Healthy Growth: Project Description and Baseline Findings

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Objectives: The purpose of the study was to describe the physical activity, blood pressure, and body fat patterns of sixth-grade, African-American girls (*N*=82), who participated in the Healthy Growth Study. The purpose of the primary study questions was to determine which sets of variables best predict blood pressure, physical activity, and body fat.

Design and Methods: This paper is a cross sectional analysis of the first assessment of a 5-year longitudinal project. Standard procedures were used to assess height, weight, skinfolds, blood pressure, physical activity, predictors of physical activity, maturation, dietary intake, fitness level, and health behaviors.

Results: The average age of the subjects was 12.3 years; almost two-thirds of the girls had reached menarche. Fifty-two percent of the 13-year-olds had body mass index (BMI) values greater than the 85th percentile for their age and sex compared to 32% of the 12-year-olds. None of the variables were significantly related to diastolic or systolic blood pressure. Physical activity was significantly and negatively related to total percent of calories from fat and to breast stages and positively related to waist/thigh ratio. Body mass index (BMI) was significantly and positively related to breast stages.

Conclusions: Important developmental differences between 12- and 13-year-olds were evident. Body mass index (BMI) was mainly dependent on physical maturity. No relationship was found between BMI and blood pressure. The relationship between physical activity and waist/thigh ratio merits further study. The importance of BMI and physical inactivity as potential indicators of cardiovascular risk in adolescent girls is discussed. Developmentally appropriate and culturally competent interventions are recommended to increase physical activity and healthy eating behaviors among adolescents. (*Ethn Dis.* 2002;12:567–577)

Key Words: Adolescence, African-American, Anthropometry, Blood Pressure, Body Mass Index, Diet, Female, Health Behavior, Physical Activity, Physical Fitness

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Introduction

During childhood and adolescence, engaging in physical activity is important in order to maintain normal growth and development.[1–3] In contrast, physical inactivity is a significant risk factor for coronary heart disease among adults.[1,3] A major health concern is that physical activity levels (total daily energy expenditure per kilogram of body weight) decrease from 6 to 18 years of age.[4,5] From 11 to 17 years of age, the decrease in physical activity is almost 45%.[4,5] The effects of changes in physical activity on cardiovascular risk factors such as body fat, blood pressure, growth, and development during adolescence are not well known, particularly among African-American girls. Healthy Growth, a 5-year cohort study of African-American adolescent girls, was designed to: 1) describe longitudinal patterns of physical activity; 2) assess longitudinal changes in blood pressure and body fat; and 3) determine predictors of changes in physical activity. Twice yearly, the Healthy Growth staff measures height, weight, body fat, body fat distribution, blood pressure, physical activity patterns, predictors of physical activity, menarche, Tanner stages, dietary intake, fitness, smoking, drinking, dieting, and drug use.

Although there have been longitudinal studies that studied adolescents,[6–9] Healthy Growth is unique because the focus is on physical activity patterns and predictors of physical activity, as well as on concomitant changes in blood pressure and body fat in African-American girls. We found no other published literature with the same focus and target population as the Healthy Growth Study. The purpose of this study was to describe Healthy Growth baseline data and examine relationships among physical activity, blood pressure, and anthropometric measurements. Specifically, in addition to descriptive analyses, the 3 main study questions are: 1) Do body fat, nutrition, maturity, physical activity, and/or physical fitness level predict blood pressure values? 2) Do body fat, nutrition, maturity, predictors of physical activity, and/or physical fitness level predict physical activity? and 3) Do nutrition, maturity, physical activity, and/or physical fitness level predict body fat?

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METHODS

Subjects and Recruitment

Sixth grade is an important developmental period for health behaviors and physical maturation. We recruited all 120 sixth-grade girls from a predominantly African-American (93% African-American, 6% Hispanic, 1% European-American) middle school in Houston, Texas. Approximately 54% of the students were on the federal program for free or reduced price lunches. The school had relatively low mobility rates (ie, movement into, out of, or within the school district during a school year), simple feeder patterns (ie, most students attended the same high school), and a supportive school administration (ie, enthusiastic principal, assistant principals, and teachers). The school district and the university's internal review board approved the study, which included parental consent and child assent forms. The methods for ascertaining each measurement are described below.

Anthropometry

The anthropometry measures included height, weight, circumferences, and skinfolds. Reliable and valid assessments were used in this study. Height was taken without shoes on a portable Harpenden stadiometer. Weight was taken on a balance beam scale. Four circumferences were taken with a retractable inelastic tape on the arm, abdomen, hip, and lower thigh. Five skinfolds were measured with a Holtain skinfold caliper on the medial calf, lower thigh, triceps, subscapular, and abdomen. Measurement procedures followed Lohman et al,[10] except for the lower thigh skinfold. The technique for the lower thigh skinfold is described in Sangi et al.[11] Based on previous research,[12] the lower thigh skinfold is a valid indicator of lower body subcutaneous fat in adults. Also, we computed a waist/thigh ratio because this ratio was the first abdominal adiposity index devised using circumferences.[13] Moreover, in a cross-sectional study of 10- to 14-year-old children, the waist/thigh ratio was consistent with skinfold measures in statistically reflecting the contours of the human body as far as distinguishing between abdominal and lower body patterns of fat distribution, whereas the waist/hip ratio was not.[14]

