dietary modifications initiated in conjunction with a trained dietitian (ie, restriction of dietary intake of saturated fat, *trans* fat, and cholesterol; increase of total fiber with emphasis on viscous fiber)[103] and physical activity/energy expenditure necessary to normalize body weight. Individual modifications are based on caloric (and macronutrient and micronutrient) needs necessary to sustain growth and developmental processes and adjusted on the basis of the child's response to treatment.

Pharmacological interventions for children with dyslipidemia and/or other CVD risk factors are (currently) prescribed as defined in Table 3 and are normally initiated in collaboration with physicians with expertise and experience in treating the respective risk factor in children. A comprehensive discussion of pharmacological agents approved for use in reducing CVD risk factors and prevention of CVD in children and adolescents is beyond the scope of this statement and is presented elsewhere.[104] The AHA guidelines (2007) for drug therapy of lipid abnormalities have recently been revised and updated[104] on the basis of available evidence. Revised guide-

TABLE 2. Cardiovascular Risk Profile

Assessment: Risk Factors/Risk Indicators	Recommendations
Family history	Integrate with well-child care; update regularly: multigenerational family history of CVD, diabetes, obesity, hypertension, dyslipidemia, cigarette smoking[79,82]
Lipids and lipoproteins: levels of concern[15,79]	
Total cholesterol: borderline, >170 mg/dL; elevated, >200 mg/dL	Targeted screening of fasting lipids in children ≥2 years of age with family history of premature CVD, diabetes, dyslipidemia; screen children with other risk factors (ie, overweight) and children whose family history of CVD, diabetes, and/or dyslipidemia is unknown[15,79,104]
LDL-C: borderline, >110 mg/dL; elevated, >130 mg/dL	Averaged results of 2 fasting lipid profiles guide treatment decisions (see Table 3)
Triglycerides: >110 mg/dL	
HDL-C: <40 mg/dL	
Note: LDL-C should be <100 mg/dL in children with diabetes	
Systolic and diastolic BP: levels of concern	
SBP and DBP >90th percentile for age, gender, and height	BP measurements should be interpreted on the basis of age, gender, and height[42] (BP percentiles are available at http://www.nhlbi.nih.gov/guidelines/hypertension/child_tbl.htm)
Note: Hypertension is defined as average SBP and/or DBP that is ≥95th percentile for gender, age, and height on ≥3 separate occasions; BP levels that are ≥90th percentile and <95th percentile are now termed prehypertension[42]	BP should be measured beginning at age 3 years and in accordance with recent guidelines[42] (see Table 3 for clinical management)
Body size: levels of concern	
Risk of overweight, BMI ≥85th percentile; overweight, ≥95th percentile	Body size should be charted by BMI (norms for BMI percentiles are available at http://www.cdc.gov/growthcharts/)
Health behaviors: areas of concern	Assess health behaviors at every visit, including tobacco use and exposure to second-hand smoke by child/family/peers; advise participation in 60 min/d moderate to vigorous physical activity such as active outdoor play, walking/biking to school and sports activities, active school recess; resistance training (10-15 repetitions at moderate intensity) can be combined with aerobic activity in an overall activity program for older school-age children and adolescents; assess patterns of dietary intake at every visit; match energy intake with energy needs for growth and developmental processes[79,82–84]
Tobacco use and/or exposure to second-hand smoke: any	
Physical activity: <60 min/d moderate to vigorous physical activity; >2 h/d sedentary activities	
Dietary intake: excess sugar, excess soft drinks and fruit juices, saturated fat, and salt; <5 servings/d of fruits and vegetables; <3 servings/d of dairy; <6 servings/d of whole grain and grain products; skipping breakfast; few family meals; large portion sizes	

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TABLE 3. Guidelines for CVD Risk Reduction Intervention for Children and Adolescents With Identified Risk*

