Published in final edited form as:
*Am J Prev Med*. 2009 July ; 37(1 Suppl): S25–S33. doi:10.1016/j.amepre.2009.04.006.

# Nutrient Intake, Physical Activity, and CVD Risk Factors in Children:

### Project HeartBeat!

**R. Sue Day, PhD**, **Janet E. Fulton, PhD**, **Shifan Dai, MD, PhD**, **Nicole L. Mihalopoulos, MD**, and **Danielle T. Barradas, BS**

From the Michael & Susan Dell Center for Advancement of Healthy Living (Day), School of Public Health, University of Texas Health Science Center, Houston, Texas; Physical Activity and Health Branch, Division of Nutrition and Physical Activity (Fulton), and Division for Heart Disease and Stroke Prevention (Dai), CDC; Program in Nutrition and Health Sciences (Barradas), Graduate Division of Biological and Biomedical Sciences, Emory University, Atlanta, Georgia; and Adolescent Medicine (Mihalopoulos), Department of Pediatrics, University of Utah, Salt Lake City, Utah

## Abstract

**Background—**Associations among dietary intake, physical activity, and cardiovascular disease (CVD) risk factors are inconsistent among male and female youth, possibly from lack of adjustment for pubertal status. The purpose of this report is to describe the associations of CVD risk factors among youth, adjusted for sexual maturation.

**Methods—**Data analyzed in 2007 from a sumsample of 556 children aged 8, 11, and 14 years in Project HeartBeat!, 1991–1993, provide cross-sectional patterns of CVD risk factors by age and gender, adjusting for sexual maturation, within dietary fat and physical activity categories.

**Results—**Girls consuming moderate- to high-fat diets were significantly less physically active than those consuming low-fat diets. Boys and girls consuming high-fat diets had higher saturated fat and cholesterol intakes than children in low-fat categories. Boys had no significant differences in physical activity, blood pressure, waist circumference, or plasma cholesterol levels across fat categories. Girls' plasma cholesterol levels showed no significant differences across fat categories. Dietary intake did not differ across moderate-to-vigorous physical activity (MVPA) categories within gender. There were no differences in BMI by fat or MVPA categories for either gender. Girls' waist circumference differed significantly by fat category, and systolic blood pressure differed significantly across fat and MVPA categories. Boys' fifth-phase diastolic blood pressure was significantly different across MVPA categories.

**Conclusions—**Girls consuming atherogenic diets were significantly less physically active than those with low fat intakes, whereas boys consuming high-fat diets did not show differences in physical activity measures. With the prevalence of overweight rising among youth, the impact of atherogenic diets and sedentary lifestyles on CVD risk factors is of concern to public health professionals.

Address correspondence and reprint requests to: R. Sue Day, PhD, Michael & Susan Dell Center for Advancement of Healthy Living, University of Texas School of Public Health, 1200 Herman Pressler, RAS Room 916, Houston TX 77030. Rena.S.Day@uth.tmc.edu.

The findings and conclusions in this report are those of the authors and do not necessarily represent the views of the CDC.

No financial disclosures were reported by the authors of this paper.

## Background

Although cardiovascular disease (CVD) is typically not diagnosed until adulthood, atheromatous lesions have been found in children and young adults.[1–3] The presence of atherosclerosis in youth has been associated with CVD risk factors such as obesity, abnormal plasma lipoprotein levels, elevated blood pressure, and insulin resistance.[4–11] The positive effect of high-fat diets on plasma lipids in children has been shown to be similar to that observed in adults.[7–12] Longitudinal studies have further indicated that measures of BMI, total cholesterol, low-density lipoprotein cholesterol (LDL-C), high-density lipoprotein cholesterol (HDL-C), and blood pressure taken during childhood and adolescence track into adulthood and predict adult values.[13–24] Because of the rising prevalence of overweight among youth, future rates of adult CVD could greatly increase.[11,25–27]

Sedentary behavior such as computer use and TV viewing has been associated with increased risk of CVD in adults[28] and children.[29] Reports show a direct relationship between daily physical activity and HDL-C among adults.[30] Changes in physical activity from adolescence to adulthood, but not during adolescence, have been related to CVD risk factors in adulthood.[31,32] Intervention and longitudinal studies involving children and adolescents have shown that healthy diet and physical activity behaviors together are related to decreases in body fat,[28,33–36] total cholesterol level,[12,36] total cholesterol-to-HDL-C ratio,[12,30] and insulin resistance.[33,34]

Inconsistent associations among youth diet, physical activity, and CVD risk factors have been reported,[37–40] possibly because CVD risk factors are associated with onset of puberty, and valid adjustments for pubertal stage have not been considered. Onset of puberty may vary by as much as 4 years within gender.[41,42] Sexual maturation and sex hormones are strongly associated with plasma total cholesterol and lipoprotein cholesterol concentrations during adolescence.[39] As sexual maturation progresses, plasma total cholesterol and LDL-C decrease, while HDL-C and weight increase.[40] The decreases are greater in boys than in girls. Sexual maturation has also been reported to affect the association between physical activity and systolic blood pressure (SBP) and diastolic blood pressure (DBP).[43]

To stem potential increases in adult CVD incidence resulting from the rising prevalence of youth overweight, risk factor relationships need to be better understood for designing interventions. Project HeartBeat!, a longitudinal study of youth, allows for the evaluation of cross-sectional patterns of CVD risk factors by age and gender groups, adjusting for sexual maturation, within categories of dietary fat intake and physical activity.

## Methods

### Study Design

Details of the Project HeartBeat! rationale, design, and data collection have been described previously.[44] Participants were recruited from schools in The Woodlands and Conroe TX. Informed consent was obtained from the parent or guardian, and child assent or consent was obtained. The protocol was approved by the Committee for Protection of Human Subjects of the University of Texas Health Science Center at Houston and the IRB of Baylor College of Medicine. A total of 678 children (49.1% girls, 79.9% nonblack) aged 8, 11, and 14 years at baseline were enrolled in three cohorts. Data from the baseline examination of 556 children (277 boys and 279 girls) between October 1991 and July 1993 are included in these 2007 analyses. Quality-control measures were used to exclude children who were missing a food-frequency questionnaire (FFQ) ($n$=90); those with more than six FFQ foods incomplete; those with more than eight FFQ extreme portion sizes ($n$=12); those with intakes ≥5000 kcal per day ($n$=10); those missing physical activity measures ($n$=30); those missing gender or cohort ($n$=2) or sexual maturation values (*n*=67); and those missing serum lipids (blood-draw refusals) (*n*=67). Some were excluded for more than one reason.

## Dietary Intake

Dietary intake was assessed using an interviewer-administered, quantified 137-item FFQ validated for this population. The FFQ food list was developed from 3-day food records from approximately 150 children in Grades 5–12 from the targeted communities.[45] Procedures for creation of the FFQ are similar to those for other reports,[46,47] with foods contributing ≥0.1% to nutrient intake included on the FFQ food list.

