ABSTRACT

Title of Document:	TIME TRENDS IN OVERALL DAILY PHYSICAL ACTIVITY AND CARDIOVASCULAR DISEASE RISK FACTORS BY ORGANIZED PHYSICAL ACTIVITY PARTICIPATION IN ADOLESCENT GIRLS.
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Many youth are involved in organized physical activity (PA); however, the impact of these activities on daily PA, body fat, and cardiovascular disease (CVD) risk factors is not well understood. *Purpose:* To compare the overall daily PA and CVD risk factors of girls who participate in organized activities to non-participants throughout adolescence. *Methods:* Data from the National Heart, Lung, and Blood Institute Growth and Health Study, a 10-year observational study of Black and White girls (N=2379), were analyzed. Organized PA was defined as participation in classes/lessons and sports (0, <4, 4-19.99, ≥20 MET times/wk). Outcomes included daily PA (3-day diary), body fat (bioelectrical impedance analysis), lipids, glucose, insulin, and blood pressure. Longitudinal data were examined for each outcome using a mixed model with repeated measures. Girls were also categorized by the number of years they reported ≥4 MET times/wk of organized PA. Outcomes and risk clustering at 18-19y were evaluated with ANOVA and logistic regression, respectively, by number of participation years. *Results:* Organized PA and participation*time*race were related to change in daily PA and body fat ($p < 0.0001$). Although daily PA declined for Black girls, those with ≥20 MET times/wk had higher PA levels than all other girls ($p < 0.0001$). Change differed by sports participation in White girls (p=0.019); those involved ≥20 MET times/wk demonstrated better maintenance of daily PA. Black girls with ≥20 MET times/wk had significantly lower body fat than non-participants (p=0.002).White non-participants had higher body fat than those with 4-19.99 MET times/wk (p=0.006). Accumulated organized PA was related to daily PA and body fat at 18-19y. Girls who never reported participation had significantly lower daily PA at 18-19y than all other groups ($p < 0.02$), and significantly higher body fat at 18-19y compared to girls who reported 4y of sports participation (p=0.038). Organized PA was not related to change in other CVD risk factors or risk factor clustering at 18-19y (OR=1.05, 95% CI=0.87-1.27, p=0.59). *Conclusion:* Organized PA was related to daily PA and body fat for Black and White girls throughout adolescence. Appealing options should be made available and participation encouraged.

TIME TRENDS IN OVERALL DAILY PHYSICAL ACTIVITY AND CARDIOVASCULAR DISEASE RISK FACTORS BY ORGANIZED PHYSICAL ACTIVITY PARTICIPATION IN ADOLESCENT GIRLS.

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Table of Contents

List of Tables

List of Figures

Chapter 1: Introduction and Statement of Purpose

Introduction

Many children and adolescents report participating in organized or structured physical activity (PA) in the form of sports, classes, or lessons at school or outside of school. These activities are not synonymous with overall PA, but rather a component of it. Overall PA has been more frequently studied than participation in specific activity types, such as team sports, or their effects throughout adolescence (Pate, Dowda, O'Neill, & Ward, 2007). Investigation of which types of activity help maintain an active lifestyle and the health benefits associated with different types of PA have been recommended as research priorities (Cavill, Biddle, & Sallis, 2001). It is important to determine the impact of organized PA on overall PA and health to guide interventions and practitioners in their recommendations for youth.

Currently, there are conflicting conclusions regarding organized sports behavior and its contribution to overall PA changes during adolescence, and only one of the investigations studied American adolescents. Some have shown that while unstructured PA declined, organized activity remained unchanged over time (Mota & Esculcas, 2002; van Mechelen, Twisk, Post, Snel, & Kemper, 2000). However, others have found that decreased participation in organized sports was a contributor to overall PA decline during adolescence (Michaud, Narring, Cauderay, & Cavadini, 1999; Pate et al., 2007). Several authors have indicated the need for more research regarding the factors that contribute to the decrease seen in total PA, as well as which activities are likely to be continued during adolescence (Aaron, Storti, Robertson, Kriska, & LaPorte, 2002; Bradley, McMurray, Harrell, & Deng, 2000; Cavill et al., 2001; Dovey, Reeder, & Chalmers, 1998; Pate et al., 2007).

While public health research indicates low levels of PA and a decline in adolescence for girls, current sport industry research is more encouraging. The National Council of Youth Sports (2001), the National Federation of State High School Associations (2007), and the National Sporting Goods Association (Doyle, 2006) all have reported an increase in the number of girls playing organized sports in recent years. Therefore, it is important to explore associations with this component specifically.

Regular bouts of PA are known to provide substantial health benefits for people of all ages. However, within childhood, the relationship between total activity and cardiovascular disease (CVD) risk factors is not well established. Total PA explains only a little of the variance in CVD risk factors, with estimates being stronger at the extremes, yet weaker for girls than boys (Eisenmann, 2004). Recent data show that relationships between PA and metabolic risk factors may be stronger (Steele, Brage, Corder, Wareham, & Ekelund, 2008). Examination of organized PA may provide an opportunity to more clearly see the effects of regular activity, as this format has the potential to be more consistent and of valuable duration and intensity. Isolation of the relationship between organized sports and activity lessons or classes and health and fitness outcomes such as daily PA, cardiovascular fitness, weight status, blood pressure (BP), and blood lipids is uncommon (Cavill et al., 2001; Hoffman, Kang, Faignbaum, & Ratamess, 2005; Michaud et al., 1999). Sports participants have reported higher overall PA levels than non-participants in some samples (Harrison & Narayan, 2003; Katzmarzyk & Malina, 1998; Pfeiffer et al., 2006; Phillips & Young, 2009; Ribeyre et al., 2000), and active children and adolescents tend to demonstrate better fitness (Ara, Moreno, Leiva, Gutin, & Casajus, 2007; Ara et al., 2004; Ara et al., 2006; Beets & Pitetti, 2005; Boreham, Twisk, Savage, Cran, & Strain, 1997; Hoffman et al., 2005; Pfeiffer, Dowda, Dishman, Sirard, & Pate, 2007; Phillips & Young, 2009), lower body fat (Ara et al., 2006; Kawabe et al., 2000; Ribeyre et al., 2000), and more favorable CVD risk profiles (Boreham et al., 1997; Cavill et al., 2001; Kawabe et al., 2000; Myers, Strikmiller, Webber, & Berenson, 1996) than those who are not active. Still, few studies have been conducted to examine the outcomes associated with organized PA participation in American adolescents. In fact, no studies of CVD risk factors other than fitness and body fat were located in the published literature. As other interests compete with sports and PA for adolescents' leisure time, it is imperative to understand the benefits associated with maintaining PA. Knowledge regarding the relationships between organized PA and health and fitness outcomes will provide guidance as to what types of activity are beneficial and should be promoted.

Statement of Purpose

The purpose of this study was to examine the longitudinal changes during adolescence in daily PA, body fat, and other CVD risk factors based on girls' level of organized PA participation in a large sample of urban Black and White girls.

Overview of Methods

Sample and measures. This dissertation examined the associations between organized PA and two main outcomes: overall daily PA and CVD risk factors including body fat, BP, blood lipids, and fasting glucose and insulin. Longitudinal data from the National Heart, Lung and Blood Institute Growth and Health Study (NGHS) were used to complete the study. A cohort of over 2300 girls from three U.S. locations was followed from age 9-10y to 18-19y. The aim of the observational study was to assess the factors associated with the onset and development of obesity in Black and White girls, and obesity's effects on CVD risk factors (NGHS Research Group, 1992). Measures included anthropometrics, PA, and several CVD risk factors. The NGHS dataset has several strengths including a large sample size, equal representation of White and Black girls, clinical measurement of maturity status, and excellent retention over the 10-year period.

For this research, "sports participants" were categorized from responses on a habitual activity questionnaire, and then examined for longitudinal differences between groups in the outcomes of interest. Girls were also categorized by the number of years they reported a minimum level of organized PA (accumulated participation). The project was organized to produce two manuscripts; one focuses on daily PA as the outcome, and the other focuses on the CVD risk factor outcomes. Figure 1.1 is a graphic representation of the project.

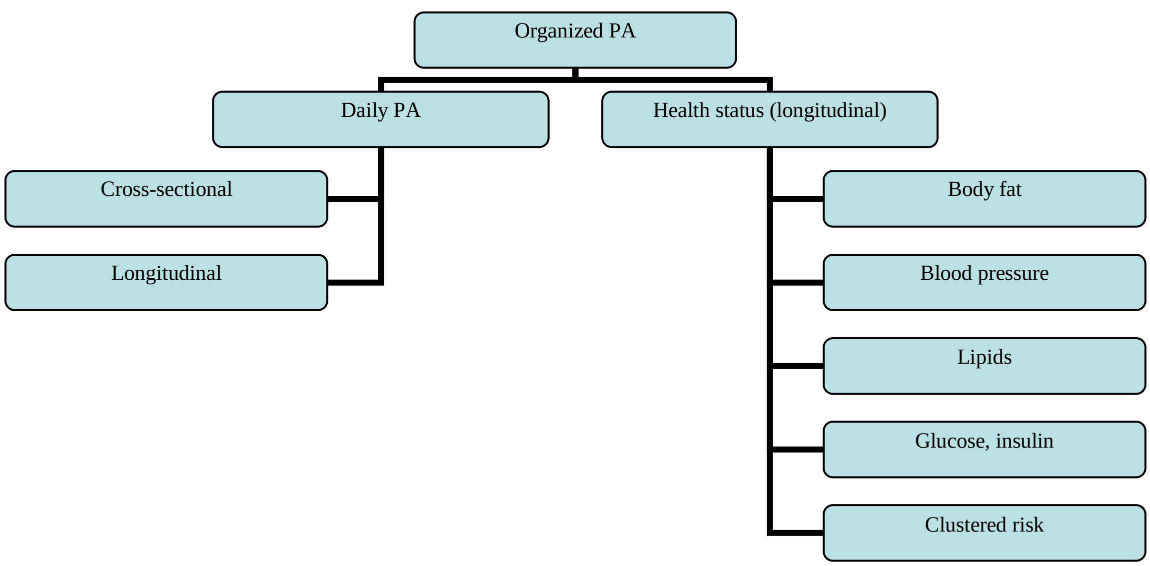


Figure 1.1. Organization of the dissertation project's main topics.

Abbreviation: PA, physical activity

Research questions.

<u>Manuscript 1</u> – Time Trends in Overall Daily Physical Activity by Organized Physical Activity Participation in Adolescent Girls.

1. Does total daily physical activity differ between those girls who do and do not participate in organized physical activity?
    - Hypothesis: Sports participants are expected to have higher physical activity levels than non-participants in each study year.

2. Is organized physical activity participation a significant factor in how daily physical activity changes during adolescence?
    - Hypothesis: Organized physical activity will be a significant factor in the daily physical activity trend.