The reliability of Healthy Growth's anthropometric measures was at an acceptable and very high level with intra-class correlations of 0.95 or greater for most measures except skinfolds (typically > 0.90) and circumference ratios (waist/hip and waist/thigh that ranged from 0.83 to 0.90). For example, the intra-class correlation coefficients for both same observer and different observer repeated measures were above 0.95 for height, weight, BMI (weight/height^2), abdominal circumference, arm circumference, hip circumference, and thigh circumference and above 0.93 for calf skinfold, subscapular skinfold, and abdominal skinfold. All correlations have been reported elsewhere in detail.[15]

The set of skinfolds and circumferences provide a complete list of variables useful in studies of fatness or obesity and anatomic fat distribution. Circumferences and skinfolds were taken on the right side of the body. Skinfold measurements are potentially less reliable than other anthropometric measures.[16] Thus, skinfolds over 20 mm were remeasured and the resultant values averaged to improve reliability, which tends to diminish with increasing skinfold thickness.[17] The measurements were taken with one technician performing the procedures and another acting as a recorder. Standard anthropometric techniques in terms of site and instruments were followed.[18]

Blood Pressure

The blood pressure measures were systolic and diastolic blood pressures, mean arterial pressure, and pulse. The Dinamap 8100 automatic monitor was used to assess these values. The equipment was calibrated before data collection began. All staff were trained for about 2 hours on the use of the instrument. Before the measurement, each subject sat quietly for several minutes (a 5 minute rest period) while the staff member explained the procedure. Based on the measured circumference of the right arm, the staff member then selected the appropriately sized cuff from the five available cuff sizes. The cuff was placed on the subject's right arm[19] with the subject sitting in a chair, feet flat on the floor, and arm elevated to the heart level. Two measurements were taken exactly one minute apart and were then averaged for analyses. Between the 2 measurements, the subjects were instructed to raise their arms, and open and close their fists 3 times. This procedure allows for the filling of the blood vessels thus preventing artificially lowering the blood pressure due to the recent constriction.[20]

Physical Activity

The frequency, duration, and intensity of physical activity were assessed. The project investigators developed a physical activity frequency interview that included a list of 41 activities, from sedentary behaviors to high intensity physical activities. Observations of girls' physical activity behaviors and published literature were used to develop the list of activities appropriate for our population.[21] An intensity index was

Antecedents		Consequences	
Distal *Environmental Factors*	Proximal *Environmental Factors*	Proximal *Environmental Factors*	Distal *Environmental Factors*
Climate Air quality	Convenience of facilities Safety of neighborhood	Equipment failure Pleasantness of exercise setting	Hot/cold temperatures
Social Factors	*Social Factors*	*Social Factors*	*Social Factors*
Past modeling and support	Friend modeling Media influences	Praise Criticism Competing opportunities	Physical attractiveness Being in shape
Cognitive Factors	*Cognitive Factors*	*Cognitive Factors*	*Cognitive Factors*
Normative beliefs	Exercise knowledge Self-efficacy	Exhaustion Positive/negative moods	Anticipated health benefits Fear of injury
Physiological Factors	*Physiological Factors*	*Physiological Factors*	*Physiological Factors*
Health status Coordination	Injury	Heart rate Perspiration Breathing rate	Weight change Fitness Chronic injury
Other Personal Factors	*Other Personal Factors*	*Other Personal Factors*	*Other Personal Factors*
Education Income Weight control history	Diet Other health-related behaviors	Smoking Alcohol use	General risk taking

Note: For each cell, examples are given. Additional variables can be added to each classification.

Fig 1. A model of determinants of physical activity based on learning theory adapted from Sallis and Hovell (1990)

used to classify the activities as light, moderate, or vigorous. The items per category were: sleeping (N=1), sedentary (N=6), light activity (N=2), moderate activity (N=11), and vigorous (N=21). Each activity was assigned a MET value based on previous research.[22,23] One MET is equivalent to an oxygen uptake of 3.5 $ml\cdot kg^{-1}\cdot min^{-1}$.[17] Sleeping had a MET value of 1, sedentary behaviors had a MET value of 1.5, light activities had a MET value of 2, moderate activities had MET values of 3, 4.5, or 5; and vigorous activities had MET values of 6.5, 7, or 8.5. With the MET value, minutes spent engaged in the activity, and body weight, we calculated kilocalories burned. The following standard formula[22] was used to calculate average daily kilocalories burned in activities:

$$(\text{weekly hours in activity} \times \text{MET value of activity} \times \text{weight in kilograms})/7$$

During the interview, the subjects were asked if they had participated in each activity in the last 7 days, how many times they had participated, and duration of the participation. For the physical activities, subjects were also asked if the activity made them breathe fast or caused their heart to beat faster. If so, they were asked how long their breathing and heartbeat were faster than usual. A higher MET value (1.5 was added to the MET value) was assigned for the minutes that the subject's breathing or heartbeat was increased during an activity. This procedure was used to accurately account for the intensity of an activity because the same activity can be performed at a low, moderate, or high intensity. The reliability and validity of this interview procedure and instrument have been documented.[24] Intra-observer and inter-observer test-retest reliabilities were conducted on a sample of 21 girls who completed a second interview after the first. The correlation coefficients for the test-retest reliabilities ranged from .70 to .92.