Risk Intervention	Recommendations
Blood cholesterol management	If LDL-C is above goals, initiate additional therapeutic lifestyle changes, including diet (<7% of calories from saturated fat; <200 mg cholesterol/d), in conjunction with a trained dietitian.
Goals	Consider LDL-C–lowering dietary options (increase total dietary fiber with emphasis on viscous fibers (ie, oat bran, pectin) by using age (in years) plus 5 g up to age 20, when the total remains at 25 g/d,[103] in conjunction with a trained dietitian.
LDL-C <160 mg/dL (<130 mg/dL is better)	Emphasize weight management and increased physical activity.
For patients with diabetes, LDL-C <100 mg/dL	If LDL-C is persistently above goals, evaluate for secondary causes (thyroid-stimulating hormone, liver function tests, renal function tests, urinalysis).
	Consider pharmacological therapy for individuals with LDL-C >190 mg/dL with no other risk factors for CVD; or >160 mg/dL with other risk factors present (BP elevation, diabetes, overweight, strong family history of premature CVD); or if treatment goals not realized after adequate trial of therapeutic lifestyle change.
Other lipids and lipoproteins	Pharmacological intervention for dyslipidemia should be accomplished in collaboration with a physician experienced in treatment of disorders of cholesterol in pediatric patients.
Goals	Elevated fasting triglycerides and reduced HDL-C are often seen in the context of overweight with insulin resistance. Therapeutic lifestyle change should include weight management with appropriate energy intake and expenditure. Decrease intake of energy-dense snack food high in sugar and sugar beverages such as soft drinks, fruit juices, and sports drinks.
Fasting triglycerides <150 mg/dL	If fasting triglycerides are persistently elevated, evaluate for secondary causes such as diabetes, thyroid disease, renal disease, and alcohol abuse. No pharmacological interventions are recommended in children for isolated elevation of fasting triglycerides unless this is very marked (treatment may be initiated at triglycerides >400 mg/dL to protect against postprandial triglycerides of ≥1000 mg/dL, which may be associated with an increased risk of pancreatitis).
HDL-C >35 mg/dL	
Management of BP elevation	
Goal	Promote achievement of appropriate weight.
SBP and DBP <95th percentile for age, sex, and height; with comorbidities, <90th percentile for age, gender, and height	Reduce sodium in the diet. Emphasize increased consumption of fruits and vegetables.
	If BP is persistently >95th percentile, consider secondary causes (ie, renal disease, coarctation of the aorta).
	Consider pharmacological therapy for individuals >95th percentile if lifestyle modification brings no improvement and there is evidence of target organ changes (left ventricular hypertrophy, microalbuminuria, renal vascular abnormalities). Start BP medication individualized to other patient requirements and characteristics (ie, age, race, need for drugs with specific benefits) and in collaboration with specialist in pediatric hypertension.
Weight management and treatment goals based on BMI percentile and health status	
BMI: <85th percentile (normal weight for height)	Guiding principles
Goal: Maintain BMI percentile to prevent overweight	Establish individual treatment goals and approaches based on the child's age, degree of overweight, and presence of comorbidities.
BMI: 85th to 95th percentile for age and gender (at risk for overweight)	Involve the family or major caregivers in treatment.
Goal: Maintain BMI with aging to reduce BMI to <85th percentile; if BMI >25 kg/m^2, weight maintenance	Provide assessment and monitoring frequently.
BMI: ≥95th percentile (overweight)	Consider behavioral, psychological, and social correlates of weight gain in the treatment plan.
Goal: Weight maintenance (younger children) or gradual weight loss (adolescents) to reduce BMI percentile	Provide recommendations for dietary changes, increasing daily physical activity and decreasing sedentary activities. Recommendations should be tailored to the characteristics, needs, and resources of the child and family, able to be implemented within the family environment, and designed to foster optimal child/family health, growth, and development.
BMI: ≥30 kg/m^2 (adult obesity cut point)	
Goal: Gradual weight loss (1-2 kg/mo) to achieve healthier BMI	
BMI ≥95th percentile and comorbidity present (overweight with comorbidity)	
Goal: Gradual weight loss (1-2 kg/mo) to achieve healthier BMI; assess need for additional treatment of associated conditions	

*Data derived from Kavey et al,[79] Daniels et al,[45] and McCrindle et al.[104]

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TABLE 4. Behavioral Change Principles and Strategies for Children, Adolescents, and Families*

Basic principles
Simplify and tailor the prescription for behavioral change to the individual and family characteristics, needs, and resources.
Ask about the behavior at every healthcare visit.
Involve the parents/family as partners in the behavioral change process.
Provide information in multiple developmentally and culturally appropriate venues.
Specific strategies
Assess, monitor, and document patterns of behavior change at every healthcare visit.
Provide developmentally appropriate behavior-specific information tailored to the child's and family's cultural background, needs, and resources.
Identify realistic goals for behaviors with the child and family.
Include activities to assist families to monitor behaviors targeted for change.
Mobilize family and social support.
Provide self-efficacy enhancement and an atmosphere of clinical empathy.
Develop a health-promoting reward system for positive behavior change.

*See references 100 through 102.

lines for treatment of hypertension in children appear in the Fourth Report on the Diagnosis, Evaluation, and Treatment of High Blood Pressure in Children and Adolescents.[42]

Across healthcare settings, management of dyslipidemia, hypertension, and other CVD risk factors in children and adolescents is best accomplished with a multidisciplinary collaborative team approach. Advanced practice nurses/nurse practitioners and nurses experienced in assessment and management of CVD risk factors in children and adolescents, including family-focused strategies for behavioral change, are essential for optimizing initiation of and long-term adherence to the treatment plan. The effectiveness of multidisciplinary nurse-directed management as a model for improving outcomes in adults with coronary heart disease risk factors and coronary heart disease has been demonstrated.[105–107] This collaborative, multidisciplinary approach is highlighted in a recent statement issued by the AHA[105] and emphasized in integrative reviews and analyses of studies that tested such models and demonstrated improved outcomes in persons with coronary heart disease (secondary prevention) and/or with coronary heart disease risk factors (primary prevention).[106,107] The essential characteristics are consistent with elements defined in the chronic care model[108,109] and include the following: advanced practice nurse with specialized knowledge and skill for collaborative practice; comprehensive, individually tailored lifestyle management programs that incorporate principles of health behavior change; systematic mechanisms for follow-up, adherence monitoring, and tracking; and coordination of services with multiple providers.[106,107] Although nurse-managed, multidisciplinary models adapted for CVD prevention with children and families have been suggested and are being implemented in selected clinical settings, process and outcome evaluation data are not available.

Summary

Compelling evidence accumulated over the past 3 decades supports a life course approach to primary prevention of CVD with efforts beginning early in childhood. Data from laboratory, clinical, and epidemiological studies also underscore the importance of both population-based/public health and individual/high-risk strategies for CVD prevention beginning early in childhood and extending across the life course. Current science-based recommendations, highlighted in this statement, emphasize the development and maintenance of healthy lifestyle behaviors and therapeutic lifestyle change as the cornerstone of interventions focused on promoting cardiovascular health and reducing the risk and burden of CVD. Additional research is needed, however, to inform, guide, and evaluate optimal life course strategies for CVD prevention, including multidisciplinary models and integrated systems of healthcare that link individual/high-risk and population-based/public health strategies. Equipped with the evidence base in prevention, developmental life course, and behavioral science and the respective skill sets and competencies, nurses will continue to be central and essential in the design and implementation of effective strategies for CVD prevention.

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*Modest.

†Significant.

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