3. Is there an association between early organized physical activity participation and later daily physical activity?
    - Hypotheses: Girls with consistent participation (3-4 years) will be more active at age 18-19y than girls who never participated. They will also be more active at 18-19y than those who participated 1-2 years. Girls who participated for 1-2 years will be more active at 18-19y than those who never participated.
    - 0 < 1 = 2 < 3 = 4

<u>Manuscript 2</u> - Time Trends in Cardiovascular Disease Risk Factors by Organized Physical Activity Participation in Adolescent Girls.

4. Is organized physical activity participation a significant factor in how cardiovascular disease risk factors change during adolescence?
   - Hypothesis: Organized physical activity will be a significant factor in the change in body fat, blood pressure, blood lipids, insulin and glucose over time.

5. Is there an association between early organized physical activity participation and later:
   A. Body fat
   B. Systolic blood pressure
   C. Diastolic blood pressure
   D. Total cholesterol
   E. High density lipoprotein cholesterol
   F. Low density lipoprotein cholesterol
   G. Triglycerides
   H. Fasting insulin
   I. Fasting glucose?
   - Hypothesis: Accumulated participation groups will differ on outcomes at age 18-19y, such that consistent participants (4y) would have healthier values than those who never participated.

6. Do non-participants have an increased risk of CVD risk factor clustering compared to those who participate in organized physical activity?
    - Hypothesis: Clustering will be more likely in non-participants.

Data analysis. Cross-sectional PA data were analyzed with analysis of variance (ANOVA) for between-group differences by sports participation level. Means, proportions, correlations, and chi-square tests were also used to describe the sample.

Longitudinal patterns of change were examined using a mixed model with repeated measures. Trends in daily PA, body fat, insulin, glucose, systolic BP, diastolic BP, triglycerides, total cholesterol, high density lipoprotein cholesterol, and low density lipoprotein cholesterol were each examined independently in relation to sports participation status. Outcomes at age 18-19y were assessed with ANOVA, looking for between-group differences based on the number of years of organized PA participation. The odds of having clustered CVD risk at age 18-19y was calculated with logistic regression, based on the number of years of organized PA participation.

Chapter 2: Time Trends in Overall Daily Physical Activity by Organized Physical Activity Participation in Adolescent Girls

(Target journal: *Medicine & Science in Sports & Exercise*; Options: *Journal of Physical Activity and Health, Pediatric Exercise Science, Journal of Adolescent Health)*

Abstract

Background: Many youth are involved in organized, structured physical activities; however, little research has examined how these activities impact daily physical activity (PA). *Purpose:* To compare the overall daily PA of adolescent girls who participate in organized PA to those who do not throughout adolescence. *Methods:* The limited access dataset from the National Heart, Lung, and Blood Institute Growth and Health Study was analyzed. The cohort was comprised of Black and White girls (N=2379) who were followed for 10 years. Organized PA was defined as participation in classes/lessons and organized sports (0, <4, 4-19.99, ≥20 MET times/wk), and average daily PA was estimated from a three-day diary. Cross-sectional data were analyzed by race with ANOVA, and longitudinal data were analyzed with a mixed model with repeated measures. Girls were also categorized by the number of years they reported ≥4 MET times/wk of organized PA. Difference in daily PA at 18-19y was evaluated with ANOVA, based on the number of participation years. *Results:* At each time point and in both race groups, girls who participated in ≥20 MET times/wk of organized activity were the most active ($p < 0.05$). Organized PA was a significant factor for change over time in daily PA ($p < 0.0001$), as was a participation*time*race interaction ($p < 0.0001$). Although daily PA declined for all Black girls, those who did ≥20 MET times/wk had higher PA levels than all other girls ($p < 0.0001$), and those who did 4-19.99 MET times/wk were more active than non-participants ($p=0.0005$). Change over time differed by sports participation in White girls ($p=0.019$); those involved $\geq$20 MET times/wk demonstrated better maintenance of daily PA. Years of accumulated organized PA were related to daily PA; at 18-19y, girls who never reported regular participation had significantly lower daily PA than all other groups ($p < 0.02$). *Conclusions:* Organized PA was significantly associated with daily PA for Black and White girls throughout adolescence. The girls most involved in lessons and sports were more active than other girls. Appealing options should be made available and participation encouraged in this population.

Introduction

Adolescents may accumulate physical activity (PA) from a variety of sources including active transportation, physical education (PE), organized sports and activities, and informal leisure activity or play. Although many studies have examined adolescent PA, few have described what specific or organized activities girls are doing and how these activities contribute to their total PA.

A large number of youth are involved in organized sport activities, ranging from classes or lessons for an hour a week to elite level competition preparation. The National Council of Youth Sports (NCYS, 2001) reported that over 38 million children participate in organized sport, 37% of them girls. Barr-Anderson et al. (2007) found 89.5% of a diverse sample of 6th grade girls had participated in at least one sport, lesson or class in the past year. Similarly, 78% of 7th and 8th grade females from four states reported participating in at least one sports program in the past year (Sirard, Pfeiffer, & Pate, 2006). In a 2003 nationally representative sample, 62% of 9- to 12-year-old children reported current sports participation, a decline of over 20% from 1997 (Hofferth, 2009). However, only 38.5% of a national telephone sample of 9- to13-year-old children reported participation ‘with an organized group that has a coach, instructor, or leader’ in the past seven days (Centers for Disease Control and Prevention [CDC], 2003). Prevalence estimates vary greatly, in part caused by different instruments, timeframe of reference, classification of participation, and age group.

Being involved in organized PA is recognized as a positive determinant for total PA in adolescents (Sallis, Prochaska, & Taylor, 2000). Sports involvement can provide an opportunity for regular PA. Objective monitoring in a sample of 6- to 12-year-old boys found that more time was spent in moderate-to-vigorous PA (MVPA) on a sport practice day than a non-sport day (Wickel & Eisenmann, 2007). More favorable PA patterns have been found for sports participants than non-participants in several studies (Harrison & Narayan, 2003; Mota & Esculcas, 2002; Pate, Trost, Levin, & Dowda, 2000; Pfeiffer et al., 2006; Sirard et al., 2006; Vilhjalmsson & Kristjansdottir, 2003). Harrison and Narayan (2003) examined sport and other extracurricular activity participation in a large sample of 9th graders and found that those who participated in sports (alone or in combination with other activities) were 3 to 4 times more likely to meet moderate or vigorous exercise guidelines than non-participants. Pate et al. (2000) reported similar findings with national data from the 1997 YRBS; female sports participants were 4.5 times more likely than non-participants to report regular vigorous PA (VPA). Examination of energy expenditure (EE) has also shown that adolescent sports participants have greater daily EE than non-participants (Katzmarzyk & Malina, 1998; Ribeyre et al., 2000). For example, in a sample of 12- to 14-year-olds, sports participants had significantly higher total daily EE and moderate-to-vigorous EE. In addition, sports participation accounted for over 60% of female participants' moderate-to-vigorous EE (Katzmarzyk & Malina, 1998).

Participation in non-school (e.g. community or club) sports programs seems to decline after the age of 10, while the greatest participation in school sports is seen from 13 to 15 years and declines thereafter (Ewing & Seefeldt, 1996). At the high school level, about half of the nation's students are estimated to participate in school sports programs (Eaton et al., 2006; Eaton et al., 2008; Johnston, Delva, & O'Malley, 2007; National Federation of State High School Associations [NFHS], 2007). Racial and age differences exist in participation rates such that participation is greater among White and younger students (Eaton et al., 2006; Eaton et al., 2008; Johnston et al., 2007).

Racial differences are noted in sports participation rates (Dowda et al., 2004; Eaton et al., 2006; Eaton et al., 2008; Hofferth, 2009; Johnston et al., 2007) and PA levels (Dowda et al., 2004; Kimm et al., 2002; Pate, Dowda, O'Neill, & Ward, 2007) of adolescent girls. However, there is little information to determine if patterns of change, especially for specific activity types, differ by race in this age group (Pate et al., 2007). In one such study from late middle school through high school, team sport activities remained stable for Black girls, but the amount of time White girls spent in these activities decreased; both races exhibited a similar rate of decrease for individual activities (Pate et al., 2007). Further investigation of these behaviors with large sample sizes, over longer time periods and accounting for maturational differences is needed.

Differences in maturation may also contribute to changes in overall and organized PA in adolescence. Patterns of PA behavior change may be more related to maturity than chronological age, such that early maturers may decline sooner (Sherar, Esliger, Baxter-Jones, & Tremblay, 2007; Thompson, Baxter-Jones, Mirwald, & Bailey, 2003). The influence of maturation has not been extensively studied.

It is known that overall PA declines in adolescence. However, how different PA types affect this trend is not well understood. Several authors have indicated the need for more research regarding the factors that contribute to the decrease seen in total PA, as well as which activities are likely to be continued during adolescence (Aaron, Storti, Robertson, Kriska, & LaPorte, 2002; Bradley, McMurray, Harrell, & Deng, 2000; Cavill, Biddle, & Sallis, 2001; Dovey, Reeder, & Chalmers, 1998; Pate et al., 2007). Existing studies of the impact of organized PA are limited by small samples and even smaller numbers of girls. Additionally, longitudinal studies of the effect of sports participation in American samples are scarce. Understanding the impact of this type of adolescent girls' PA behavior is essential to guide interventions and policies in the future to improve their activity and health status. The purpose of this study was to compare the overall daily PA levels of adolescent girls who participate in organized PA to those who do not. Of particular interest was to examine how daily PA changes throughout adolescence for the different participation categories. Racial differences in these changes were examined as well.

Methods

Data from the National Heart, Lung, and Blood Institute Growth and Health Study (NGHS) were analyzed to examine the relationship between organized PA participation and overall daily PA. The limited access dataset was obtained from the National Heart, Lung, and Blood Institute, and the secondary analysis was approved by the University of

Maryland Institutional Review Board. NGHS was a longitudinal, observational multi-site study of obesity in Black and White girls throughout adolescence. A total of 2379 girls were recruited between 1987 and 1988 from schools near San Francisco, California and Cincinnati, Ohio, and from a health maintenance organization in the Washington, D.C. area. Participants were 9-10y at enrollment and were followed until they were 18-19y. The overall follow up rate was 89% at the end of the study (Kimm et al., 2002). Data were collected annually and included: physical examination with a visual assessment of maturity, anthropometric measurements, dietary assessment, PA, blood pressure, fasting blood sample, family socioeconomic status (SES), and psychosocial factors. The primary variables of interest for this study were overall daily PA and organized PA.

Daily physical activity. Data from the three-day activity diary (AD; Kimm et al., 2000) were used to describe overall PA level. The AD consisted of several activities commonly performed by children (active and sedentary) as well as several blank spaces to write additional activities. After the first year of the study, activities were rearranged into groups by similar intensity level. Activities were periodically added or deleted as the girls aged. For example, household chores were added in Year 8, when girls were 16-17y (Kimm et al., 2000). Girls completed the AD by checking which activities they did, for how long (interval categories), and at what time of day (morning, afternoon, evening). The AD was collected for two weekdays and a weekend day in 8 of the 10 years of the study. MET values were assigned to each activity grouping and average MET min/day was calculated. Data were not manipulated from the NGHS dataset for this variable.