At the end of the interview, the interviewer rated the overall quality of the girl's responsiveness on a scale of 1 to 5 with one being poor and 5 being excellent. The criteria for the ratings were attentiveness, ability to recall activities, ability to estimate time, and overall quality of interview. The purpose of the ratings was to identify girls who were very inattentive or disinterested during the interview. If the interview's overall quality was rated as poor, the subject was eliminated from the analyses. Based on this criterion, only one interview was excluded.

Predictors of Physical Activity

Factors and conditions potentially related to physical activity were assessed. Sallis and Howell's multidimensional model of determinants of physical activity based on operant and cognitive learning theories was used to assess predictors of physical activity.[25] This model postulates that learning theories and learning processes provide a comprehensive basis for explaining and influencing behavior. Therefore, the model is a useful conceptual framework to analyze the complex behavior of physical activity (Figure 1).[25] The multidimensional model[25] has 5 classifications: 1) environment (eg, characteristics of the physical environment, climate, convenient access to facilities, safety of neighborhood); 2) social (eg, modeling, social support, encouragement, praise, teasing, criticism); 3) cognitive (eg, knowledge, perceptions, intentions, health benefits, fear of injury); 4) physiological (eg, coordination, fatigue, exertion, perspiration, breathing hard, relaxation, soreness) and 5) other personal factors (eg, education, income, smoking, alcohol use, injury history, other health behaviors). An important structure to the multidimensional model is consequences and antecedents. Within each of the 5 classifications, variables representing both consequences (effects that can occur after physical activity such as fatigue, praise, health benefits) and antecedents (influences that precede participating in physical activity such as expectations, attitudes, knowledge, encouragement, access to facilities) are included in the model.

We adapted this theoretically based multidimensional model[25] and developed the 54-item Predictors of Physical Activity Questionnaire. The questionnaire includes 4 environment, 16 social, 18 cognitive, 9 physiological, 1 other personal factor, and 6 self-efficacy items. We added the self-efficacy classification because self-efficacy perceptions can be a strong predictor of behavior.[26] All analyses of this questionnaire were conducted using the 6 broad classifications, rather than the consequences and antecedents dimensions.

The questionnaire was interviewer-administered. The response categories were: yes (4), sort of yes (3), sort of no (2), and no (1). For the self-efficacy subscale only, the response categories were: very sure (4), sort of sure (3), sort of not sure (2), and not sure (1). As a measure of a scale's internal consistency, the Cronbach alpha coefficient for the questionnaire was .97. The individual subscales' Cronbach alpha coefficients were: cognitive—.91; social—.89; physiological—.84; self efficacy—.79; and environmental—.63. The personal factor classification had only one item and therefore no Cronbach's alpha coefficient was calculated. Having Cronbach alpha coefficients $\geq$0.70 is the standard criterion for new scales.[27]

The test-retest (the time frame for the first and second administration was 7 to 36 days) correlation coefficients (Pearson for normally distributed scores or Spearman for distributions not normally distributed) were: overall questionnaire (Pearson r=.82); cognitive (Pearson r=.76); self efficacy (Spearman r=.73); environment (Spearman r=.63); social (Pearson r=.56); and physiological (Pearson r=.22). All correlation coefficients were significant ($P\leq$.001) except for the physiological classification.

Stage of Maturation

Each subject self-assessed her secondary sex characteristics by comparing her body to drawings of the Tanner stages.[28] Each drawing was accompanied with a detailed written description. The drawings depict 5 successive stages of breast development and pubic hair growth. The first stage is preadolescence and the fifth stage is the mature adult. The 5 stages of pubic hair development were: 1) no pubic hair; 2) a little long, lightly colored hair; 3) the hair is darker, coarser, and more curled and thinly covers a larger area; 4) the hair is dark, curly, and coarse and has not spread out to the thighs; and 5) the hair has a triangular pattern as it spreads out to the thighs. The 4 stages of breast development were: 1) the nipple is raised and the rest of the breast is flat; 2) the nipple is raised and the breast is a small mound; 3) the areola and the breast are larger than stage 2 and the areola does not protrude from the breast; 4) the areola and the nipple make up a mound that protrudes from the shape of the breast; and 5) the breasts are fully developed, only the nipple protrudes, and the areola has receded into the general shape of the breast. The self-assessment activity was performed in a private area with instruction from a woman staff member. This procedure is a valid non-invasive method of measuring female maturation.[29] Additionally, the subjects were asked about the onset of menses.