Interviews using FFQs were conducted at the child's home or in the field center within 3 weeks of the baseline examination. Children aged 8 and 11 years were accompanied by a parent or an adult involved in food preparation for the 35- to 40-minute interview; those aged 14 years were interviewed independently. Children reported the frequency and quantity of consumption of foods for the week preceding the interview, estimating portion size using two-dimensional and household food models. Food- and brand-specific serving sizes (e.g., slices of bread or cans of soft drinks) were also used. The Food Frequency Data Entry and Analysis Program 1.0 and FIAS 2.0 were used for data entry and nutrient analyses utilizing nutrient and gram weight information from the U.S. Department of Agriculture Nutrient Database for Individual Intake Surveys.[48]

## Physical Activity and TV Viewing

Physical activity and TV viewing were assessed using a 24-hour recall, interviewer-administered questionnaire adapted from a 7-day recall instrument for use with pre-adolescent children that has been validated among 5th-grade children.[49] Parents assisted children aged <10 years. Using a segmented-day approach, children recalled the active and sedentary behaviors in which they participated during the preceding 24 hours. Most interviews (97%) were scheduled to allow recall of weekday physical activity and TV viewing. Only 15% of children interviewed on Monday afternoons recalled a weekend activity from the preceding 24 hours.

For each physical activity, participants estimated three time segments: (1) total time (e.g., 2-hour baseball game); (2) time spent truly participating (e.g., 1 hour participating in the baseball game); and (3) time in vigorously intense activity (activity that caused hard breathing or sweating; e.g., 10 minutes of the baseball game). Physical activities were grouped into categories of moderate and vigorous physical activity (MPA; VPA) using published estimates of physical activity energy expenditure in MET equivalents (ratio of work metabolic rate to a standard resting metabolic rate).[49,50] A measure of minutes per day was calculated for each of the child's physical activities by category. As part of the questionnaire, participants recalled time spent (minutes/day) viewing TV during the preceding 24 hours.

## Sexual Maturation

Children's sexual maturity stages were assessed by research nurses at the field center using the method of Reynolds and Wines[51,52] later popularized by Tanner.[53] Tanner staging classifies the sexual development of children and adolescents using a 5-point scale from 1 (pre-pubertal) to 5 (complete sexual maturation), based on the development of genitalia and pubic hair for boys and breasts and pubic hair for girls. Tanner female breast and male genitalia stages (without consideration of pubic hair stages) were used to adjust for sexual maturation in analyses.

### Blood Pressure

Blood pressure was measured during two appointments within 2 weeks of the baseline examination using mercury sphygmomanometers and detailed procedures.[44] Participants were seated for at least 5 minutes followed by two sets of blood pressure measurements. The mean of the readings was used for SBP; fourth-phase DBP (DBP4); and fifth-phase DBP (DBP5).

### Anthropometry

Height and weight were measured with children in light clothes without shoes. Height was measured using a wall-mounted stadiometer and recorded to the nearest 0.1 cm. Weight was measured to the nearest 0.1 kg with a beam-balance scale calibrated daily. Participants' BMI was calculated by standard formula (kg/m$^2$). Waist circumference was measured to the nearest 0.1 cm at the level of the greatest frontal extension of the abdomen between the bottom of the rib cage and the top of the iliac crest. Bioelectrical impedance assessments were obtained following standardized procedures using an RJL Systems bioelectric impedance analyzer BIA 101-A measuring reactance and resistance.[24] Percent body fat was calculated by gender-specific formulas[54–57] using resistance, anthropometry, and skinfold measurements among the various formulas for bio-impedance. Skinfold measurements were taken for triceps, subscapular, midaxillary, abdominal, distal thigh, and lateral calf areas with calipers, following standardized procedures, each recorded in triplicate and analyzed as the mean value for the measures.[24,54–58]

### Plasma Lipids

Blood samples, after an 8- to 12-hour fast, were drawn by a phlebotomist on the morning of each examination at the participant's home, as described elsewhere.[44] Plasma lipid concentrations were determined in plasma samples using standardized methods in the Lipid Research Laboratory of the Baylor College of Medicine in Houston TX.

### Data Analysis

Descriptive measures are provided of dietary intake and physical activity with CVD risk factors by gender and age. Categories of total fat intake (% kcal) were created based on dietary intake recommendation levels for total fat intake at the time of data collection.[59–61] The category of low fat intake was ≤30% kcal per day, the moderate category was 31%–38% kcal, and the high category was ≥39% kcal. Moderate-to-vigorous physical activity (MVPA; minutes/day) categories were created using tertiles of the population distribution, resulting in categories of low active (0–30 minutes per day); moderate active (31–89 minutes per day); and high active (≥90 minutes per day). The CVD risk factor differences were assessed using ANCOVA adjusted for age (continuous variable) and sexual maturation (categoric variable) within gender, across categories of fat intake and MVPA. Predicted Ms and SEs were calculated from the covariance procedure for variables in the fat and MVPA categories. A *p*-value of 0.05 was used as the criterion for all statistical testing, and no correction was made for repeated testing. Within-gender comparisons provide descriptive information of the relationships of CVD risk factors at baseline, setting the context for longitudinal analyses.

## Results

Descriptive information regarding age, height, weight, and sexual maturation is in Table 1. Mean daily energy intakes ranged from 2026 kcal for girls aged 8 years to 2796 kcal for boys aged 14 years. Mean protein, carbohydrate, total fat, and saturated fat intakes as a percentage of energy were almost identical across age and gender groups. Total fat averaged 34%–35% kcal, and saturated fat about 13% kcal, across age and gender groups. Mean intakes of cholesterol and fiber were similar within gender groups; boys aged 14 years had the highest absolute values for cholesterol (310 mg) and fiber (17 g). Mean calcium intakes ranged from 1020 mg among girls aged 8 years to 1438 mg among boys aged 14 years.

On average, those aged 11 years reported watching more TV than other age groups, ~2 hours per day for girls and 1.75 hours per day for boys (Table 1). Interestingly, the boys aged 11 years also reported the highest amount of MPA, 33 minutes. Girls' mean MPA, 11 minutes, was the same for all age groups. Girls and boys aged 8 years reported the highest number of minutes of VPA. For MVPA, boys aged 11 years and girls aged 8 years had the highest reported amounts, 94 and 70 minutes, respectively.

Mean values for diet, physical activity, and CVD risk factors by fat categories and gender, adjusted for age and sexual maturation, are in Table 2. Seventeen percent consumed high-fat diets; means were 42% kcal for boys and 43% kcal for girls. Girls in the high-fat category had significantly higher protein (% kcal), saturated fat (% kcal), and cholesterol intakes, and lower carbohydrate (% kcal) intakes, than girls consuming diets low in fat. Boys in the high-fat category had significantly lower carbohydrate (% kcal) and higher saturated fat (% kcal) and cholesterol intakes than boys in the lower-fat categories. Mean calcium intake was significantly greater among boys with low versus high fat intakes.

Boys and girls in the high-fat category had higher mean minutes of TV viewing than those in the low-fat category (Table 2). Girls had significant differences in minutes of VPA and MVPA across fat categories; those in the low-fat category had the highest mean minutes. There were significant differences in SBP and waist circumference of girls across fat categories; the lowest values being in the moderate fat category.

Time spent on TV viewing was significantly greater in the low-MVPA category (Table 3). There were no significant gender differences in dietary intake by MVPA. Girls had a significant difference in SBP across MVPA categories. Boys had a significant difference in DBP5 across MVPA categories.

## Discussion

Differences in VPA, MVPA, SBP, waist circumference, and DBP5 were evident within gender groups when children were grouped by fat intake and MVPA, after adjustment for sexual maturation and age. Children with high fat intakes consumed more saturated fat and cholesterol, and girls in this category spent significantly less time engaged in MVPA and VPA than those eating low-fat diets. Boys had no significant differences in physical activity measures, blood pressure, BMI, waist circumference, or plasma cholesterol levels across fat intake categories. Girls also had no significant differences in BMI and plasma cholesterol across fat categories. Because dietary risk factors for CVD such as high intake of fat and cholesterol[62–64] have the possibility of continuing into adulthood and having a negative effect on morbidity and mortality,[65,66] children with high fat intakes are a concern.