Organized physical activity. The habitual activity questionnaire (HAQ) was interviewer-administered in Years 1, 3, and 5 and self-administered in Years 7-10 (Kimm et al., 2000). Participants were asked about classes/lessons, sports, and other physical activities throughout the past year. Classes/lessons were asked about separately from sports and other activities through Year 8; in Years 9 and 10, a single question addressed all physical activities, sports and classes/lessons. Girls were asked which activities they did, how many times per week, and how much of the year they participated. MET values were assigned to recorded activities, and a summary score of MET times/wk was calculated. For this study, the HAQ was used to categorize girls as "sports participants" examining only those activities of an organized nature (classes/lessons and sports; see Appendix A for inclusive list), excluding those physical activities expected to have been completed without instruction or leadership (e.g., walking, jogging). The distribution of volume (MET times/wk) was examined and found to be significantly skewed towards lower participation, particularly in later years of the study. Due to this skewness as well as the desire to separate "non-participants" girls were categorized into one of four groups: 1) no organized PA, 2) greater than 0 but less than 4 MET times/wk, 3) 4 to less than 20 MET times/wk, 4) at least 20 MET times/wk. A girl with a value of 4 MET times/wk could have reported participating in one hour of organized activity of moderate intensity (e.g., ballet or gymnastics) per week consistently over the year. A value of 20 MET times/wk is equivalent to five sessions of 30 minutes of moderate PA.

Accumulated organized physical activity. Participants were categorized based on the number of years, up to and including Year 7 (age 15-16y), in which they reported at least 4 MET times/wk of organized PA participation. The HAQ was administered four times (Years 1, 3, 5, 7) during this period, resulting in five categories indicating zero to four years of reported participation.

Anthropometrics and maturation. Height, weight, and body fat were obtained at each annual visit (NGHS Research Group, 1992). This study used the bioelectrical impedance analysis (BIA) results for body fat percentage in analyses. Supine hand-to-foot BIA was conducted (Morrison et al., 2001), and resistance and reactance measures were evaluated to calculate fat-free mass (FFM) and percent body fat with race-specific equations (Thompson et al., 2007). Calculations that resulted in body fat values less than 1% were deleted and set to missing.

Maturation was visually assessed by trained examiners and classified into four stages (prepubertal, pubertal but premenarchal, less than two years postmenarchal, two years or more postmenarchal). Age at menarche was also reported.

Sociodemographics. Eligibility was limited to girls who declared themselves as Black or White and lived in racial concordant households (NGHS Research Group, 1992). Education level and annual family income were reported by parents at baseline. Annual income was collapsed into the categories of less than $10,000, $10,000 to $19,999, $20,000-$39,999, and $40,000 or more.

Data analysis. Missing data were imputed with mean values. Race-specific means replaced missing values for age at menarche, body fat, MET min/day (AD), and MET times/wk (HAQ). When maturity status was missing, the predominant stage for the study year and race was used. Years of accumulated sports participation was calculated without imputation, only for those with four complete data points.

Means, standard deviations, and t-tests were used to report participant characteristics and to examine racial differences. Chi-square analyses were used to determine differences in categorical distribution.

Cross-sectional analyses were conducted for the six years in which both the AD and HAQ were administered (Years 1,3,5,7,8,10). Mean MET min/day were compared between sports participation categories with analysis of variance (ANOVA) by race. Additionally, the correlation between daily PA from the AD and organized PA participation from the HAQ was computed by race for each year.

Longitudinal data were analyzed using a mixed model with repeated measures. Models were constructed to examine the association of overall PA (MET min/day) and sports participation, time point, race and significant two- and three-way interactions while controlling for maturational stage, SES, and body fat. To control for the relatedness of repeated measures, the Heterogeneous Toeplitz covariance structure was chosen based on Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC) values.

The relationship between accumulated years of sports participation and daily PA at 18-19y (Year 10) was also investigated. As previously mentioned, participants were categorized based on the number of years, up to and including Year 7 (age 15-16y), in which they reported at least 4 MET times/wk of organized PA participation. Between group differences were assessed with ANOVA, controlling for race, age, maturation (age at menarche), SES, and body fat. Relevant two-way interactions were examined, but not found to be significant, and therefore, were not used in the final model.

All analyses were conducted using SAS Version 9.1 (Cary, NC). The Bonferroni adjustment option was used to control for multiple comparisons, and significance level was set at $p < 0.05$.

Results

Demographics. A total of 1213 Black and 1166 White girls participated in NGHS. Their average age was 10.0 years at baseline and 19.1 years at Year 10. Participant characteristics are reported in Table 2.1.

Table 2.1

Participant Characteristics by Race

	Black				White				Racial difference (p-value)
Total sample size	N=1213				N=1166				
Maturational stage (%)	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	
Year 1 (9-10y)	35.7	60	4.3	0.1	67.6	31.6	0.8	0	< 0.0001
Year 3 (11-12y)	0.8	53.9	38.8	6.5	5.9	70.0	22.5	1.6	< 0.0001
Year 5 (13-14y)	0	5.3	43.6	51.1	0.3	17.0	54.2	28.4	< 0.0001
Year 7 (15-16y)	0	0	5.6	94.5	0	0.5	14.7	84.9	< 0.0001
Age at menarche (mean ± SD)	12.1 ± 1.2				12.6 ± 1.2				< 0.0001
Annual household income (%)									< 0.0001
< $10,000	27.9				7.8				
$10,000 – 19,999	19.2				9.5				
$20,000 – 39,999	29.5				32.4				
≥ $40,000	23.4				50.3				
Body fat (%; mean (SE))									
Year 1 (9-10y)	20.50 (0.31)				18.75 (0.27)				< 0.0001
Year 3 (11-12y)	22.22 (0.31)				19.49 (0.27)				< 0.0001
Year 5 (13-14y)	27.85 (0.28)				23.40 (0.26)				< 0.0001
Year 7 (15-16y)	30.93 (0.26)				26.69 (0.22)				< 0.0001
Year 10 (18-19y)	34.46 (0.29)				29.77 (0.26)				< 0.0001

Maturational stages: 1=Prepubertal, 2=Pubertal, 3=Postmenarchal, 4=2+years postmenarchal

Organized physical activity. At baseline, 83% of Black girls and 88% of White girls participated in some organized activity. The most commonly reported activities are shown in Tables 2.2, 2.3, and 2.4. The average amount of organized PA was higher in White girls than Black in total number of activities and volume of activity (Table 2.5). When the girls were 11-12y was the only time that organized PA participation was similar in the two race groups. At all other times, White girls reported more involvement in organized PA. The number of activities ranged from 2 to 3 until they were 15-16y, when there was a substantial drop, particularly in Black girls. At this time there was also a substantial increase in the proportion of girls reporting no organized activity (Table 2.6).

Table 2.2

Most Frequently Reported Classes/Lessons by Year

Rank	Year 1 Age 9-10 y	Year 3 Age 11-12 y	Year 5 Age 13-14 y	Year 7 Age 15-16 y	Year 8 Age 16-17 y
1	Swimming 569	Ballet 329	Ballet 202	Ballet 139	Ballet 111
2	Gymnastics 314	Gymnastics 212	Gymnastics 80	Aerobics 45	Aerobics 31
3	Dance 259	Tennis 53	Tennis 62	Cheer 34	Tennis 20
4	Swimming/pool 144	Judo 49	Soccer 35	Gymnastics 29	Gymnastics 19
5	Ballet 127	Cheerleading 48	Horseback 34	Tennis 26	Cheer 15
6	Soccer 96	Soccer 47	Basketball 33	Basketball 17	Judo 14
7	Tap dance 45	Basketball 40	Softball 32	Judo 12	Basketball 13
8	Tennis 36	Horseback 38	Cheerleading 26	Horseback 11	Horseback 13
9	Basketball 30	Softball 32	Aerobics 21	Swim team 11	Soccer 9
10	Jazz dance 30	Track 23	Judo 21	General PA 11	Volleyball 8
Sample	**2287**	**2186**	**2012**	**1910**	**1974**

Data presented are the number of girls reporting an activity
Abbreviation: PA- Physical activity

Table 2.3

Most Frequently Reported School-Year Sports by Year

Rank	Year 1 Age 9-10 y	Year 3 Age 11-12 y	Year 5 Age 13-14 y	Year 7 Age 15-16 y	Year 8 Age 16-17 y	Year 10 Age 18-19 y
1	Kickball 440	Basketball 472	Basketball 489	Basketball 191	Cheerleading 164	Ballet 236
2	Soccer 363	Volleyball 338	Volleyball 312	Cheerleadin g 166	Basketball 146	Aerobics 148
3	Baseball 316	Soccer 315	Soccer 232	Softball 144	Softball 136	Basketball 94
4	Basketball 293	Kickball 245	Softball 212	Track 138	Track 98	Volleyball 50
5	Volleyball 189	Baseball 217	Ballet 197	Volleyball 121	Volleyball 97	Soccer 48
6	Football 148	DD Rope 216	Cheerleading 189	Soccer 117	Soccer 97	Ice skating 47
7	Dance 133	Softball 195	Track 115	Ballet 49	Ballet 69	Softball 43
8	Gymnastics 130	Ice skating 164	Baseball 105	Tennis 44	Tennis 36	Cheerleading 37
9	Tennis 58	Ballet 156	Ice skating 85	Aerobics 40	Swim team 28	Tennis 32
10	DD Rope 57	Football 122	Football 78	Field hockey 29	Field hockey 25	Track 25
11	Softball 50	Gymnastics 106	Tennis 66	Swim team 28	Aerobics 20	Judo 14
Sample	**2287**	**2186**	**2012**	**1910**	**1974**	**2037**

Data presented are the number of girls reporting an activity
Abbreviation: DD Rope- Double Dutch Jump Rope

Table 2.4

Most Frequently Reported Summer Sports by Year

	Year 1 Age 9-10 y	Year 3 Age 11-12 y	Year 5 Age 13-14 y	Year 7 Age 15-16 y	Year 8 Age 16-17 y	Year 10 Age 18-19 y
Rank						
1	Baseball 279	Basketball 324	Basketball 394	Basketball 151	Basketball 130	Ballet 221
2	Kickball 248	Baseball 313	Baseball 230	Softball 95	Softball 92	Aerobics 111
3	Soccer 221	Kickball 268	Ballet 205	Volleyball 66	Volleyball 62	Basketball 105
4	Basketball 152	Ice skating 267	Soccer 203	Soccer 62	Cheerleading 61	Softball 64
5	Tennis 133	Soccer 265	Volleyball 198	Tennis 62	Soccer 58	Volleyball 60
6	Volleyball 118	DD Rope 185	Softball 196	Ballet 57	Ballet 48	Ice skating 55
7	Football 107	Softball 168	Ice skating 187	Cheerleading 56	Tennis 44	Tennis 50
8	Gymnastics 83	Volleyball 165	Tennis 129	Baseball 35	Aerobics 32	Soccer 40
9	Dance 60	Tennis 146	Football 100	Swim team 34	Baseball 24	Cheerleading 22
10	Horseback 52	Football 143	Kickball 88	Aerobics 32	Track 21	Baseball 13
11	Softball 44	Ballet 138	DD Rope 76	Track 23	Swim team 17	Horseback 13
Sample	**2287**	**2186**	**2012**	**1910**	**1974**	**2037**