Dietary Intake

The dietary habits of each girl were assessed. The purpose of the dietary interview was to determine the usual nutrient intake of the girl during the previous week to evaluate the potential confounding role that dietary intake might have on the relationship between physical activity, body fat, and blood pressure. An interviewer administered a food frequency questionnaire (FFQ) at each examination period to determine the usual intake of a list of 137 foods. FFQs have been shown to provide acceptable estimates of nutrient intake in adolescents.[30] The interviewers were trained for several hours to enable them to conduct the 20-minute interview. The food list for the FFQ was developed from the analysis of 3-day food records collected from school-aged children and adolescents in Houston, Texas.[31] Using data from the food records, the foods that were the most important contributors to energy intake, and the macro- and micro-nutrients that may be related to the development of cardiovascular disease, were identified. Thus, the food list represents those foods that are major contributors to the usual nutritional intake of children and adolescents in this area. Nutrient amounts are estimated using standard portion sizes of each food that are developed using data from the USDA Survey Nutrient Data Base.[32] Data were entered into the Food Frequency Data Entry and Analysis Program (FFDEAP)[33] in order to calculate the individual usual daily intake of 30 nutrients and the amount of nutrients consumed from each food on the FFQ per individual. The gram weight and nutrient data used in the FFDEAP are from the Survey Nutrient Data Base. Nutrient densities were also calculated for each participant in order to provide an estimate of the overall quality of the diets.

Fitness

Fitness levels were assessed by reliable and valid measures. We estimated cardiovascular fitness of our subjects by measuring their aerobic capacity (VO_2max) levels. Each girl, except for those with medical conditions that precluded maximal exercise testing, completed a continuous incremental walk/run protocol to volitional exhaustion on a motorized treadmill. Each subject began walking at 2.5 mph. Speed was increased by 0.5 mph at 1-minute intervals until 6.0 mph. At this point, if the subject was still exercising, treadmill elevation was increased by 3% each minute until she could no longer continue running. The subject was verbally encouraged to do her best as she ran continuously until volitional exhaustion. The test began after the girl was familiar with the treadmill and comfortable with all procedures.

Oxygen consumption and carbon dioxide production were measured continuously via the open circuit method using an MMC Horizon metabolic cart (Sensor Medics; Yorba Linda, Calif). Prior to each test, flow meter accuracy was checked with a 3-liter calibration syringe that holds 3 liters of air when the piston is wide open. Metabolic analyzers and flow controller were calibrated with certified standard gases of known concentrations, which had been verified by the micro-Scholander technique. Single trial reliability of maximal treadmill testing in adolescent girls has been established at $Rxx=0.87$ with a standard error of measurement of only 1.8 ml kg^{-1} min^{-1}.[34] VO_2 was calculated in ml min^{-1} and each girl's VO_2max value was divided by her body weight to account for differences in body size (mL O_2, per kg body wt, per minute). The criteria for determination of VO_2max have been documented.[35]

Health Behavior Questionnaire

Health behaviors that affect growth, maturity, fitness, blood pressure, and physical activity were assessed. The Youth Risk Behavior Survey Questionnaire developed in 1990 by the Centers for Disease Control and Prevention was modified to assess alcohol, tobacco, oral contraceptive use, recent medical conditions, and dieting behaviors. The girls were asked to read each question carefully and to be completely honest, while being assured that their responses were confidential.

We selected 26 items from the Youth Risk Behavior Survey Questionnaire. Seven items asked about cigarette use and chewing tobacco. For example, "How old were you when you smoked a whole cigarette for the first time?" "During your lifetime, how many days have you smoked at least 1 cigarette?" These 2 questions had 7 response categories. Four questions asked about alcohol use. For example, "How old were you when you had your first drink of alcohol other than a few sips?" This question had 7 response categories. Six questions asked about body weight. For example, "Do you think of yourself as being: very underweight, slightly underweight, about the right weight, slightly overweight, or very overweight." "Which of the following are you trying to do—lose weight, gain weight, stay the same weight, or I am not trying to do anything about my weight." One question was about the use of oral contraceptives. Eight questions were about illegal drug use. For example, "During your life, how many times have you used marijuana?" For this question there were 7 response categories.

A test-retest reliability study of the Youth Risk Behavior Survey Questionnaire was conducted with 1,679 students and the results indicate that students report health behaviors reliably over time.[36] The validity of self-report measures of illicit drug use, alcohol use, and tobacco use has been documented.[36]

Analysis Plan

For descriptive purposes, the means and standard deviations for blood pressure, physical activity, and anthropometric measures are presented. To determine levels of obesity and hypertension, we used body mass index (BMI is calculated by weight in kilograms divided by height in meters squared), skinfolds (triceps and subscapular) exceeding the 85th percentile on the second National Health and Nutrition Examination Survey,[37] and high levels of blood pressure, as recommended by the Task Force on Blood Pressure Control in Children.[19,38]

The statistical analyses addressed the 3 study questions: 1) Do body fat, nutrition, maturity, physical activity, and physical fitness level predict blood pressure values? 2) Do body fat, nutrition, maturity, predictors of physical activity, and physical fitness level predict physical activity? 3) Do nutrition, maturity, physical activity, and physical fitness level predict body fat? The 3 dependent variables were modeled in 3 separate groups of regressions. The following measures were independent variables for the appropriate regressions: 1) a body fat measure (BMI), a body fat distribution measure (waist/thigh ratio); 2) nutrition variables (total fat and energy); 3) maturity measures (breast and menarche stages); 4) physical activity (moderate to vigorous minutes); 5) a combination of BMI and moderate to vigorous minutes; 6) predictors of physical activity (social and cognitive factors); 7) physical fitness (VO_2max); and 8) height.