Dietary intake as a percentage of energy was similar across age groups, consistent with previous research.[45] Dietary intake was similar to that of youth (aged 12–19 years) in the 1994–1996, 1998 USDA Continuing Survey of Food Intakes by Individuals (CSFII).[67] The mean cholesterol intake of boys in the high-fat category, and the mean intake of boys aged 12–19 years in the CSFII, exceeded the American Heart Association recommendation of <300 mg per day.[68] Fiber intake was similar to, and calcium intake greater than, the intake of CSFII youths. Project HeartBeat! children's dietary intake was typical of youth at the study time, supporting extrapolation of these results to American youth.

Children in the low-MVPA category had higher mean minutes of TV viewing than those in other categories, with girls being significantly different. This pattern of TV viewing rather than

NIH-PA Author Manuscript

NIH-PA Author Manuscript

physical activity is occurring across the nation and can lead to obesity, high blood pressure, and increased risk of CVD.[65,69,70] Although computer and video game use was minimal at the time of the study, 2–4 hours per day are now spent on this activity[71,72]; thus the impact of TV viewing instead of physical activity is enhanced in today's environment. Watching TV has been associated with the consumption of high-fat, sugar, and energy foods and with low intakes of fruits and vegetables, habits that can increase weight gain.[73–77] Older boys had less VPA than those aged 8 years. Results, however, do not show significant differences in BMI among children stratified by fat categories or by MVPA categories, after adjustment for age and sexual maturation. Variability in the children's BMI is not explained by differences in fat intake or MVPA minutes. These cross-sectional data are not adequate to assess the risk for future CVD, but because these negative behaviors may track into adulthood, their persistence is worrisome.

Girls' SBP differed significantly within fat and MVPA categories; the highest SBP was among those with low fat intake and high MVPA. Among boys, DBP5 differed significantly by MVPA category, with the highest value in the moderate category. These results are contrary to inverse associations between youth physical activity and blood pressure shown in other studies,[78–83] and to direct associations among age, sexual maturation, and blood pressure,[84] which may be stronger than the decrease in blood pressure seen with physical activity. The current results may be explained by small numbers in categories, the use of a 24-hour measure of physical activity, and the multiple comparisons evaluated. These results may be consistent with results[85] showing that boys experienced a sixfold increase and girls a threefold increase in SBP during pubertal growth. Participants may not have engaged in amounts of regular MVPA adequate to produce a blood pressure decrease. Another explanation may be that cross-sectional associations of diet and physical activity with CVD risk factors have been inconsistent[86–90] because precise estimation is difficult. However, differences in blood pressure measures across these categories are small in absolute value and may not be clinically significant; thus, they are interpreted cautiously.

The effect of using a distributional approach to creating MVPA categories was assessed by comparing categories of MVPA using physical activity recommendation levels of 0–29 minutes, 30–59 minutes, and ≥60 minutes. Results were the same; except for girls, a significant difference in plasma cholesterol was seen across MVPA categories (data not shown).

There are several possible limitations to interpretation. First, stratifying the data into categories resulted in small cell sizes, producing less-stable estimates. However, because these data are descriptive and include measures of variability, they do offer informative profiles of the variable relationships. Second, unlike trends from longitudinal analyses, cross-sectional trends cannot show cause and effect. Third, FFQs have been shown to overestimate children's intakes; nevertheless, the FFQ is reported as a good group measure for ranking youth intakes.[86–88] The FFQ data are appropriate to explore patterns of intake and relationships with CVD risk factors. Fourth, collection of physical activity data may be compromised for children aged <10 years because of a lack of cognitive ability.[89,90] In addition, the 24-hour recall measure of physical activity may not have captured the true variation in physical activity, causing a bias in these analyses. Although some SDs of the physical activity measures are large, the similarity in variability across age groups, and not just among the younger youths, increases the validity of these results. Fifth, racial/ethnic variations were not included in these analyses because of limited numbers; the population was 20.1% black and 79.9% nonblack.

The use of a validated physical activity assessment tool for young children was a strength; however, the instrument has not been validated among children aged 12–18 years. Total physical activity minutes are underestimated because the measure of MVPA in this study includes only minutes of physical activity at this level of intensity, and total physical activity minutes were not part of the physical activity measure. Further, age- and gender-specific percentiles were not used to make BMI comparisons of boys and girls. This issue was addressed by stratifying data by gender with adjustment for age and sexual maturation.

Girls who consumed atherogenic diets were significantly less physically active than those with low fat intakes, whereas boys consuming high-fat diets did not show differences in physical activity measures. There were no BMI differences by fat and MVPA categories, yet SBP, DBP5, and waist circumference did differ significantly (not in the same way for both genders) after adjustment for sexual maturation. With the prevalence of youth overweight rising, the impact of atherogenic diets and sedentary lifestyles on CVD risk factors is of concern to public health professionals.[91,92] These gender-specific findings of the relationships among diet, physical activity, and CVD risk factors, adjusted for sexual maturation, provide a benchmark for investigating the trajectories of risk factors during children's growth.

## Acknowledgments

The authors thank Stephanie A. Carter for assistance with manuscript preparation. The authors gratefully acknowledge the contribution of each Project HeartBeat! participant and family. The researchers recognize the support of the Conroe Independent School District and the generous support of The Woodlands Corporation. Funding for the study was from the National Heart, Lung, and Blood Institute through Cooperative Agreement U01-HL-41166 and by the CDC through the Southwest Center for Prevention Research (U48/CCU609653).

## References

1. Strong JP, McGill HC Jr. The natural history of coronary atherosclerosis. Am J Pathol 1962;40:37–49. [PubMed: 13917861]
2. McNamara JJ, Molot MA, Stremple JF, Cutting RT. Coronary artery disease in combat casualties in Vietnam. JAMA 1971;216(7):1185–7. [PubMed: 5108403]
3. Strong JP, Zieske AW, Malcom GT. Lipoproteins and atherosclerosis in children: an early marriage? Nutr Metab Cardiovasc Dis 2001;11(5S):16–22. [PubMed: 12063771]
4. Zieske AW, Malcom GT, Strong JP. Natural history and risk factors of atherosclerosis in children and youth: the PDAY study. Pediatr Pathol Mol Med 2002;21(2):213–37. [PubMed: 11942537]
5. Berenson GS, Bao W, Srinivasan SR. Does adult onset diabetes begin in childhood? The Bogalusa Heart Study. Am J Med Sci 1995;310(1S):S77–82. [PubMed: 7503129]
6. Berenson GS, Bao W, Srinivasan SR. Rationale to study the early natural history of heart disease. The Bogalusa Heart Study. Am J Med Sci 1995;310(1S):S22–28. [PubMed: 7503119]
7. Srinivasan SR, Berenson GS. Childhood lipoprotein profiles and implications for adult coronary artery disease—the Bogalusa Heart study. Am J Med Sci 1995;310(1S):S62–7. [PubMed: 7503126]
8. Tracy RE, Newmn WP III, Wattigney WA, Berenson GS. Risk factors and atherosclerosis in youth. Autopsy findings of the Bogalusa Heart Study. Am J Med Sci 1995;310(1S):S37–41. [PubMed: 7503122]
9. Webber LS, Wattigney WA, Srinivasan SR, Berenson GS. Obesity studies in Bogalusa. Am J Med Sci 1995;310(1S):S53–61. [PubMed: 7503125]
10. Dwyer JT, Stone EJ, Yang M, et al. Prevalence of marked overweight and obesity in a multiethnic pediatric population: findings from the Child and Adolescent Trial for Cardiovascular Health (CATCH) study. J Am Diet Assoc 2000;100(10):1149–56. [PubMed: 11043699]
11. Hedley AA, Ogden CL, Johnson CL, Carroll MD, Curtin LR, Flegal KM. Prevalence of overweight and obesity among U.S. children, adolescents, and adults, 1999–2002. JAMA 2004;291(23):2847–50. [PubMed: 15199035]
12. Nicklas TA, Dwyer J, Feldman HA, Luepker RV, Kelder SH, Nader PR. Serum cholesterol levels in children are associated with dietary fat and fatty acid intake. J Am Diet Assoc 2002;102(4):511–7. [PubMed: 11985407]
13. Clarke WR, Schrott HG, Leaverton PE, Connor WE, Lauer RM. Tracking of blood lipids and blood pressures in school age children: the Muscatine study. Circulation 1978;58(4):626–34. [PubMed: 688572]