Data presented are the number of girls reporting an activity
Abbreviation: DD Rope- Double Dutch Jump Rope

Table 2.5

Organized Physical Activity by Study Year and Race

	Number of Activities				Total volume (MET times/wk)
	Total	**Classes/ lessons**	**Sports**		
			School year	**Summer**	
Year 1 9-10 y					
Black	2.4 (1.9)*	0.65 (0.87)*	1.0 (1.1)	0.70 (0.96)	11.60 (12.03)*
White	2.7 (2.0)	0.98 (0.99)	1.0 (1.1)	0.74 (0.93)	14.44 (12.86)
Year 3 11-12 y					
Black	3.0 (2.0)	0.36 (0.68)*	1.3 (1.2)	1.3 (1.2)*	13.04 (12.07)
White	3.0 (2.0)	0.59 (0.86)	1.3 (1.2)	1.1 (1.0)	13.33 (11.57)
Year 5 13-14 y					
Black	2.4 (1.9)*	0.23 (0.55)*	1.1 (1.1)*	1.1 (1.1)	10.52 (10.76)*
White	2.8 (2.0)	0.43 (0.73)	1.3 (1.2)	1.1 (1.1)	12.45 (11.15)
Year 7 15-16 y					
Black	0.9 (1.3)*	0.15 (0.43)*	0.46 (0.78)*	0.29 (0.61)*	5.01 (8.39)*
White	1.6 (1.6)	0.27 (0.57)	0.76 (0.92)	0.55 (0.75)	9.25 (10.26)
Year 8 16-17 y					
Black	0.8 (1.3)*	0.10 (0.34)*	0.41 (0.77)*	0.27 (0.59)*	4.55 (8.50)*
White	1.2 (1.4)	0.20 (0.49)	0.61 (0.85)	0.42 (0.67)	7.45 (9.63)
Year 10 18-19 y					
Black	0.58 (1.14)*	--	0.28 (0.62)*	0.30 (0.64)*	3.02 (6.25)*
White	1.08 (1.46)	--	0.56 (0.81)	0.53 (0.82)	5.47 (8.13)

Data are presented as Mean (SD)
*Means significantly different between races, $p < 0.05$
--Year 10 classes/lessons and sports are pooled in questionnaire

Table 2.6

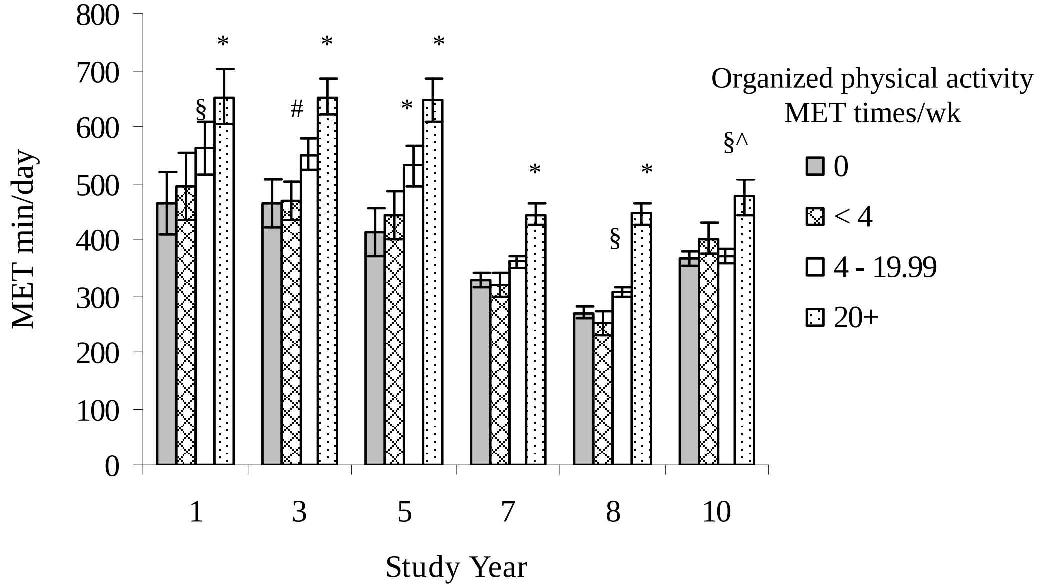
Organized Physical Activity Participation Categorized by MET times/week by Study Year and Race

		Black					**White**				Racial difference (p-value)
MET times/week		**0**	**<4**	**4-19.99**	**≥20**		**0**	**<4**	**4-19.99**	**≥20**	
	N	%				N	%				
Year 1 9-10 y	1152	17.2	16.1	47.5	19.3	1135	12.3	10.0	50.3	27.4	< 0.0001
Year 3 11-12 y	1133	9.1	18.5	49.6	22.8	1053	8.5	14.9	52.7	23.9	0.12
Year 5 13-14 y	1054	16.2	21.1	46.2	16.5	958	13.5	14.8	51.8	19.9	0.0002
Year 7 15-16 y	1006	58.2	8.0	27.3	6.6	904	35.0	12.1	36.8	16.2	< 0.0001
Year 8 16-17 y	1024	62.4	8.4	23.5	5.7	950	46.1	10.6	34.2	9.2	< 0.0001
Year 10 18-19 y	1046	72.5	6.8	16.9	3.8	991	52.6	9.9	30.4	7.2	< 0.0001

Cross-sectional relationships. Correlation coefficients between organized PA (HAQ; MET times/wk) and daily PA (AD; MET min/day) ranged from r=0.10-0.27. The correlations were all statistically significant ($p \leq 0.0003$) and higher for White than Black participants at each time point. For example, at age 11-12y the correlations were r=0.21 ($p < 0.0001$) for White girls and r=0.19 ($p < 0.0001$) for Black girls. These values indicate that the measures are related but are different constructs. Correlations were the lowest at age 18-19y (r=0.10, 0.11; Black and White girls, respectively), but there was no discernable pattern over time.

Cross-sectional analyses showed that at each time point and in both race groups, sports participation groups differed on daily PA (F values ≥ 3.99, $p < 0.008$). As displayed in Figure 2.1, PA was consistently highest in the group with at least 20 MET times/wk of organized activity. Within race, their PA was significantly higher than one or more of the other sports participation groups at each time point.

a. White



b. Black

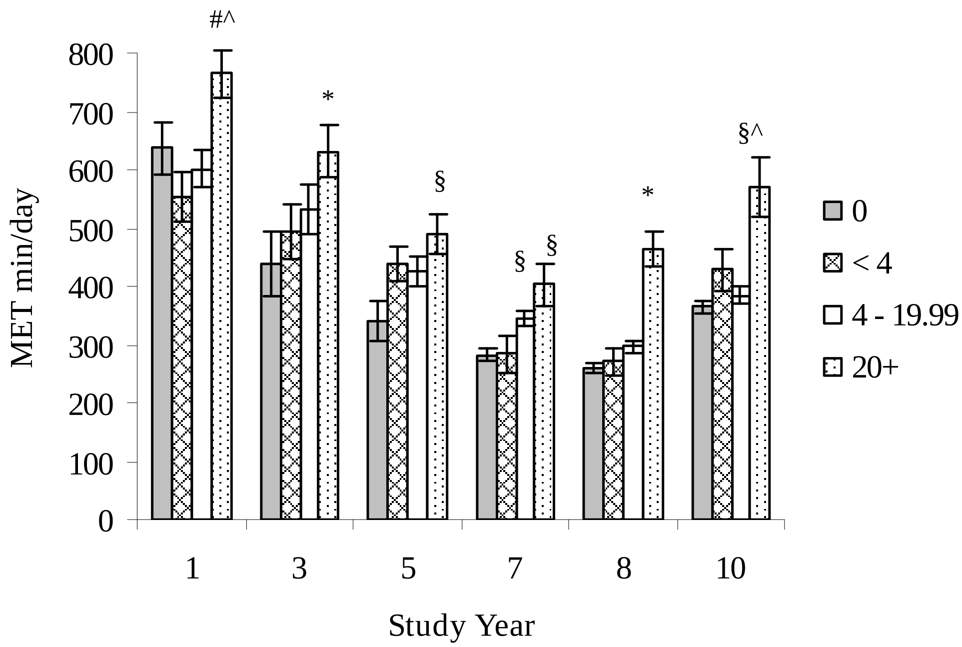


Figure 2.1. Daily physical activity by race, organized physical activity, and study year

* Significantly different than all other participation groups within time and race ($p < 0.05$)
§ Significantly different than 0 MET times/wk within time and race ($p < 0.05$)
#Significantly different than < 4 MET times/wk within time and race ($p < 0.05$)
^Significantly different than 4-19.99 MET times/wk within time and race ($p < 0.05$)

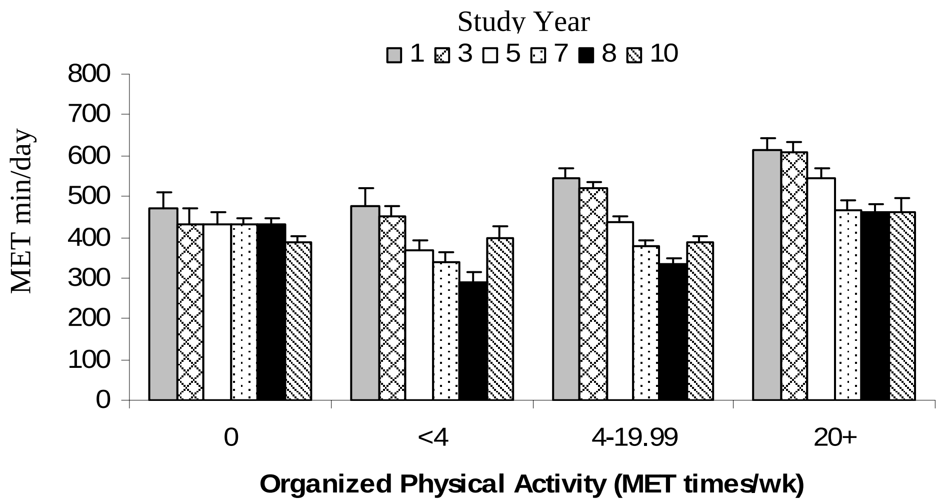
Time trends in daily physical activity. Time and sports participation were significantly associated with the change in daily PA ($p < 0.0001$, Table 2.7). In general, average PA declined from 9-10y to 16-17y, then increased between 16-17y and 18-19y (Figure 2.2). Daily PA was greater at 9-10y and 11-12y than all other future time points ($p \leq 0.003$); however, an increase at 18-19y resulted in similar levels as 13-14y. Across all time points, girls who participated in at least 20 MET times/wk of organized activity had greater PA levels than all other groups ($p < 0.0001$). Those with the highest involvement (≥20 MET times/wk) had a mean of 524.2 MET min/day (SE=10.2) versus 387.7 MET min/day (SE=9.3) for the non-participants, 396.4 MET min/day (SE=10.0) for those with <4 MET times/wk, and 430.7 MET min/day (SE=7.0) for those with 4-19.99 MET times/wk. Those who participated in a moderate amount of organized PA (4-19.99 MET times/wk) were also significantly more active than those in the two lower sports participation categories ($p < 0.001$).