The independent variables were selected from a larger series of measurements in preliminary analyses. The correlations between physical activity (moderate to vigorous minutes), blood pressure, and 7 different body fat indices were performed. The body fat measures were: BMI (weight/height^2), Rohrer Index (weight/height^3), abdomen circumference, and the sum of 5 skinfolds—medial calf, lower thigh, triceps, subscapular, and abdomen. The indices of abdominal fat distribution were waist/hip ratio, waist/thigh ratio, and conicity index. Both BMI and waist/

thigh ratio were chosen to enter in the regression analysis because these variables exhibited the strongest correlations with systolic blood pressure, and the least correlation with each other in the preliminary analysis.

A similar correlation matrix was computed with 5 nutrition variables (protein, carbohydrate, total fat, saturated fat, energy), physical activity (moderate to vigorous minutes) and blood pressure. Total fat had the highest Pearson correlation coefficient (r=.15) with blood pressure, and was retained for further analyses.

The maturity measure (breast stages) was selected because it had a strong and significant correlation with BMI. Further, moderate to vigorous minutes of physical activity was selected as the primary measure of physical activity, because it represents the intensity most associated with health benefits and national standards.[1–3]

To visually inspect the relationship between variables, a graph was plotted comparing moderate to vigorous physical activity minutes to BMI. There was considerable variance in the middle of the graph, indicating perhaps the need for a combination term to explore the possible synergism between the 2 variables. Thus, a variable (RiskBMI) was created to represent cardiovascular risk of BMI and physical activity combined. This variable was determined by the product of BMI and physical activity reversed (ie, low BMI and high activity are scored as 'lowest risk', and so on).

Cognitive (18 items related to physical activity and knowledge, attitudes, and expectations) and social (16 items related to physical activity and family, friends, coaches, and teachers) factors from the Predictors of Physical Activity Questionnaire were chosen to be included in the regression analysis because they had the highest Cronbach alpha coefficient values (ie, the most internally consistent scales). Physical fitness was included as an independent variable in the physical activity regression, because fitness level and activity can be related. Height was included in the regression model when BMI and waist/thigh ratio were the dependent variables, because height is a measure of overall physical size and maturation, a possible confounder for blood pressure. The statistical method was linear regression computed by SAS version 6.12.

RESULTS

Data Collection

Baseline data collection took place during April and May. At the end of the 2-month recruitment period, 91 of 105 (86.7%) sixth grade girls returned consent forms. Of the 91 girls, 89 completed some parts of the assessment; one girl did not complete data collection because she was suspended from school and one girl withdrew from the study. Additionally, a treadmill exercise test to volitional exhaustion (a funded supplement to Healthy Growth) was conducted for 54 girls. Thirty-five girls did not have a fitness score—21 girls did not reach volitional exhaustion, 13 girls had asthma and did not attempt the test, and one girl did not complete the test because she was suspended from school. The girls completed all assessments, usually during physical education classes, in a schoolroom designated for Healthy Growth. The girls received a small incentive (eg, movie ticket, amusement park coupon) for participating in each data collection period. Each semester, field staff received 12 to 16 hours of measurement instruction and evaluation from a master trainer who also monitored data collection at the school.

Univariate Analyses

The ethnic composition of the school was predominantly African-American (N=82, 93.2%) followed by Hispanic-American (N=5, 5.7%) and European-American (N=1, 1.1%). Subsequent analyses focus on African-American participants; non-African-American girls were not included in further analyses. The African-American subjects ages ranged from 11 to 13 years old, with an average age of 12.3 years old (SD=0.5). Approximately 54% of students in the selected school participated in a free or reduced price lunch program.

Stage of Maturation

Almost two-thirds (62%) of the girls had reached menarche. To assess differences by menarche status, a Wilcoxon rank sum test was performed. The postmenarcheal girls were significantly (P = .03) older than the pre-menarcheal girls (12.4 vs 12.1 years). Also, the postmenarcheal girls were significantly more advanced in breast (P=.0001) and pubic hair stages (P=.005) compared to the premenarcheal girls.

Anthropometric Measures

The mean subscapular and triceps skinfolds were 16.9 mm and 18.8 mm, respectively. The mean height in centimeters, weight in kilograms, and BMI were 156.4, 57.0, and 23.2, respectively. The means and standard deviations for the anthropometric measures are presented in Table 1.

Blood Pressure

The mean systolic blood pressure and diastolic blood pressure values were 115.8 mm Hg (SD=10.0) and 58.5 mm Hg (SD=8.0), respectively. The means and standard deviations for anthropometric and blood pressure values for each age (11, 12, and 13 years old) are presented in Table 2.