14. Kemper HC, Snel J, Verschuur R, Storm-van Essen L. Tracking of health and risk indicators of cardiovascular diseases from teenager to adult: Amsterdam Growth and Health Study. Prev Med 1990;19(6):642–55. [PubMed: 2263575]
15. Laskarzewski P, Morrison JA, deGroot I, et al. Lipid and lipoprotein tracking in 108 children over a four-year period. Pediatrics 1979;64(5):584–91. [PubMed: 226923]
16. Lauer RM, Lee J, Clarke WR. Factors affecting the relationship between childhood and adult cholesterol levels: the Muscatine Study. Pediatrics 1988;82(3S):309–18. [PubMed: 3405659]
17. Lauer RM, Clarke WR. Childhood risk factors for high adult blood pressure: the Muscatine Study. Pediatrics 1989;84(4):633–41. [PubMed: 2780125]
18. Orchard TJ, Donahue RP, Kuller LH, Hodge PN, Drash AL. Cholesterol screening in childhood: does it predict adult hypercholesterolemia? The Beaver County experience. J Pediatr 1983;103(5):687–91. [PubMed: 6631595]
19. Pagnan A, Ambrosio GB, Vincenzi M, Mormino P, Maiolino P, Gerin L, Barbieri E, Cappelletti F, Dal Palu C. Precursors of atherosclerosis in children: the Cittadella study. Follow-up and tracking of total serum cholesterol, triglycerides, and blood glucose. Prev Med 1982;11(4):381–90. [PubMed: 7122430]
20. Porkka KV, Viikari JS, Akerblom HK. Tracking of serum HDL-cholesterol and other lipids in children and adolescents: the Cardiovascular Risk in Young Finns Study. Prev Med 1991;20(6):713–24. [PubMed: 1766943]
21. Porkka KV, Viikari JS, Taimela S, Dahl M, Akerblom HK. Tracking and predictiveness of serum lipid and lipoprotein measurements in childhood: a 12-year follow-up. The Cardiovascular Risk in Young Finns study. Am J Epidemiol 1994;140(12):1096–110. [PubMed: 7998592]
22. Twisk JW, Kemper HC, Mellenbergh GJ. Longitudinal development of lipoprotein levels in males and females aged 12–28 years: the Amsterdam Growth and Health Study. Int J Epidemiol 1995;24 (1):69–77. [PubMed: 7797358]
23. Webber LS, Srinivasan SR, Wattigney WA, Berenson GS. Tracking of serum lipids and lipoproteins from childhood to adulthood. The Bogalusa Heart Study. Am J Epidemiol 1991;133(9):884–99. [PubMed: 2028978]
24. Mueller WH, Harrist RB, Doyle SR, Ayars CL, Labarthe DR. Body measurement variability, fatness, and fat-free mass in children 8, 11, and 14 years of age: Project HeartBeat! Am J Human Biol 1999;11 (1):69–78. [PubMed: 11533935]
25. Ogden CL, Carroll MD, Flegal KM. High body mass index for age among U.S. children and adolescents. 2003–2006. JAMA 2008;299(20):2401–5. [PubMed: 18505949]
26. Hoelscher DM, Day RS, Lee EL, Frankowski R, Kelder SH, Ward J, Scheurer ME. Measuring the prevalence of overweight in Texas school children. Am J Public Health 2004;94(6):1002–8. [PubMed: 15249306]
27. Bjørge T, Engeland A, Tverdal A, Smith GD. Body mass index in adolescence in relation to cause-specific mortality: a follow-up of 230,000 Norwegian adolescents. Am J Epidemiol 2008;168:30–7. [PubMed: 18477652]
28. Twisk JW, Kemper HC, van Mechelen W. Tracking of activity and fitness and the relationship with cardiovascular disease risk factors. Med Sci Sport Exerc 2000;32(8):1455–61.
29. Ekelund U, Anderssen SA, Froberg K, Sardinha LB, Andersen LB, Brage S. Independent associations of physical activity and cardiorespiratory fitness with metabolic risk factors in children: the European Youth Heart Study. J Hypertens 2007;50:1832–40.
30. Ferreira I, Twisk JW, van Mechelen W, Kemper HC, Stehouwer CD. Development of fatness, fitness, and lifestyle from adolescence to the age of 36 years: determinants of the metabolic syndrome in young adults: the Amsterdam Growth and Health Study. Arch Intern Med 2005;165(1):42–8. [PubMed: 15642873]
31. Boreham C, Twisk J, Neville C, Savage M, Murray L, Gallagher A. Associations between physical fitness and activity patterns during adolescence and cardiovascular risk factors in young adulthood: the Northern Ireland Young Hearts Project. Int J Sport Med 2002;23(1S):S22–6.
32. Hasselstrom H, Hansen SE, Froberg K, Andersen LB. Physical fitness and physical activity during adolescence as predictors of cardiovascular disease risk in young adulthood. Danish Youth and Sports Study. An eight-year follow-up study. Int J Sport Med 2002;23(1S):S27–31.