Table 2.7

Factors Associated with Trend in Daily Physical Activity

Variable	**F value**	**p-value**
Sports participation	59.00	**< 0.0001**
Time point	34.04	**< 0.0001**
Income category	15.62	**< 0.0001**
Race	0.61	0.44
Maturation stage	0.52	0.67
Body fat	0.13	0.72
Sports participation * time point	1.79	**0.03**
Sports participation * race	1.14	0.33
Sports participation * time point * race	3.19	**< 0.0001**

a. White



b. Black

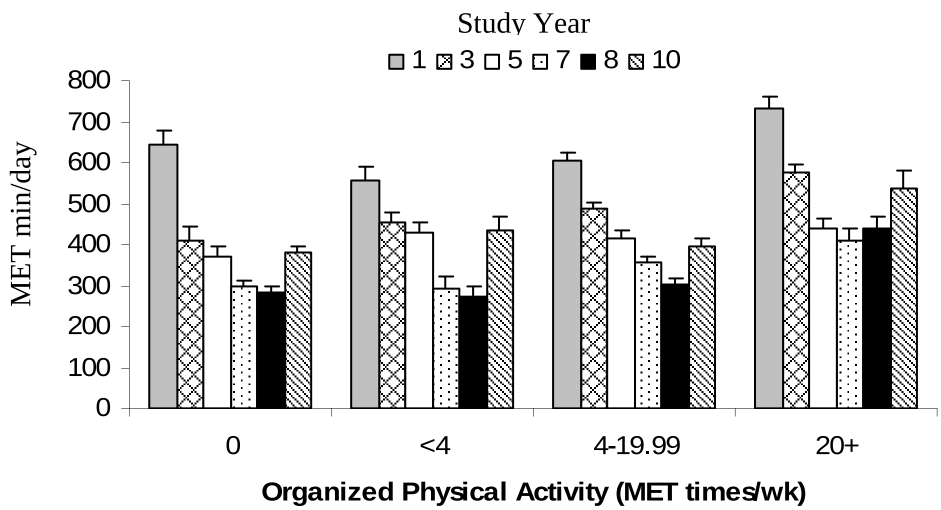


Figure 2.2. Time trend in daily physical activity by race and organized physical activity

A significant three-way interaction between sports participation, race, and time point was observed. Data are presented by race in Figure 2.2. The two-way interaction between sports participation and time point was significant in the White girls (p=0.019), however, only the main effects of sports participation and time were evident in the Black girls.

Black girls in all sports participation categories showed the same pattern of change over time; following baseline measurement, daily PA declined significantly and remained lower than baseline throughout the study ($p < 0.0001$). Across all time points, Black girls who were involved in at least 20 MET times/wk of organized PA had higher PA levels than all other Black girls ($p < 0.0001$). Those who participated in a moderate amount of organized PA (4-19.99 MET times/wk) were also significantly more active than non-participants (p=0.0005).

The change over time in daily PA for White girls varied by their sports participation status (p=0.019). The moderately involved girls (4-19.99 MET times/wk) had a significant decline in PA between 11-12y and 13-14y (p=0.0007) which was earlier than the girls who were most involved (≥20 MET times/wk) and non-participants, who didn't have a significant between-visit decline until 15-16y and 16-17y. Additionally, the PA of those who participated in little (< 4 MET times/wk) or no organized activity was not significantly lower than their baseline level until 16-17y, while the girls with 4-19.99 MET times/wk were significantly lower than baseline by 13-14y. The groups also changed differently in the later years. Two of the groups (0 and 4-19.99 MET times/wk) continued to decline from 15-16y to 16-17y and then significantly increase between 16-17y and 18-19y. Those with little sports participation (< 4 MET times/wk) showed the same trend although differences did not remain statistically significant after controlling the experiment-wide error rate. However, those with higher sports participation (≥20 MET times/wk) maintained a stable PA level over this time period.

Accumulated organized physical activity. Girls who had complete HAQ data for Years 1, 3, 5, and 7 (n=1670) were included in an analysis of the association between accumulated organized PA participation and daily PA at 18-19y. Baseline organized activity volume, baseline body fat, and body fat at age 18-19y were similar for those with and without complete data. Girls with complete data had lower daily PA at baseline and 18-19y than those missing at least one data point, however, girls with complete data had a higher volume of organized activity at 18-19y ($p < 0.04$). Missing data were more common in White and lower income participants ($p \leq 0.01$). For each of the four years, girls were categorized as participants if they had at least 4 MET times/wk of organized PA. As shown in Table 2.8, the distribution across these categories was different for Black and White girls ($\chi 2=95.02$, $p < 0.0001$). Although similar proportions of girls never participated (~4%), a larger proportion of White than Black girls were sports participants at all four time points (33.8 vs. 15.5%). As seen in Figure 2.3, those girls who reported organized PA participation at one or more time points were more active at 18-19y than girls who never reported any participation ($p < 0.02$).

Table 2.8

Years of Accumulated Sports Participation by Race

	Black	**White**
	N=879	N=791
Years of participation*	**%**	**%**
0	4.4	4.1
1	16.4	10.9
2	32.3	19.1
3	31.4	32.2
4	15.5	33.8

*Distribution significantly different between races (p < 0.0001)

Accumulated sports participation: Number of years girl reported an average of at least 4 MET times/wk of organized PA

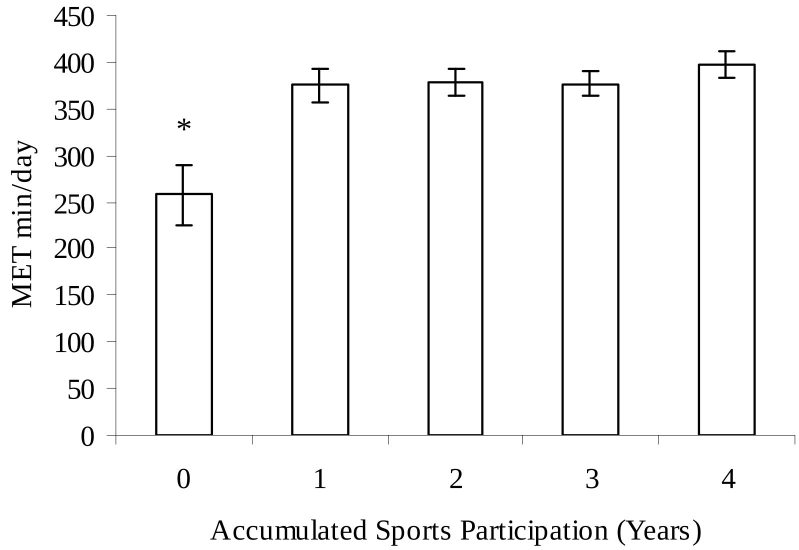


Figure 2.3. Daily physical activity at 18-19y by accumulated sports participation

* Significantly different than all other groups ($p < 0.02$)

Discussion

Time trends in daily physical activity. This study provided the opportunity to examine the association between organized PA and overall daily PA over a 10-year time period in a large, multi-site, racially-balanced sample of girls. The main findings indicated that sports participation was a significant determinant of physical activity from 9 to 19 years of age, as well as associated with change in PA over this time period. This is consistent with others who have reported a positive relationship between sports participation and PA for adolescent girls cross-sectionally (Baumert, Henderson, & Thompson, 1998; Fernandes et al., 2008; Harrison & Narayan, 2003; Kurc & Leatherdale, 2009; Pabayo, O'Loughlin, Gauvin, Paradis, & Gray-Donald, 2006; Pate et al., 2000; Phillips & Young, 2009; Sirard, Pfeiffer, Dowda, & Pate, 2008; Sirard et al., 2006; Vilhjalmsson & Kristjansdottir, 2003; Walters, Barr-Anderson, Wall, & Neumark-Sztainer, 2009; Ward et al., 2006) as well as those who have found prospective relationships in early adolescence (Pate et al., 2007) and across the high school years (Belanger, Gray-Donald, O'Loughlin, Paradis, Hutcheon et al., 2009; Pfeiffer et al., 2006). A novel finding of this study was the interaction between sports participation, race, and time, indicating that the relationship between organized PA and daily PA over time was different for Black and White girls.

The findings for the Black girls were similar to that of recent studies suggesting that although prior sports participation is beneficial at an individual time point, overall, all groups decline over time (Belanger, Gray-Donald, O'Loughlin, Paradis, Hutcheon et al., 2009; Walters et al., 2009). In fact, in one study, females who were participants in high school demonstrated a steeper decline in the transition into young adulthood than non-participants (Walters et al., 2009). Even with the decline over time in the current study, those with the most organized PA (≥20 MET times/wk) demonstrated greater daily PA at each time point, resulting in a main effect such that across all time points, they were more active than all three other groups. Averaged over the study period, Black girls at this level performed 90.6, 112.1, and 125 more MET min/day than those with moderate, low, or no participation, respectively. This translates to the most involved sports participants performing 22.5 to 31 minutes more moderate PA, such as brisk walking, than the other groups, on a daily basis.

As seen in Figure 2.2, the pattern of change over time was different for White girls; sports participation appeared to have a stronger relationship with the maintenance of total PA. Those who were most involved (≥20 MET times/wk) had better continuation of PA over time, especially in the later years. Significant decline was the earliest for the White girls who were moderately involved in organized activity. Looking at year to year comparisons, the moderately involved girls' PA dropped between 11-12y and 13-14y while the most involved group didn't have a statistically significant decline until between 13-14y and 15-16y. From this point, the most involved girls maintained daily PA, while all other groups decreased further at 16-17y.

In a shorter prospective study of 9- to 12-year-old urban Canadians, Barnett and colleagues (2002) reported that girls who did not participate in school sports were twice as likely to move from being classified as active to inactive over two years than girls who did participate at baseline. Interestingly, this relationship only held for school sports, not for community-based activities. The authors speculated that children who did not participate in school activities at baseline may have been active through play or community activities, which were more commonly reported, but did not maintain this behavior at follow up, whereas the school sports participation had a more salient influence. In a cross-sectional sample of Canadian high school students, both intramural and varsity school sports, as well as community sports were associated with activity classification (Kurc & Leatherdale, 2009). In fact, the strongest relationship was found for those involved in community sports teams; girls who participated were almost three times as likely to be classified as active as those who did not do community sports. Although organized activity setting (school- or community-based) is unknown in the NGHS sample, it can be seen that organized activity may help to maintain PA over time, and it may be different types at different times. This relationship warrants further investigation.