Physical Activity, Dietary Intake, and Fitness

The physical activity measure was classified into 4 categories: vigorous, moderate-to-vigorous, moderate, and sedentary. The mean number of hours per week of moderate-to-vigorous activity was 13.2 (SD=15.2). Correspondingly, the mean number of hours per

Table 1. Anthropometric measures in African-American girls 12.3 years of age (±0.5)

Measure	Total (N = 82)			
	Mean	SD	Range	Median
Height, cm	156.4	7.2	136.5–172.9	157.6
Weight, kg	57.0	15.4	32.0–101.9	53.8
BMI (kg/m^2)	23.2	5.5	15.6–37.6	21.9
Waist-hip ratio	0.8	0.1	0.7–1.0	0.8
Waist-thigh ratio	2.0	0.1	1.7–2.3	2.0
Abdomen skinfold, mm	20.3	8.1	6.8–40.4	19
Calf skinfold, mm	18.6	8.3	6.4–43.8	16.1
Subscapular skinfold, mm	16.9	8.4	7.0–40.8	14.9
Lower thigh skinfold, mm	19.3	7.6	6.8–45.5	17.1
Triceps skinfold, mm	18.8	9.1	7.2–40.1	15.7
Arm circumference, cm	26.8	4.9	19.0–41.3	26.1
Abdomen circumference, cm	75.1	12.2	58.5–114.5	72.8
Hip circumference, cm	94.5	11.3	74.1–123.2	94.0
Lower thigh circumference, cm	38.2	5.4	29.6–51.0	37.4

week of sedentary behavior was 35.6 (SD=30.8). The dietary intake mean for total energy (kcal) was 1525 (SD=454). The percent total energy from total fat was 37% (SD=5), from carbohydrate—51% (SD=8), from saturated fat—30% (SD=6), and from protein—13% (SD=3). As a measure of fitness, the mean for VO_2max, ml/kg min was 30 (SD=5).

Predictors of Activity

The predictors of physical activity were classified as environmental, social, cognitive, physiological, other personal factors, and self-efficacy. The girls perceived variables in each of the 6 classifications as influences on their physical activity patterns. The means ranged from 3.0 to 3.3. The standard deviations were small, ranging from 0.4 to 0.6.

Health Behavior

Based on self-report, most of the girls did not smoke (84%), drink (54%), or take drugs (92%). Approximately 12% of the girls were dieting. Only 56% of the girls felt they were about the right weight.

Obesity and Hypertension

Among the 12-year-olds, 19% to 35% had BMI, tricep skinfold, and subscapular skinfold values greater than the 85th percentile for their age and sex.[37] Among 13-year-olds, 41% to 52% had BMI, triceps skinfold, and subscapular skinfold values greater than the 85th percentile for their age and sex.[37] Among the 12-year-olds, 12% (N=6) had significant hypertension, and 4% (N=2) had severe hypertension. Among the 13-year-olds, 4% (N=1) had significant hypertension.[19,38] Table 3 illustrates these data.

None of the 11-year-olds had significant (≥126 and <134 systolic blood pressure) or severe (≥134) hypertension. Five 12-year-olds categorized as having significantly high blood pressure (≥126 and <134 systolic blood pressure) also had a BMI greater than the 85th percentile (>22.7). The two 12-year-olds who had severe high blood pressure (≥134) had a BMI greater than the 85th percentile (>22.7). The only 13-year-old with significant high blood pressure (≥136 and <144) also had a BMI greater than the 85th percentile (>23.2).

Multivariate Analyses

Four linear regressions were performed. Independent variables for the linear regression analyses were selected

Table 2. Mean (SD) anthropometric and blood pressure values by age

Age (years)	N	BMI	Subscapular Skinfold (mm)	Triceps Skinfold (mm)	Systolic Blood Pressure (mm Hg)	Diastolic Blood Pressure (mm Hg)
11	3	27.9 (6.2)	21.8 (1.1)	27.5 (1.1)	114.3 (6.8)	52.2 (10.6)
12	52	22.2 (4.9)	15.7 (7.7)	17.2 (8.6)	115.2 (9.9)	58.1 (7.8)
13	27	24.5 (6.2)	18.6 (9.7)	20.9 (9.6)	117.3 (10.6)	60.0 (7.8)
Total	82	23.2 (5.5)	16.9 (8.4)	18.8 (9.1)	115.8 (10.0)	58.5 (8.0)

Age	Significant Hypertension	Severe Hypertension
11	≥126 and <134	≥134
12	≥126 and <134	≥134
13	≥136 and <144	≥144

Note: Guidelines from Second Task Force on Blood Pressure Control in Children, 85th percentile for Systolic Blood Pressure

Age	90th percentile (high normal)	95th percentile (hypertensive)
11	≥117 and <121	≥121
12	≥119 and <123	≥123
13	≥121 and <125	≥125

Note: Guidelines from the Update on the Second Task Force Report on High Blood Pressure in Children and Adolescents, Systolic Blood Pressure for Girls, 50th percentile height

Table 3. Percent of girls by age with BMI, subscapular skinfold (SSF), and triceps skinfold (TSF) greater than 85th percentile*

	BMI		Subscapular Skinfold		Triceps Skinfold	
Age Group	85th Percentile	*N* (%)† >85th	85th Percentile	*N* (%)† >85th	85th Percentile	*N* (%)† >85th
11 (*N* = 3)	21.6	3 (100)	17.0	3 (100)	21.5	3 (100)
12 (*N* = 52)	22.7	18 (35)	17.0	16 (31)	21.5	10 (19)
13 (*N* = 27)	23.2	14 (52)	17.5	12 (44)	22.0	11 (41)
Total (*N* = 82)		35 (43)		31 (38)		24 (29)

* Eighty-fifth percentile based on Second National Health and Nutrition Examination Survey stratified by sex and age. (The standards are not stratified by ethnic background.)
† The ''*N* (%)'' is the number and percent of the total sample for the respective age group.

from a series of preliminary analyses. The dependent variables were systolic blood pressure, diastolic blood pressure, minutes of moderate-to-vigorous physical activity, and BMI. Residual analyses were performed for each regression to detect extreme outliers. In the physical activity analysis, one girl had a residual value more than 3 standard deviations away from zero. This outlier was then removed.