33. Balagopal P, George D, Patton N, et al. Lifestyle-only intervention attenuates the inflammatory state associated with obesity: a randomized controlled study in adolescents. J Pediatr 2005;146(3):342–8. [PubMed: 15756217]
34. Balagopal P, George D, Yarandi H, Funanage V, Bayne E. Reversal of obesity-related hypoadiponectinemia by lifestyle intervention: a controlled, randomized study in obese adolescents. J Clin Endocrinol Metab 2005;90(11):6192–7. [PubMed: 16131584]
35. Eliakim A, Makowski GS, Brasel JA, Cooper DM. Adiposity, lipid levels, and brief endurance training in nonobese adolescent males. Int J Sport Med 2000;21(5):332–7.
36. Harrell JS, McMurray RG, Bangdiwala SI, Frauman AC, Gansky SA, Bradley CB. Effects of a school-based intervention to reduce cardiovascular disease risk factors in elementary-school children: the Cardiovascular Health in Children (CHIC) Study. J Pediatr 1996;128(6):797–805. [PubMed: 8648539]
37. Guillaume M, Lapidus L, Lambert A. Differences in associations of familial and nutritional factors with serum lipids between boys and girls: the Luxembourg Child Study. Am J Clin Nutr 2000;72(2): 384–8. [PubMed: 10919931]
38. Ku CY, Gower BA, Nagy TR, Goran MI. Relationships between dietary fat, body fat, and serum lipid profile in prepubertal children. Obes Res 1998;6(6):400–7. [PubMed: 9845229]
39. Kwiterovich PO Jr, Barton BA, McMahon RP, et al. Effects of diet and sexual maturation on low-density lipoprotein cholesterol during puberty: the Dietary Intervention Study in Children (DISC). Circulation 1997;96(8):2526–33. [PubMed: 9355889]
40. Tell GS. Cardiovascular disease risk factors related to sexual maturation: the Oslo Youth Study. J Chronic Dis 1985;38(8):633–42. [PubMed: 4019701]
41. Marshall WA, Tanner JM. Variations in the pattern of pubertal changes in girls. Arch Dis Child 1969;44:291–303. [PubMed: 5785179]
42. Marshall WA, Tanner JM. Variations in the pattern of pubertal changes in boys. Arch Dis Child 1970;45(13):13–23. [PubMed: 5440182]
43. Eissa MAH, Meininger JC, Nguyen TQ, Chan W. The relationship of ambulatory blood pressure to physical activity in a tri-ethnic population of obese and nonobese adolescents. Am J Hypertens 2007;20:140–7. [PubMed: 17261458]
44. Labarthe DR, Nichaman MZ, Harrist RB, Grunbaum JA, Dai S. Development of cardiovascular risk factors from ages 8 to 18 in Project HeartBeat!: study design and patterns of change in plasma total cholesterol concentration. Circulation 1997;95(12):2636–42. [PubMed: 9193432]
45. McPherson RS, Nichaman MZ, Kohl HW, Reed DB, Labarthe DR. Intake and food sources of dietary fat among schoolchildren in The Woodlands Texas. Pediatrics 1990;86(4):520–6. [PubMed: 2216615]
46. Block G, Hartman AM, Dresser CM, Carroll MD, Gannon J, Gardner L. A data-based approach to diet questionnaire design and testing. Am J Epidemiol 1986;124(3):453–69. [PubMed: 3740045]
47. Thompson FE, Byers T. Dietary assessment resource manual. J Nutr 1994;124(11S):2455S–3175S.
48. U.S. Department of Agriculture Human Nutrition Information Service. USDA Nutrient Data Base for Individual Intake Surveys. Release 6.0. Springfield VA: National Technical Information Service; 1991.
49. Simons-Morton BG, Taylor WC, Huang IW. Validity of the physical activity interview and Caltrac with preadolescent children. Res Q Exerc Sport 1994;65(1):84–8. [PubMed: 8184216]
50. Ainsworth BE, Haskell WL, Leon AS, et al. Compendium of physical activities: classification of energy costs of human physical activities. Med Sci Sports Exerc 1993;25(1):71–80. [PubMed: 8292105]
51. Reynolds EL, Wines JV. Individual differences in physical changes associated with adolescence in girls. Am J Dis Child 1948;75:329–50. [PubMed: 18882060]
52. Reynolds EL, Wines JV. Physical changes associated with adolescence in boys. Am J Dis Child 1951;82:529–47.
53. Tanner, JM. Growth at adolescence. Vol. 2. Oxford: Blackwell Scientific Publications; 1962.
54. Dai S, Labarthe DR, Grunbaum JA, Harrist RB, Mueller WH. Longitudinal analysis of changes in indices of obesity from age 8 to 18 years: Project HeartBeat! Am J Epidemiol 2002;156:720–9. [PubMed: 12370160]

55. Houtkooper LB, Going SB, Lohman TG, Roche AF, Van Loan M. Bioelectrical impedance estimation of fat-free body mass in children and youth: a cross-validation study. J Appl Physiol 1992;72(1): 366–73. [PubMed: 1537738]
56. Baumgartner RN, Heymsfield SB, Roche AF. Human body composition and the epidemiology of chronic disease. Obes Res 1995;3(1):73–95. [PubMed: 7712363]
57. Guo SM, Roche AF, Houtkooper L. Fat-free mass in children and young adults predicted from bioelectric impedance and anthropometric variables. Am J Clin Nutr 1989;50(3):435–43. [PubMed: 2773822]
58. Cameron, N. The methods of auxological anthropometry. In: Falkner, F.; Tanner, JM., editors. Human growth: a comprehensive treatise. New York: Plenum Press; 1986. p. 3-46.
59. Weidman W, Kwiterovich P, Jesse MJ, Nugent E. Diet in the healthy child: Task Force Committee of the Nutrition Committee and Cardiovascular Disease in the Young Council of the American Heart Association. Circulation 1983;67(6):1141A–4A.
60. Consensus Development Panel. Lowering blood cholesterol to prevent heart disease. JAMA 1986;253:2080.
61. American Academy of Pediatrics Committee on Nutrition. Prudent life style for children: dietary fat and cholesterol. Pediatrics 1986;78(3):521–5. [PubMed: 3748694]
62. Bendich, A.; Deckelbaum, RJ. Preventive nutrition. Vol. 1. Totowa NJ: Humana Press, Inc; 1997.
63. Ziegler, EE.; Filer, LJ, Jr. Present knowledge in nutrition. Vol. 7. Washington DC: ILSI Press; 1996.
64. National Research Council. Diet and health. Vol. 3. Washington DC: National Academy Press; 1991.
65. Dietz WH. Childhood weight affects adult morbidity and mortality. J Nutrition 1998;128(2):411S–14S. [PubMed: 9478038]
66. Williams CL, Hayman LL, Daniels SR, et al. A statement for health professionals from the Committee on Atherosclerosis, Hypertension, and Obesity in the Young (AHOY) of the Council on Cardiovascular Disease in the Young, American Heart Association. Circulation 2002;106:143–60. [PubMed: 12093785]
67. U.S. Department of Agriculture, Agriculture Research Service. Food and nutrient intakes by children 1994–96, 1998. ARS Food Surveys Research Group. 1999. http://www.ars.usda.gov/SP2UserFiles/Place/12355000/pdf/scs_all.PDF
68. Lichtenstein AH, Appel LJ, Brands M, Carnethon M, Daniels S, Franch HA, Franklin B, Kris-Etherton P, Harris WS, Howard B, Karanja N, Lefevre M, Rudel L, Sacks F, Van Horn L, Winston M, Wylie-Rosett J. Diet and lifestyle recommendations revision 2006: a scientific statement from the American Heart Association Nutrition Committee. Circulation 2006;114(1):82–96. [PubMed: 16785338]Epub 2006 Jun 19
69. Boone JE, Gordon-Larsen P, Adair LS, Popkin BM. Screen time and physical activity during adolescence: longitudinal effects on obesity in young adulthood. IJBNPA 2007;4:26–36. [PubMed: 17559668]
70. Wells JCK, Hallal PC, Reichert FF, Menezes AMB, Araujo CLP, Victora CG. Sleep patterns and television viewing in relation to obesity and blood pressure: evidence from an Adolescent Brazilian Birth Cohort. Int J Obes 2008;32:1042–9.
71. O'Brien M, Nader PR, Houts RM, et al. The ecology of childhood overweight: a 12-year longitudinal analysis. Int J Obes 2007;31:1469–78.
72. Vandewater EA, Bickham DS, Lee JH. Time well spent? Relating television use to children's free-time activities. Pediatrics 2006;117(2):e181–91. [PubMed: 16452327]
73. Wardle J, Guthrie C, Sanderson S, Birch L, Plomin R. Food and activity preferences in children of lean and obese parents. Int J Obes Relat Metab Disord 2001;25(7):971–7. [PubMed: 11443494]
74. Coon KA, Goldberg J, Rogers BL, Tucker KL. Relationships between use of television during meals and children's food consumption patterns. Pediatrics 2001;107(1):E7. [PubMed: 11134471]
75. Lowry R, Wechsler H, Galuska DA, Fulton J, Kann L. Television viewing and its associations with overweight, sedentary lifestyle, and insufficient consumption of fruits and vegetables among U.S. high school students: differences by race, ethnicity, and gender. J Sch Health 2002;72(101):413–21. [PubMed: 12617028]
76. Matheson DM, Killen JD, Wang Y, Varady A, Robinson TN. Children's food consumption during television viewing. Am J Clin Nutr 2004;79(6):1088–94. [PubMed: 15159240]