Another interesting pattern that emerged was that of the change from 16-17y to 18-19y, where the White girls who were most involved in sports did not show the increase in daily PA that all other groups did. Although White girls in the most involved category didn’t have an increase between 16-17y and 18-19y like other groups, they still remained more active at 18-19y than White girls in the other participation groups. It is possible that the addition of household and job-related activity contributed to the increase for other girls, and this was not seen in the girls who were still highly active in sports because the time was allocated to sports.

Overall, the main effect of sports participation status was also highly significant for White girls. Over the study period, the most involved group performed 91.7, 138.1, and 145.5 more MET min/day than those with moderate, low, or no participation, respectively. The difference in total PA between those who were the most involved in sports (≥ 20 MET times/wk) and those with less than 4 MET times/wk is approximately 35 minutes per day of moderate PA.

Although racial differences are commonly reported for total PA and sports participation, other studies have not found race to be a factor in the relationship between them. The interaction with race and sports participation over time was significant in a model including SES, indicating the effect was not due to SES differences. The extended length of the follow-up period in the current study may have allowed this interaction to become apparent. Additionally, the NGHS cohort was comprised of girls from three urban U.S. areas, who could be very different from girls in less dense areas like those of the LEAP cohort in South Carolina. LEAP was a four-year study of girls from 8th through 12th grades in South Carolina who were recruited for a school-based PA intervention. The base cohort consisted of over 2700 girls from 31 middle schools and had equal representation of Whites and African-Americans (Dowda et al., 2004). Finally, there is a possibility of a secular change because data from NGHS are older than other cohorts. For example, LEAP was initiated in 1999, two years after the 10-year NGHS concluded. Cultural differences in the effect of sports participation could have changed in this time period.

Sports participation may have a direct influence on PA time by providing regularly scheduled bouts of activity, or indirectly by enhancing other factors known to be positively related to PA, such as perceived competence, social support and enjoyment. Girls participating in sports are learning and practicing sports skills, which in turn, would be expected to increase both their actual and perceived competence in their sports skills. Perceived competence is believed to positively influence PA behavior; those girls who consider themselves skilled are more likely to participate (Barnett, Morgan, van Beurden, & Beard, 2008; Haverly & Davison, 2005; Neumark-Sztainer, Story, Hannan, Tharp, & Rex, 2003). Conversely, those with low perceived sport competence have been found to be at increased risk for inactivity (Haverly & Davison, 2005).

Participation in organized PA can be associated with positive social support from several sources: parents who arrange, pay for, and provide transportation to an activity, the coach or instructor, and other participants or teammates. Having social support has been reported to influence adolescents' PA initiation (Jago et al., 2009), participation (Neumark-Sztainer et al., 2003), and maintenance (Belanger, Gray-Donald, O'Loughlin, Paradis, & Hanley, 2009; Jago et al., 2009). Girls have stated that they were motivated to do fun PA, and that being active with others was related to fun; additionally, girls expressed that having active friends, supportive teammates and peers participating with them would be motivational factors in their PA (Mabry et al., 2003). However, in general, these girls did not consider “sports” as fun because high level of competition and exclusion. Still, team sports can be opportunity to development interpersonal relationships, group work skills, and friendships (Seabra, Mendonca, Thomis, Malina, & Maia, 2007) for those who enjoy the atmosphere. These factors need to be taken into consideration, and schools and communities should be encouraged to provide enjoyable activities that are desirable to girls who may be less interested in competition in addition to the traditional competitive activities.

It was of interest to see if the girls who did even a little organized activity throughout the year were different than non-participants. In this cohort, PA was very similar between girls who were involved for less than 4 MET times/wk and non-participants. The longitudinal main effect showed a dose-response beyond those with little or no organized activity. Those in the moderately involved group (4-19.99 MET times/wk) were more physically active overall than the least involved groups, and those who averaged at least 20 MET times/wk were more active than all other groups as well. This is an important consideration for parents and professionals promoting organized activity; it appears that participation needs to be consistent and regular, with at least one weekly activity year-round. A stronger impact can be attained by participation in organized activity 20 MET times/wk, which could be accomplished in five 30-minute sessions of moderate intensity activity.

These findings also highlight the importance of being able to further partition the level of involvement beyond the categories of participants and non-participants. Many studies have been limited to dichotomization of participation or questions addressing the number of sports teams on which one has participated in a given timeframe (Baumert et al., 1998; Kurc & Leatherdale, 2009; Pfeiffer et al., 2006; Phillips & Young, 2009; Sirard et al., 2008; Walters et al., 2009); this is a obstacle in understanding the true level of participation and PA. The estimate of MET times/wk offers a way to better summarize the volume of participation over the past year. This measure can equalize a girl who did four activities, each for a quarter of the year, and a girl who did one activity consistently throughout the year. Additionally, it includes an estimate of intensity of activity. Nonetheless, there can still be wide variation among participants in active time and intensity based on factors such as personal motivation and athletic position (e.g., soccer goalie versus midfielder). As we move forward to further understand the role of organized PA in youth, measurement of these constructs must move forward as well.

Accumulated organized physical activity. To examine the association with accumulating several years of organized activity, girls who participated in at least 4 MET times/wk were considered participants. As would be expected based on other results, there was a significant difference in the distribution by race. About twice the percentage of White girls reported participation at all four time points. The group of girls who never achieved 4 MET times/wk of participation was significantly less active at 18-19y than all other girls. When looking at the relationship in this manner, it appears that as little as one year of organized activity was beneficial for PA behavior in late adolescence. This activity has a potentially long-lasting effect because the sports participation could have been as early as when the girls were 9-10y.

It is interesting that those who participated in one to four years had similar daily activity levels in late adolescence. It is possible that most organized participation had ceased, therefore all former participants were maintaining a similar amount of other recreational PA. Perhaps the more recent years are more important to differentiate girls in late adolescence; such was the finding in LEAP (Pfeiffer et al., 2006). As previously mentioned, LEAP was a longitudinal study of 8^{th} -12^{th} grade girls. Those who participated in sports at only one time point, 8^{th} or 9^{th} grade, were not at an advantage in their 12^{th} grade PA (Pfeiffer et al., 2006). However, girls who participated in 8^{th} and 9^{th} grade, or at all three time points, had higher odds of being active in 12^{th} grade than non-participants, particularly for vigorous PA. Timing of discontinuation of sports participation may be an important factor for future PA and needs further study.

Organized physical activity participation. Physical activity and its relationship to obesity development have been a focus of NGHS analyses. Over the 10-year span, three PA measures were employed (HAQ, AD, and accelerometry), and a significant decline was observed in both Black and White girls with each measure (Kimm et al., 2002; Kimm et al., 2000). The current study examined a subcomponent of habitual activity, those activities believed to have been performed in an organized setting, to complement existing knowledge.

Organized PA participation rates are high in late childhood and early adolescence (Barr-Anderson et al., 2007; Belanger, Gray-Donald, O'Loughlin, Paradis, Hutcheon et al., 2009; Michaud, Narring, Cauderay, & Cavadini, 1999; Sirard et al., 2006); consistent with previous research, the majority of NGHS girls participated in some organized PA in the early years of the study. In the first five years, NGHS girls did an average of two to three activities, with the majority of them being sports rather than classes or lessons. However, in high school years, non-participation was much more common, ranging from 58% to 72.5% in Black girls and 35% to 52.6% in White girls. Almost all girls did some organized activity by the time they were 15-16y (Year 7). Of the 1670 who had sports participation data for those four time points, only 8 (0.48%) reported no participation in any organized PA.

When the girls were 9-10y, swimming was the most commonly reported lesson, by almost a quarter of the girls; however, it was never again in the top 10. Dance, gymnastics, and cheerleading were popular activities, consistent with other studies. As may be expected, dance seems to be the most consistent activity across samples (Barr-Anderson et al., 2007; Bradley et al., 2000; Grieser et al., 2006; Harrell et al., 2003; Pate et al., 2007; Rekers, Sanders, Rasbury, Strauss, & Morey, 1989). Aerobics first appeared when the girls were in their early teens, and became the second most reported class from 15 to 17y. Aaron et al. (2002) also found an increased interest in aerobics in late adolescence, it moved from the fifth- to the second-ranked activity over four years in adolescent girls. Aerobics also had the highest tracking from baseline to the four-year follow up for girls in their study.

Team sports such as basketball, soccer, softball, and volleyball were commonly reported during both the school year and the summer, and were highly ranked from year to year. These activities have been consistently reported by girls in other samples (Aaron et al., 2002; Bradley et al., 2000; Grieser et al., 2006; Harrell et al., 2003; Pate et al., 2007; Rekers et al., 1989). It is important to note that while the same activities were mentioned from year to year, the number of girls reporting participation decreased over time. For example, basketball was reported by over 20% of girls at 11-12y and 13-14y, but only 7% at 16-17y and 4.6% at 18-19y. Similar participation and subsequent decline were reported for basketball and softball in both CHIC and LEAP cohorts, as well as for soccer with the LEAP girls (Bradley et al., 2000; Pate et al., 2007).

In general, Black girls in this sample reported much less participation in organized PA than White girls. This was true for both the number of activities reported and the total volume of PA in this context. The only time girls had similar participation was when they were 11-12y. At this time, both groups had small increases in the number of activities from the previous report. This is an interesting timeframe for speculation on this increase. It is possible that as they entered middle school or junior high, more opportunities were available at school or in the community, and the girls were interested in sampling them. This possibility is supported by the CHIC Study where girls reported more participation in basketball and softball in middle school years (Bradley et al., 2000).

Limitations and strengths. While the current estimate of organized PA is stronger than many previously used, it is not without faults. Several assumptions were made in determining which activities should be considered “organized”. A rather loose inclusion strategy was used for classes/lessons since the question was specific to them. Anything active in nature was included; however, it is possible that activities such as Double Dutch jump rope and hiking were not performed with leadership associated with organized PA. A more strict strategy was employed for the sports activities because the question was more open to include “sports and other physical activities”. In this case, only activities generally performed with a group, team, or leader were included. Again, it is possible that credit was given for activity not performed in this setting. For example, it is possible a girl was credited for organized basketball participation when in actuality she was “shooting hoops” at a local park. On the other hand, a girl may have reported running and been excluded, but she may have truly been in a competitive track program. It is assumed that these misclassifications are minimal and would not lead to overestimation of the relationship with participation.

Both PA measures were subject to recall bias, especially in the earlier years when the girls were relatively young. Instruments were designed to minimize the age-related limitations (Kimm et al., 2000), however, the HAQ may have been particularly difficult since children were asked to recall the prior year and estimate how much of the year they were active in each setting. While this was likely an issue, it is expected to be relatively uniform across same-age participants, and age was used as a covariate to minimize the impact. Additionally, the HAQ does not include an estimation of the duration of activity.

The wealth of information collected in the NGHS is a significant strength. In the current analysis the inclusion of covariates, such as body fat and maturation, strengthened the findings. It had been previously reported that weight status influenced PA decline in this group (Kimm et al., 2002); therefore it was important to include it in the current analysis. Puberty has been noted as a potential influence on the change in PA during adolescence as well as a possible confounder of age and race effects (Bradley et al., 2000). Maturational stage was not significant factor in change over time in daily activity in current model. Similarly, age at menarche was not significant in analysis of accumulated sports participation.