No significant relationships were found between systolic blood pressure and BMI, breast stage, percent of calories from fat, RiskBMI (combination term of physical activity and BMI), or physical activity in a model that included all of the above variables. Similarly, no significant relationships were found for diastolic blood pressure with the same predictor variables as in the systolic blood pressure analyses.

Physical activity was significantly and negatively related to total percent of calories from fat (P=.021) and breast stage (P=.013), and positively related to waist/thigh ratio (P=.013) while adjusting for physical fitness, cognitive factor, BMI and social factor (Table 4). Body mass index (BMI) was significantly and positively related to breast stage (P=.001), after adjusting for the following variables: social factors, cognitive factors, physical activity, and percent of calories from fat (Table 5).

In summary, physical activity had no detectable direct effect on systolic or diastolic blood pressure. Physical activity was significantly associated with total percent of calories from fat and maturity, adjusting for the other variables. Social and cognitive variables were not related to physical activity. Finally, BMI was mainly associated with physical maturity (breast stage), but had no significant relationship to diet, predictors of physical activity, or physical activity.

Table 4. Summary of regression analysis for variables predicting moderate-to-vigorous physical activity (daily minutes) (*N* = 38)*

Variables	Estimate	Std Error of Estimate	*P* Value
Total dietary fat, % kcal	−7.30	2.99	0.02
Breast stages			
Stage 3 and lower	−15.31	58.11	0.01
Stage 4	−97.08	44.88	
Stage 5	reference		
Waist-thigh ratio	511.86	192.31	0.01
BMI	1.55	4.63	0.74
VO_2max, ml/kg=min	1.24	3.56	0.73
Social factor	−8.47	45.24	0.85
Cognitive factor	−28.49	34.93	0.42

* Sample size is based on the number of girls with complete data for all variables in the analysis.

DISCUSSION

There is an absence of longitudinal data related to physical activity patterns, anthropometric variables, and predictors of cardiovascular health among adolescent girls, particularly African-American girls. One of the purposes of this study was to describe the anthropometric variables, blood pressure values, eating habits, fitness levels, and physical activity patterns of adolescent African-American girls. Further, the main study questions assessed which sets of variables best predict blood pressure, physical activity, and body fat. Most of the Healthy Growth girls' measurements for BMI, skinfolds, and blood pressures were in the normative ranges based on national standards. Nonetheless, more than one-third of the 13-year-old girls exceeded the 85th percentile for BMI and skinfolds (subscapular and triceps). Because obesity is associated with hypertension, diabetes, stroke, and cardiovascular disease, interventions to prevent obesity and to minimize the chronic conditions related to obesity are needed.

Healthy Growth's anthropometric measures (eg, height, weight, BMI, subscapular skinfold) were greater than the measures for African-American girls reported in another longitudinal study with a younger sample (mean age=10).[8,9] Anthropometric measures should be monitored for dramatic increases during adolescence.

For blood pressure, the systolic values of our subjects were greater than, and the diastolic values were similar to, the values from a national sample of 10-year-old African-American girls[9] and the Pediatric Task Force Blood Pressure

Table 5. Summary of regression analysis for variables predicting BMI (*N* = 69)*

Variables	Estimate	Std Error of Estimate	*P* Value
Total dietary fat, % kcal	0.032	0.118	0.789
Breast stages			
Stage 3 and lower	−7.235	1.882	0.001
Stage 4	−4.460	1.535	
Stage 5	reference		
Social factor	−1.492	1.763	0.4
Cognitive factor	0.601	1.460	0.682
Moderate-to-vigorous physical activity (daily minutes)	−0.001	0.005	0.846

* Sample size is based on the number of girls with complete data for all variables in the analysis.

. . . more than one-third of the 13-year-old girls exceeded the 85th percentile for BMI and skinfolds (subscapular and triceps).

summary statistics.[39] None of the mean blood pressure values indicated hypertension. Repeated measurements of blood pressure and observation of other risk factors are national objectives.[19]

The dietary intake of our sample compared to a multi-ethnic sample of 10-year-old children in 6 cross-sectional surveys[40] (average sample size was 240) indicates that Healthy Growth girls consumed less energy (kcal) and protein, but had comparable levels of carbohydrates. Additionally, Healthy Growth girls consumed less energy (kcal), more saturated fat (% kcal), and similar levels of total fat (% kcal) compared to a national sample of 10-year-old African-American girls.[8] Interventions to encourage the consumption of more fruits and vegetables would be important health promoting strategies for schools, public health agencies, and community organizations.