77. Giammattei J, Blix G, Marshak HH, Wollitzer AO, Pettitt DJ. Television watching and soft drink consumption: associations with obesity in 11–13 year old schoolchildren. Arch Pediatr Adolesc Med 2003;157(9):882–6. [PubMed: 12963593]
78. Andersen LB, Harro M, Sardinha LB, et al. Physical activity and clustered cardiovascular risk in children: a cross-sectional study (The European Youth Heart Study). Lancet 2006;368(9532):299–304. [PubMed: 16860699]
79. Ribeiro JC, Guerra S, Oliveira J, et al. Physical activity and biological risk factors clustering in pediatric population. Prev Med 2004;39(3):596–601. [PubMed: 15313100]
80. Azizi F, Mirmiran P, Azadbakht L. Predictors of cardiovascular risk factors in Tehranian adolescents: Tehran Lipid and Glucose Study. Int J Vitamin Nutr Res 2004;74:307–12.
81. Gidding SS, Barton BA, Dorgan JA, et al. Higher self-reported physical activity is associated with lower systolic blood pressure: the Dietary Intervention Study in Childhood (DISC). Pediatrics 2006;118(6):2388–93. [PubMed: 17142523]
82. Dasgupta K. Sex differences in the development of higher systolic blood pressure during adolescence. Cardiol Rev 2008;25(5):54–7.
83. Pardee PE, Norman GJ, Lustig RH, Preud'homme D, Schwimmer JB. Television viewing and hypertension in obese children. Am J Prev Med 2007;33(6):439–43. [PubMed: 18022058]
84. Moran A, Jacobs DR Jr, Steinberger J, et al. Changes in insulin resistance and cardiovascular risk during adolescence: establishment of differential risk in males and females. Circulation 2008;117 (18):2361–9. [PubMed: 18427135]
85. Shankar RR, Eckert GJ, Saha C, Tu W, Pratt JH. The change in blood pressure during pubertal growth. J Clin Endocrinol Metab 2005;90(1):163–7. [PubMed: 15509638]
86. McPherson RS, Montgomery DH, Alexander M, Scanlon K, Serdula MK. Dietary assessment methods among school-aged children: validity and reliability. Prev Med 2000;31(2):S11–33.
87. Day, RS.; Hoelscher, DM.; Eastham, C.; Koers, E. Lessons learned over 35 years: dietary assessment methods for school aged children. In: Berdanier, CD.; Dwyer, J.; Beldman, EB., editors. Handbook of nutrition and food. Boca Raton FL: CRC Press, Taylor & Francis Group; 2008.
88. McPherson, RS.; Hoelscher, DM.; Alexander, M.; Scanlon, KS.; Serdula, MK. Validity and reliability of dietary assessment in school-age children (a 30 year review). In: Berdanier, CD., editor. Handbook of nutrition and food. Boca Raton FL: CRC Press; 2002.
89. Sallis JF, Buono MJ, Roby JJ, Micale FG, Nelson JA. Seven-day recall and other physical activity self-reports in children and adolescents. Med Sci Sports Exerc 1993;25(1):99–108. [PubMed: 8423762]
90. Sirard JR, Pate RR. Physical activity assessment in children and adolescents. Sports Med 2001;31 (6):439–54. [PubMed: 11394563]
91. Daniels SR, Greer FR. Committee on Nutrition. Lipid screening and cardiovascular health in childhood. Pediatrics 2008;122:198–208. [PubMed: 18596007]
92. Wang Y, Beydoun MA, Liang L, Caballero B, Kumanyika SK. Will all Americans become overweight or obese? Estimating the progression and costs of the U.S. obesity epidemic. Obesity (Silver Spring) 2008;16:2323–30. [PubMed: 18719634]

NIH-PA Author Manuscript
NIH-PA Author Manuscript



**Table 1**

Characteristics of participants by age and gender, Project HeartBeat!, 1991–1995 (N=556), % unless otherwise indicated

| | Boys (*n*=277) | | | Girls (*n*=279) | | |
|---|---|---|---|---|---|---|
| **Variables** | **Aged 8 years (*n*=122) %** | **Aged 11 years (*n*=89) %** | **Aged 14 years (*n*=66) %** | **Aged 8 years (*n*=124) %** | **Aged 11 years (*n*=82) %** | **Aged 14 years (*n*=73) %** |
| **Descriptive characteristics** | | | | | | |
| Sexual maturation | | | | | | |
| Pubic stage | | | | | | |
| 1 | 97.2 | 69.9 | 3.5 | 88.0 | 25.6 | 0.0 |
| 2 | 2.8 | 24.7 | 17.5 | 10.3 | 46.2 | 1.7 |
| 3 | 0.0 | 5.5 | 17.5 | 1.7 | 16.7 | 6.9 |
| 4 | 0.0 | 0.0 | 45.6 | 0.0 | 10.3 | 39.7 |
| 5 | 0.0 | 0.0 | 15.8 | 0.0 | 1.3 | 51.7 |
| | | **Genital stage** | | | **Breast stage** | |
| 1 | 93.4 | 47.9 | 1.8 | 90.8 | 13.9 | 0.0 |
| 2 | 6.6 | 45.2 | 7.0 | 7.6 | 48.1 | 0.0 |
| 3 | 0.0 | 6.8 | 28.1 | 1.7 | 25.3 | 14.8 |
| 4 | 0.0 | 0.0 | 40.4 | 0.0 | 10.1 | 24.6 |
| 5 | 0.0 | 0.0 | 22.8 | 0.0 | 2.5 | 60.7 |
| | **M (SD)** | **M (SD)** | **M (SD)** | **M (SD)** | **M (SD)** | **M (SD)** |
| Age (years) | 8.5 (0.3) | 11.5 (0.3) | 14.4 (0.1) | 8.5 (0.3) | 11.5 (0.4) | 14.4 (0.2) |
| Height (cm) | 131.6 (5.8) | 147.8 (7.1) | 166.6 (6.7) | 130.7 (6.8) | 147.9 (8.1) | 162.8 (5.4) |
| Weight (kg) | 29.7 (5.9) | 43.6 (11.5) | 57.8 (12.4) | 29.7 (8.0) | 42.0 (12.9) | 60.4 (14.5) |
| **Nutrient intake per day** | | | | | | |
| Energy (kcal) | 2277 (680) | 2323 (754) | 2796 (881) | 2026 (576) | 2193 (717) | 2190 (680) |
| Protein (g) | 82 (27) | 82 (29) | 102 (40) | 69 (25) | 77 (28) | 74 (27) |
| Protein (% kcal) | 14 (2) | 14 (2) | 14 (2) | 14 (2) | 14 (2) | 14 (2) |
| Carbohydrate (g) | 298 (91) | 303 (102) | 362 (107) | 274 (91) | 286 (94) | 293 (97) |
| Carbohydrate (% kcal) | 53 (6) | 52 (5) | 53 (7) | 54 (6) | 53 (6) | 54 (8) |
| Total fat (g) | 88 (32) | 91 (34) | 109 (42) | 77 (23) | 86 (32) | 85 (34) |
| Total fat (% kcal) | 34 (5) | 35 (5) | 35 (5) | 34 (5) | 35 (4) | 34 (7) |
| Saturated fat (g) | 33 (12) | 34 (12) | 41 (17) | 28 (9) | 32 (12) | 31 (12) |