Conclusion. In conclusion, there was a consistent and substantial decline in all PA measures in this cohort (Kimm et al., 2002; Kimm et al., 2000). However, when girls were classified by their participation in organized PA, new information regarding their daily PA was gained. It is apparent that those girls who were most involved in lessons and sports were more active than other girls. Even though there were racial differences in PA, sports participation was an important factor for Black and White girls throughout adolescence.

Chapter 3: Time Trends in Cardiovascular Disease Risk Factors by Organized Physical Activity Participation in Adolescent Girls

(Target journal: *Journal of Adolescent Health*; Options: *Pediatrics, Archives of Pediatric and Adolescent Medicine, Preventive Medicine)*

Abstract

Background: A large number of youth are involved in organized physical activity (PA), however, the impact of these activities on body fat and cardiovascular health are not well understood. *Purpose:* To examine the longitudinal relationship between organized PA and cardiovascular disease (CVD) risk factors. *Methods:* The limited access dataset from the National Heart, Lung, and Blood Institute Growth and Health Study was analyzed. The cohort was comprised of Black and White girls (N=2379) who were followed for 10 years. Girls' organized PA was categorized based on their responses to a habitual activity questionnaire (0, <4, 4-19.99, ≥20 MET times/wk). Outcome measures included body fat (bioelectrical impedance analysis), lipids, glucose, insulin, and blood pressure. Longitudinal data were examined using a mixed model with repeated measures. Girls were also categorized by the number of years they reported at least 4 MET times/wk of organized PA. Differences in each outcome at age 18-19y were evaluated with ANOVA, based on the number of participation years. Odds of having clustered risk factors at 18-19y was assessed with logistic regression. *Results:* Organized PA was not a significant factor for change in insulin, glucose, lipid profile or blood pressure throughout adolescence. Years of reported organized PA were not associated with CVD risk factor clustering at 18-19y (OR=1.05, 95% CI=0.87-1.27, p=0.59). Organized PA was a significant factor for change over time in body fat (p < 0.0001), and a 3-way interaction between participation, time, and race ($p < 0.0001$) indicated that the relationship between organized PA and body fat was different for Black and White girls. White non-participants had higher body fat levels than those who participated for 4-19.99 MET times/wk ($p=0.006$). Black girls who participated at least 20 MET times/wk had significantly lower body fat than non-participants ($p=0.002$). Body fat levels at 18-19y were significantly lower in the girls who consistently reported regular sports participation compared to girls who never reported more than 4 MET times/wk ($p=0.038$). *Conclusion:* Organized PA was associated with healthier body fat during adolescence; however, participation was not related to other CVD risk factors in this sample.

Introduction

Research is limited concerning the relationship between structured sports and activity lessons or classes and health and fitness outcomes such as cardiovascular fitness, weight status, blood pressure (BP), and blood lipids (Cavill, Biddle, & Sallis, 2001; Hoffman, Kang, Faignbaum, & Ratamess, 2005; Michaud, Narring, Cauderay, & Cavadini, 1999). Sports participants have reported higher overall PA levels than non-participants in some samples (Harrison & Narayan, 2003; Katzmarzyk & Malina, 1998; Pfeiffer et al., 2006; Ribeyre et al., 2000), and active children and adolescents tend to demonstrate better fitness (Ara, Moreno, Leiva, Gutin, & Casajus, 2007; Ara et al., 2004; Ara et al., 2006; Beets & Pitetti, 2005; Boreham, Twisk, Savage, Cran, & Strain, 1997; Hoffman et al., 2005; Pfeiffer, Dowda, Dishman, Sirard, & Pate, 2007), lower body fat (Ara et al., 2006; Kawabe et al., 2000; Ribeyre et al., 2000), and more favorable cardiovascular disease (CVD) risk profiles (Boreham et al., 1997; Cavill et al., 2001; Kawabe et al., 2000; Myers, Strikmiller, Webber, & Berenson, 1996) than those who are not active.

Weight status. Cross-sectional data generally indicate a negative relationship between overall PA and body mass index (BMI) and other body fat measures (Ara et al., 2004, 2007; Ness et al., 2007; Stevens et al., 2007). The few studies of sports participation have had similar results (Boreham et al., 1997; Dowda, Ainsworth, Addy, Saunders, & Riner, 2001; Kawabe et al., 2000; Ribeyre et al., 2000; Sirard, Pfeiffer, Dowda, & Pate, 2008). When examining the relationship between sports participation and weight status, it is important to look at a more precise estimate of body fat than BMI. For example, a study of Japanese male high school students found that although students who had belonged to sports clubs for the past two years had higher BMIs than non-exercisers, body fat percentage was significantly lower in the sports participants (Kawabe et al., 2000). Similarly, Ribeyre et al. (2000) reported athletes and non-athletes to have similar BMIs, but the athletes had significantly lower percent body fat and greater fat free mass.

Maintaining PA is thought to be critical in preventing the development of overweight and obesity in adolescence (Kimm et al., 2005). Longitudinal studies of sports participation and body composition tend to be focused on one sport (e.g., gymnastics, dance) and bone mass (Laing et al., 2002; Laing et al., 2005) or maturation (Matthews et al., 2006). Athletes increased lean and bone masses over time, indicating that body composition was more favorable in sports participants than their counterparts. Children and adolescents participate in a variety of organized activities, and research regarding weight status and this general category of PA is scarce, particularly for girls. A study of prepubertal boys found that total body fat mass increased less in those who maintained sports activity over three years compared to inactive boys, and at the end of the period, total body fat tended to be lower in the active group than the non-active boys (Ara et al., 2006). The active group also benefited by a greater increase in lean mass, bone mineral content, and bone mineral density.

Cardiovascular disease risk factors. Observational studies such as the Young Hearts Project, the Bogalusa Heart Study, Danish Youth and Sport Study, the National Health and Nutrition Examination Survey, and the European Youth Heart Study have found associations between PA (Boreham et al., 1997; Myers et al., 1996) or fitness (Andersen, Hasselstrom, Gronfeldt, Hansen, & Froberg, 2004; Carnethon, Gulati, & Greenland, 2005; Wedderkopp, Froberg, Hansen, Riddoch, & Andersen, 2003) and CVD risk factors in youth. Very few analyses of organized PA participation and its relationship with CVD risk factors other than body composition and fitness have been completed. In fact, no analyses with American youth were located. Some factors have been reported to be beneficially associated with sports participation. In a study of Japanese males, athletes were found to have lower diastolic BP, resting heart rate, and triglycerides (TG) and higher high density lipoprotein cholesterol (HDL-C) than non-exercisers (Kawabe et al., 2000). Similar results have not been reported for girls. In the Young Hearts Project (Northern Ireland), neither sports participation nor PA was related to BP or the ratio of total cholesterol (TC) to HDL-C for 12- or 15-year-old girls (Boreham et al., 1997).

The tendency for multiple CVD risk factors to cluster has been noted for children and adults (Katzmarzyk et al., 2004). Having multiple risk factors in adulthood puts individuals at an increased risk of CVD and premature death (Katzmarzyk et al., 2004). As with individual risk factors, study of the role of organized PA on the clustering of risk factors is scarce.

The relationship between organized PA and CVD risk factors has likely been under-researched due to lower prevalence of CVD risk factors in youth than adults. However, as obesity and inactivity have climbed, risk factors have become more apparent at younger ages. For example, there is evidence of increased prevalence of type 2 diabetes, especially in minority children and adolescents (Rosenbloom, Joe, Young, & Winter, 1999). Therefore, it is important to examine the potential benefit organized PA participation can offer for CVD protection. Investigation of the health benefits associated with PA of different types is a research priority (Cavill et al., 2001). As other interests compete with sports and PA for adolescents' leisure time, it is imperative to understand the benefits associated with maintaining PA. Knowledge regarding the relationships between organized PA and health outcomes will provide guidance as to what types of activity are beneficial and should be promoted. The purpose of this study was to determine if there is an association between participation in organized PA and development of CVD risk factors such as body fat percentage, BP, and lipid profiles. This study also explored potential race differences in these relationships.

Methods

Data from the National Heart, Lung, and Blood Institute Growth and Health Study (NGHS) were analyzed to examine the relationship between organized PA participation and health outcomes including body fat and CVD risk factors. The limited access dataset was obtained from the National Heart, Lung, and Blood Institute, and the secondary analysis was approved by the University of Maryland Institutional Review Board. NGHS was a longitudinal, observational multi-site study of obesity in Black and White girls throughout adolescence. A total of 2379 girls were recruited in 1987-1988 from schools near San Francisco, California and Cincinnati, Ohio, and from a health maintenance organization in the Washington, D.C. area. Participants were 9-10y at enrollment and were followed until they were 18-19y. The overall follow up rate was 89% at the end of the study (Kimm et al., 2002). Data were collected annually and included: physical examination with a visual assessment of maturity, anthropometric measurements, dietary assessment, PA, BP, fasting blood sample, family socioeconomic status (SES), and psychosocial factors. This analysis will include organized PA, body fat, BP, lipids, insulin, and glucose.

Habitual activity questionnaire. The habitual activity questionnaire (HAQ) was interviewer-administered in Years 1, 3, and 5 and self-administered in Years 7-10 (Kimm et al., 2000). Participants were asked about classes/lessons, sports, and other physical activities throughout the past year. Girls were asked which activities they did, how many times per week, and how much of the year they participated. MET values were assigned to recorded activities, and a summary score of MET times/week was calculated. For this study, the HAQ was used to categorize girls as “sports participants” examining only those activities of an organized nature (classes/lessons, and sports; see Appendix for inclusive list), excluding those physical activities expected to have been completed without instruction or leadership (e.g., walking, jogging). The distribution of volume (MET times/wk) was examined and found to be significantly skewed towards lower participation, particularly in later years of the study. Due to this skewness as well as the desire to separate “non-participants” girls were categorized into one of four groups: 1) no organized PA, 2) greater than 0 but less than 4 MET times/week, 3) 4 to less than 20 MET times/week, 4) at least 20 MET times/week. A girl with a value of 4 MET times/week could have reported participating in one hour of organized activity of moderate intensity (e.g., ballet or gymnastics) per week consistently over the year. A value of 20 MET times/week is equivalent to five sessions of 30 minutes of moderate PA.

Accumulated organized physical activity. Participants were categorized based on the number of years, up to and including Year 7 (age 15-16y), in which they reported at least 4 MET times/week of organized PA participation. The HAQ was administered four times (Years 1, 3, 5, 7) during this period, resulting in five categories indicating zero to four years of reported participation.