A treadmill protocol was used to measure the aerobic capacity of Healthy Growth girls. Our VO_2max values were less than the values obtained in a sample of 27 11-to-12-year-old African-American girls.[41] Furthermore, based on a review by Pivarnik et al,[42] the Healthy Growth girls were less aerobically fit when compared to girls of similar age nationwide. Given the current data related to fitness, maintaining a healthy body weight and being physically active should be priorities. Among adults, low fitness levels are a risk factor for coronary heart disease and all-cause mortality.[1,3]

Healthy Growth girls reported a mean of 13.2 hours per week of moderate to vigorous activity, as well as 35.6 hours per week of sedentary behaviors. The International Consensus Conference on Physical Activity Guidelines for Adolescents (ages 11 through 21 years) established 2 main guidelines: 1) adolescents should be physically active daily or nearly every day as part of their lifestyles; and 2) adolescents should engage in 3 or more sessions per week of activities that last 20 minutes or longer and that require moderate-to-vigorous levels of exertion.[2] The majority of adolescents in the United States meet the first guideline, and about two-thirds of the boys and half the girls meet the second guideline. Healthy Growth girls are generally active; however, daily recall instead of weekly recall of activity would determine whether the guidelines established by the Consensus Conference are being met.

The majority of Healthy Growth girls did not smoke, drink, or take drugs. Even though the average age of our sample was 12.3 years, 12% of the sample reported dieting and only 56% of the sample said they were about the right weight. Concerns about weight are evident in our sample of preteen girls. Previous studies report that 80% of 10-year-old girls claim they are dieting,[43] and White females are more likely to think of themselves as overweight and to try to lose weight than are African-American females.[44]

In analyzing variables related to blood pressure, physical activity, and body fat, we found that systolic and diastolic blood pressure were not significantly associated with BMI, maturity, physical activity, percent of calories from fat, or a combination of BMI and physical activity. In these analyses, the absence of significant findings may be the result of the small sample size.

Physical activity was negatively related to both total percent of calories from fat and breast stages and positively related to waist/thigh ratio. Body mass index (BMI) was positively related to breast stage. Additionally, more 13-year-olds than 12-year-olds had BMI values greater than the 85th percentile. This finding is consistent with those of previous studies. For example, one study[45] reported that substantially lower estimates of cardiovascular risk were observed in younger children. Future research can address developmental differences and risk factors.

Although 8 of the 9 girls who had significant or severe high blood pressure also had a BMI greater than the 85th percentile, the regression analysis did not show a significant relationship between BMI and blood pressure in our small sample. An earlier study[46] reported that systolic and diastolic blood pressures were positively related with increasing BMI in Navajo adolescent girls, ages 14- to 18-years-old; however, sexual maturation, physical activity, and fitness were not measured. This limitation was noted by the study's researchers because these variables may modify the relationship between blood pressure and BMI. Our study included measures of sexual maturation, physical activity, and fitness. The maturity (breast stages) and physical activity measures were not significantly related to blood pressure. The fitness measure was not included in the analyses because of the small sample size.

Another study[45] in children and adolescents found a strong relationship between risk for elevated blood pressure and percent body fat. These authors[45] recommended that body fat standards as significant predictors of cardiovascular risk factors be included in epidemiologic surveys, pediatric health screenings, and youth fitness tests. Our findings, among a small sample, did not establish a consistent relationship between BMI and blood pressure. Body mass index (BMI) and blood pressure merit further study, particularly in children younger than 14 years of age because other factors may affect this relationship.

Our findings showed that BMI and breast stages were related, with the more mature girls having greater BMI values. Further, physical activity was negatively related to total fat consumption and breast stages, and positively related to waist/thigh ratio. Girls who were more physically active had consumed a lower percentage of calories from fat. From Table 4, the most mature girls and the least mature girls were the most physically active. Also, girls with greater waist/thigh ratios were more physically active than girls with lower waist/thigh ratios. The waist/thigh ratio is an abdominal adiposity index that distinguishes between abdominal and lower body patterns of fat distribution. Tubular-shaped and slender girls were more physically active than girls with more lower body distribution of fat. In summary, the most physically active girls were more slender and consumed a lower percentage of calories from fat.

Our findings are limited by the small sample size, cross sectional analyses, self report measures (eg, physical activity and dietary intake), season of year (spring vs fall or summer), geographic location (Southwest), income level, and habits during the school year vs those during the summer. Given these considerations, appropriate caution is needed in generalizing our results. Nonetheless, because cardiovascular risk factors begin in childhood,[19,38] identifying risk factors and intervening in their early development is an important public health objective.

In summary, we have described the Healthy Growth project and presented baseline findings. The significant relationships among cardiovascular risk factors were physical activity, total fat, breast stage, and waist/thigh ratio, and BMI and breast stage. Although African-American women have higher rates of hypertension and obesity compare to White women,[37,47,48] and African-American children have higher blood pressure levels compared to those of White children,[19] few longitudinal studies exist to aid in a better understanding of the patterns and relationships among blood pressure, growth and development, body fat, physical activity, fitness, dietary intake, and predictors of physical activity in African-American girls. Data from Healthy Growth can help fill this gap. These results in combination with data from other studies can help in developing effective programs and interventions. The objective is to reduce cardiovascular risk in adolescent girls by identifying predictors of risk factors. The overall goal is to eliminate the excess prevalence of morbidity, and mortality related to hypertension, obesity, physical inactivity, and unhealthy eating habits among African-American women.

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