| Variables | Boys (*n*=277) Aged 8 years (*n*=122) % | Boys Aged 11 years (*n*=89) % | Boys Aged 14 years (*n*=66) % | Girls (*n*=279) Aged 8 years (*n*=124) % | Girls Aged 11 years (*n*=82) % | Girls Aged 14 years (*n*=73) % |
|---|---|---|---|---|---|---|
| Saturated fat (% kcal) | 13 (2) | 13 (2) | 13 (2) | 13 (2) | 13 (2) | 12 (3) |
| Cholesterol (mg) | 255 (109) | 258 (123) | 310 (144) | 216 (102) | 251 (115) | 230 (104) |
| Fiber (g) | 14 (6) | 15 (6) | 17 (7) | 14 (5) | 14 (6) | 14 (5) |
| Calcium (mg) | 1196 (503) | 1146 (509) | 1438 (755) | 1020 (424) | 1109 (617) | 1077 (614) |
| **Physical activity per day** | | | | | | |
| TV viewing (min) | 102 (96) | 106 (93) | 95 (86) | 79 (92) | 119 (125) | 99 (104) |
| Moderate physical activity (min) | 14 (28) | 33 (58) | 27 (44) | 11 (18) | 11 (22) | 11 (23) |
| Vigorous physical activity (min) | 74 (81) | 61 (66) | 63 (70) | 59 (52) | 38 (48) | 44 (70) |
| Moderate-to-vigorous physical activity (min) | 87 (88) | 94 (80) | 90 (72) | 70 (56) | 50 (55) | 55 (73) |

**Table 2**

CVD risk factors by fat intake, adjusted for age and sexual maturation, Project HeartBeat!, 1991–1995

| | **Boys ($n$=236)[a] Dietary total fat (%kcal/day)** | | | | | | **Girls ($n$=253)[a] Dietary total fat (%kcal/day)** | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Low[b] ($n$=58)** | | **Moderate[b] ($n$=137)** | | **High[b] ($n$=41)** | | **Low ($n$=61)** | | **Moderate ($n$=151)** | | **High ($n$=41)** | |
| **Variables** | **M[c]** | **SE[c]** | **M** | **SE** | **M** | **SE** | **M** | **SE** | **M** | **SE** | **M** | **SE** |
| Energy (kcal/day) | 2229 | 100.6 | 2443 | 65.4 | 2557 | 119.6 | 2140 | 83.6 | 2080 | 53.1 | 2283 | 102.0 |
| Protein (g) | **77**[*] | 4.2 | **89** | 2.7 | **92** | 5.0 | **67** | 3.4 | **73** | 2.1 | **84** | 4.1 |
| Protein (% kcal/day) | 14 | 0.3 | 15 | 0.2 | 14 | 0.3 | **13** | 0.3 | **14** | 0.2 | **15** | 0.3 |
| Carbohydrate (g/day) | 330 | 12.8 | 315 | 8.3 | 290 | 15.3 | **328** | 11.7 | **274** | 7.4 | **249** | 14.2 |
| Carbohydrate (% kcal/day) | **59** | 0.5 | **52** | 0.3 | **46** | 0.5 | **61** | 0.5 | **53** | 0.3 | **44** | 0.6 |
| Total fat (g/day) | **71** | 4.2 | **96** | 2.8 | **119** | 5.1 | **68** | 3.4 | **81** | 2.2 | **109** | 4.2 |
| Total Fat (% kcal/day) | **29** | 0.3 | **35** | 0.2 | **42** | 0.3 | **29** | 0.4 | **35** | 0.2 | **43** | 0.4 |
| Saturated fat (g/day) | **27** | 1.6 | **36** | 1.1 | **43** | 1.9 | **25** | 1.3 | **30** | 0.8 | **39** | 1.5 |
| Saturated fat (% kcal/day) | **11** | 0.2 | **13** | 0.1 | **15** | 0.2 | **10** | 0.2 | **13** | 0.1 | **15** | 0.2 |
| Cholesterol (mg/day) | **202** | 14.9 | **285** | 9.7 | **316** | 17.8 | **196** | 13.2 | **230** | 8.4 | **288** | 16.2 |
| Fiber (g/day) | 15 | 0.8 | 15 | 0.5 | 16 | 1.0 | 15 | 0.7 | 13 | 0.4 | 14 | 0.8 |
| Calcium (mg/day) | **1341** | 75.2 | **1230** | 48.9 | **1008** | 89.5 | 1042 | 69.4 | 1084 | 44.1 | 1006 | 84.7 |
| TV viewing (min/day) | 97 | 12.0 | 91 | 7.8 | 129 | 14.3 | 79 | 13.8 | 98 | 8.8 | 100 | 16.8 |
| MPA (min/day) | 25 | 6.1 | 24 | 3.9 | 33 | 7.2 | 14 | 2.7 | 11 | 1.7 | 10 | 3.3 |
| VPA (min/day) | 66 | 10.1 | 73 | 6.6 | 62 | 12.0 | **67** | 7.3 | **43** | 4.6 | **53** | 8.9 |
| MVPA (min/day) | 90 | 11.1 | 96 | 7.2 | 95 | 13.2 | **81** | 7.9 | **54** | 5.0 | **63** | 9.6 |
| SBP (mmHg) | 102 | 0.9 | 102 | 0.6 | 101 | 1.1 | **102** | 1.0 | **99** | 0.6 | **101** | 1.2 |
| DBP4 (mmHg) | 66 | 0.8 | 65 | 0.5 | 66 | 1.0 | 65 | 0.8 | 64 | 0.5 | 64 | 0.9 |
| DBP5 (mmHg) | 54 | 1.0 | 56 | 0.7 | 57 | 1.2 | 57 | 0.9 | 55 | 0.6 | 55 | 1.1 |
| BMI ($kg/m^2$) | 19 | 0.4 | 19 | 0.3 | 19 | 0.5 | 19 | 0.5 | 19 | 0.3 | 20 | 0.6 |
| PBF (%) | 21 | 1.0 | 22 | 0.7 | 22 | 1.2 | 27 | 0.9 | 26 | 0.6 | 26 | 1.2 |
| Waist circumference (cm) | 65 | 1.0 | 65 | 0.7 | 64 | 1.2 | **63** | 0.9 | **61** | 0.6 | **64** | 1.1 |
| Plasma cholesterol (mg/dL) | 159 | 3.4 | 160 | 2.2 | 161 | 4.0 | 162 | 3.6 | 160 | 2.3 | 165 | 4.4 |
| HDL-C (mg/dL) | 51 | 1.5 | 52 | 1.0 | 54 | 1.8 | 50 | 1.4 | 50 | 0.9 | 51 | 1.7 |
| LDL-C (mg/dL) | 92 | 3.0 | 93 | 2.0 | 91 | 3.6 | 94 | 3.4 | 95 | 2.2 | 100 | 4.2 |
| Triglycerides (mg/dL) | 77 | 5.6 | 80 | 3.6 | 78 | 6.6 | 86 | 5.2 | 81 | 3.3 | 78 | 6.3 |

[*] Bold indicates significant differences ($p$<0.05) between total fat intake categories, within gender.

NIH-PA Author Manuscript

NIH-PA Author Manuscript

[a] N=489 (236 boys and 253 girls) because of missing serum values

[b] Low= ≤30% kcal; moderate=31%–38% kcal; high=≥39% kcal

[c] From ANCOVA, adjusted for pubertal stage with age as covariate

DBP4, fourth-phase diastolic blood pressure; DBP5, fifth-phase diastolic blood pressure; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; MPA, moderate physical activity; MVPA, moderate-to-vigorous physical activity; PBF, percent body fat; SBP, systolic blood pressure; VPA, vigorous physical activity

**Table 3**

CVD risk factors by MVPA, adjusted for age and sexual maturation, Project HeartBeat!, 1991–1995

| | Boys (*n*=236)[a] MVPA (min/day) | | | | | | Girls (*n*=253)[a] MVPA (min/day) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Low[b] (*n*=59) | | Moderate[b] (*n*=69) | | High[b] (*n*=108) | | Low (*n*=99) | | Moderate (*n*=82) | | High (*n*=72) | |
| **Variables** | **M**[c] | **SE**[c] | **M** | **SE** | **M** | **SE** | **M** | **SE** | **M** | **SE** | **M** | **SE** |
| Energy (kcal/day) | 2394 | 100.7 | 2432 | 93.2 | 2404 | 74.5 | 2084 | 74.5 | 2094 | 72.2 | 2225 | 77.1 |
| Protein (g/day) | 88 | 4.2 | 87 | 3.9 | 85 | 3.1 | 73 | 3.1 | 70 | 3.0 | 78 | 3.2 |
| Protein (% kcal/day) | 15 | 0.3 | 14 | 0.3 | 14 | 0.2 | 14 | 0.2 | 13 | 0.3 | 14 | 0.3 |
| Carbohydrate (g/day) | 310 | 12.8 | 314 | 11.9 | 316 | 9.5 | 269 | 9.5 | 286 | 10.4 | 299 | 11.1 |
| Carbohydrate (% kcal/day) | 52 | 0.7 | 52 | 0.7 | 53 | 0.5 | 52 | 0.5 | 54 | 0.7 | 54 | 0.8 |
| Total fat (g/day) | 93 | 4.7 | 96 | 4.3 | 93 | 3.4 | 83 | 3.4 | 79 | 3.3 | 84 | 3.5 |
| Total fat (% kcal/day) | 35 | 0.6 | 35 | 0.6 | 35 | 0.5 | 36 | 0.5 | 34 | 0.6 | 34 | 0.6 |
| Saturated fat (g/day) | 35 | 1.7 | 35 | 1.6 | 35 | 1.3 | 30 | 1.3 | 29 | 1.2 | 31 | 1.3 |
| Saturated fat (% kcal/day) | 13 | 0.2 | 13 | 0.2 | 13 | 0.2 | 13 | 0.2 | 12 | 0.2 | 13 | 0.2 |
| Cholesterol (mg/day) | 269 | 15.7 | 266 | 14.5 | 273 | 11.6 | 229 | 11.6 | 220 | 11.8 | 247 | 12.6 |
| Fiber (g/day) | 15 | 0.8 | 16 | 0.7 | 15 | 0.6 | 13 | 0.6 | 14 | 0.6 | 15 | 0.6 |
| Calcium (mg/day) | 1244 | 75.8 | 1244 | 70.1 | 1189 | 56.0 | 1018 | 56.0 | 1031 | 59.6 | 1154 | 63.6 |
| TV viewing (min/day) | 124 | 11.9 | 89 | 11.0 | 92 | 8.8 | **120**[*] | 8.8 | **71** | 11.7 | **84** | 12.5 |
| MPA (min/day) | **4** | 5.6 | **16** | 5.2 | **43** | 4.1 | **2** | 4.1 | **12** | 2.1 | **23** | 2.3 |
| VPA (min/day) | **8** | 7.8 | **41** | 7.2 | **121** | 5.7 | **9** | 5.7 | **39** | 3.9 | **120** | 4.2 |
| MVPA (min/day) | **12** | 6.9 | **56** | 6.4 | **164** | 5.1 | **11** | 5.1 | **52** | 3.5 | **144** | 3.7 |
| SBP (mmHg) | 101 | 0.9 | 102 | 0.9 | 102 | 0.7 | **99** | 0.7 | **99** | 0.8 | **102** | 0.9 |
| DBP4 (mmHg) | 65 | 0.8 | 66 | 0.7 | 65 | 0.6 | 65 | 0.6 | 64 | 0.7 | 65 | 0.7 |
| DBP5 (mmHg) | **54** | 1.0 | **58** | 1.0 | **55** | 0.8 | 56 | 0.8 | 55 | 0.8 | 56 | 0.9 |
| BMI ($kg/m^2$) | 19 | 0.4 | 18 | 0.4 | 19 | 0.3 | 20 | 0.3 | 19 | 0.4 | 19 | 0.5 |
| PBF (%) | 21 | 1.0 | 22 | 0.9 | 22 | 0.7 | 27 | 0.7 | 25 | 0.8 | 25 | 0.9 |
| Waist circumference (cm) | 65 | 1.0 | 65 | 0.9 | 65 | 0.7 | 64 | 0.7 | 61 | 0.8 | 61 | 0.8 |
| Plasma cholesterol (mg/dL) | 160 | 3.3 | 161 | 3.1 | 160 | 2.5 | 158 | 2.5 | 162 | 3.1 | 165 | 3.3 |
| HDL-C (mg/dL) | 53 | 1.5 | 53 | 1.4 | 51 | 1.1 | 49 | 1.1 | 52 | 1.2 | 49 | 1.3 |
| LDL-C (mg/dL) | 91 | 3.0 | 93 | 2.8 | 92 | 2.2 | 93 | 2.2 | 96 | 3.0 | 98 | 3.2 |
| Triglycerides (mg/dL) | 78 | 5.4 | 73 | 5.0 | 83 | 4.0 | 82 | 4.0 | 77 | 4.5 | 87 | 4.8 |

NIH-PA Author Manuscript
NIH-PA Author Manuscript

[*] Bold indicates significant differences ($p<0.05$) between MVPA categories, within gender.

[a] N=489 (236 boys and 253 girls) because of missing serum values

[b] Low=0–30 minutes; moderate=31–89 minutes; high=≥90 minutes

[c] From ANCOVA, adjusted for pubertal stage with age as covariate

DBP4, fourth-phase diastolic blood pressure; DBP5, fifth-phase diastolic blood pressure; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; MPA, moderate physical activity; MVPA, moderate-to-vigorous physical activity; PBF, percent body fat; SBP, systolic blood pressure; VPA, vigorous physical activity