Anthropometrics and maturation. Height, weight, and body fat were obtained at each annual visit (NGHS Research Group, 1992). Height and weight were each measured two times in a hospital gown and socks. Height was measured with a custom portable stadiometer, and weight was measured with an electronic scale. If the two measures differed by more than 0.5cm for height or 0.3kg for weight, a third was taken. The average of the closest two measurements are used (NGHS Research Group, 1992). This study used the bioelectrical impedance analysis (BIA) results for body fat in analyses. Supine hand-to-foot BIA was conducted (Morrison et al., 2001), and resistance and reactance measures were evaluated to calculate fat-free mass (FFM) and percent body fat (Thompson et al., 2007). Race-specific equations were used to calculate FFM as follows (R is resistance and Xc is reactance):

White girls FFM= $-6.41 + 0.56\ \text{height}^2/R + 0.34\ \text{weight} + 0.06Xc$

Black girls FFM= $-8.78 + 0.78\ \text{height}^2/R + 0.18\text{weight} + 0.10Xc$

Percent body fat was calculated as weight minus FFM divided by weight times 100. Calculations that resulted in body fat values less than 1% were deleted and set to missing.

Maturation was visually assessed by trained examiners and classified into four stages (prepubertal, pubertal but premenarchal, less than two years postmenarchal, two years or more postmenarchal). Age at menarche was also reported.

Cardiovascular disease risk factors. The CVD risk factors of interest assessed in NGHS included BP, TG, TC, HDL-C, low density lipoprotein cholesterol (LDL-C), (NGHS Research Group, 1992), fasting insulin, and fasting plasma glucose. Seated BP was obtained through a standardized protocol using a standard mercury sphygmomanometer and an appropriate-sized cuff at each annual visit (Thompson et al., 2007). Three BP measurements were taken, and the average of the second and third recorded (NGHS Research Group, 1992). Overnight fasting blood samples were obtained in Years 1,3,5,7, and 10 for the remainder of the variables with the exception of insulin and glucose, which were only available for Years 7 and 10. The Cholesterol CHOD-PAP method was used to determine TC and HDL-C, TG was analyzed enzymatically, and LDL-C was determined with the Friedewald equation modified based on the Lipid Research Clinics data as follows: LDL-C = TC – HDL-C – (TG/6.5) (NGHS Research Group, 1992). Fasting insulin and glucose were measured at two of the three clinical centers (Ohio and Washington, D.C.; Klein et al., 2004).

Sociodemographics. Eligibility was limited to girls who declared themselves as Black or White and lived in racial concordant households (NGHS Research Group, 1992). Education level and annual family income were reported by parents at baseline. Annual income was collapsed into the categories of less than $10,000, $10,000 to $19,999, $20,000-$39,999, and $40,000 or more.

Data analysis. Missing data were imputed with mean values. Race-specific means replaced missing values for age at menarche, body fat, and MET times/week (HAQ). The remaining outcome values and age at examination were replaced with overall means. When maturity status was missing, the predominant stage for the study year and race was used. Years of accumulated sports participation was calculated without imputation, only for those with four complete data points.

Means, standard deviations, and t-tests were used to report participant characteristics and to examine racial differences. Chi-square analyses were used to determine differences in categorical distribution.

Longitudinal data were analyzed using a mixed model with repeated measures. Models were constructed to examine the association of health outcomes with sports participation, time point, and race, while controlling for body fat, age or maturational stage, and SES. Two-way interactions between sports participation and race as well as sports participation and time point were included in all models. The three-way interaction between sports participation, race, and time point was run in each model, and retained only where significant. Outcomes were examined separately and included insulin, glucose, TG, TC, HDL-C, LDL-C, systolic BP (SBP), diastolic BP (DBP), and body fat. Body fat percentage was included in all other analyses because of the known association between body fat and CVD risk factors. To control for the relatedness of repeated measures, the covariance structure for each outcome variable was examined and based on Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC) values, the best fit was chosen.

The relationship between accumulated years of early sports participation and outcomes (insulin, glucose, TG, TC, HDL-C, LDL-C, SBP, DBP, and body fat) at 18-19y was also investigated. Participants were categorized based on the number of years, up to and including Year 7, in which they reported at least 4 MET times/week of organized PA participation. Between group differences were assessed with ANOVA, controlling for race, age, maturation (age at menarche), SES, and body fat. Relevant two-way interactions were examined, but not found to be significant, and therefore, were not used in the final models.

The likelihood of CVD risk factor clustering at 18-19y (Year 10) was explored with logistic regression. The accumulated sports participation score was used as the independent variable in this analysis. Clustering was defined as having an unfavorable level on three or more of six CVD risk factors (BP [high systolic, diastolic or both], TG, TC, HDL-C, LDL-C, glucose). Because girls were at least 18 years old, adult cutpoints were used to define risk. Table 3.6 shows the risk factor levels.

All analyses were conducted using SAS Version 9.1 (Cary, NC). The Bonferroni adjustment option was used to control for multiple comparisons, and significance level was set at $p < 0.05$.

Results

A total of 1213 Black and 1166 White girls participated in NGHS. Their average age was 10.0 years at baseline and 19.1 years at Year 10. Participant characteristics are reported in Table 3.1. At baseline, 83% of Black girls and 88% of White girls participated in some organized activity. When the girls were 11-12y was the only time that the organized PA participation was similar in the two race groups. At all other times, White girls were more likely to be in the higher categories of organized PA. By the time the girls were 15-16y, there was a large proportion reporting no organized activity (Table 3.2).

Table 3.1

Participant Characteristics by Race

	Black				White				Racial difference (p-value)
Total sample size	N=1213				N=1166				
Maturational stage (%)	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	
Year 1 (9-10y)	35.7	60	4.3	0.1	67.6	31.6	0.8	0	< 0.0001
Year 3 (11-12y)	0.8	53.9	38.8	6.5	5.9	70.0	22.5	1.6	< 0.0001
Year 5 (13-14y)	0	5.3	43.6	51.1	0.3	17.0	54.2	28.4	< 0.0001
Year 7 (15-16y)	0	0	5.6	94.5	0	0.5	14.7	84.9	< 0.0001
Age at menarche (mean ± SD)	12.1 ± 1.2				12.6 ± 1.2				< 0.0001
Annual household income (%)									< 0.0001
< $10,000	27.9				7.8				
$10,000 – 19,999	19.2				9.5				
$20,000 – 39,999	29.5				32.4				
≥ $40,000	23.4				50.3				
Body fat (%; mean (SE))									
Year 1 (9-10y)	20.50 (0.31)				18.75 (0.27)				< 0.0001
Year 3 (11-12y)	22.22 (0.31)				19.49 (0.27)				< 0.0001
Year 5 (13-14y)	27.85 (0.28)				23.40 (0.26)				< 0.0001
Year 7 (15-16y)	30.93 (0.26)				26.69 (0.22)				< 0.0001
Year 10 (18-19y)	34.46 (0.29)				29.77 (0.26)				< 0.0001

Maturational stages: 1=Prepubertal, 2=Pubertal, 3=Postmenarchal, 4=2+years postmenarchal

Table 3.2

Organized Physical Activity Participation Categorized by MET times/week by Study Year and Race

		Black					White				Racial difference (p-value)
MET times/week		**0**	**<4**	**4-19.99**	**≥20**		**0**	**<4**	**4-19.99**	**≥20**	
	N	%				N	%				
Year 1 9-10 y	1152	17.2	16.1	47.5	19.3	1135	12.3	10.0	50.3	27.4	< 0.0001
Year 3 11-12 y	1133	9.1	18.5	49.6	22.8	1053	8.5	14.9	52.7	23.9	0.12
Year 5 13-14 y	1054	16.2	21.1	46.2	16.5	958	13.5	14.8	51.8	19.9	0.0002
Year 7 15-16 y	1006	58.2	8.0	27.3	6.6	904	35.0	12.1	36.8	16.2	< 0.0001
Year 8 16-17 y	1024	62.4	8.4	23.5	5.7	950	46.1	10.6	34.2	9.2	< 0.0001
Year 10 18-19 y	1046	72.5	6.8	16.9	3.8	991	52.6	9.9	30.4	7.2	< 0.0001

Change over time in cardiovascular disease risk factors. Table 3.3 shows the final mixed models and their respective p-values for each CVD risk factor. Each of the models had significant time point effects ($p < 0.0001$), and body fat was consistently related to all other outcomes ($p < 0.0001$). The main effect of sports participation was only significant for the change in body fat over time ($p < 0.0001$).

Table 3.3

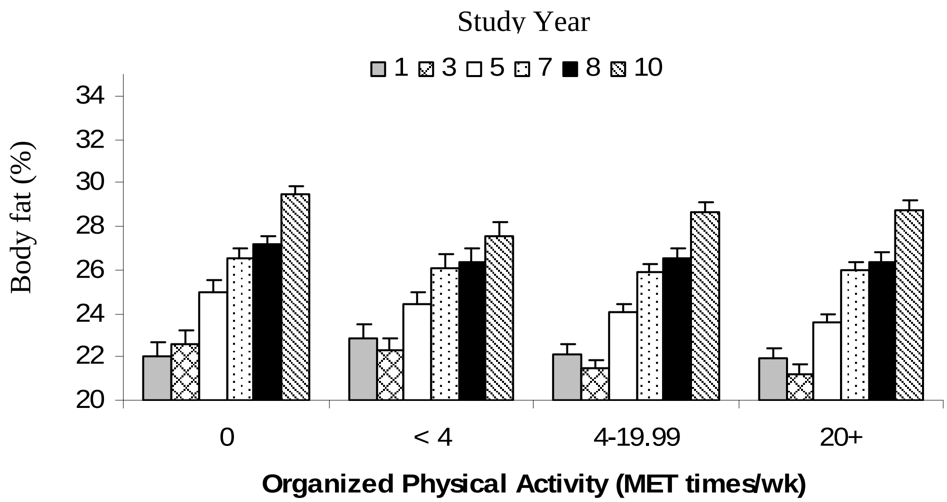
Factors Associated with Trend in Cardiovascular Disease Risk Factors

	Insulin	**Glucose**	**TG**	**TC**	**HDL-C**	**LDL-C**	**SBP**	**DBP**	**Body fat**
Variable					**p-values**				
SP	0.30	0.57	0.11	0.88	0.09	0.94	0.53	0.99	< **0.0001**
Time point	< **0.0001**	< **0.0001**	< **0.0001**	< **0.0001**	< **0.0001**	< **0.0001**	< **0.0001**	< **0.0001**	< **0.0001**
Race	**0.0001**	0.59	< **0.0001**	0.94	< **0.0001**	0.98	**0.0004**	**0.04**	< **0.0001**
Age	0.83	0.84	**--**	**--**	**--**	**--**	**--**	**--**	**--**
Maturation	--	--	**0.0002**	< **0.0001**	0.37	< **0.0001**	< **0.0001**	< **0.0001**	< **0.0001**
Income	0.12	0.88	0.32	0.30	0.67	0.14	0.40	0.55	**0.0001**
Body fat	< **0.0001**	< **0.0001**	< **0.0001**	< **0.0001**	< **0.0001**	< **0.0001**	< **0.0001**	< **0.0001**	--
SP*time	0.89	0.94	0.84	0.12	0.74	0.05	0.40	0.68	0.70
SP*race	**0.04**	0.19	0.49	0.65	0.94	0.99	0.51	0.15	0.16
SP*time*race	--	--	**0.002**	--	0.14	--	**0.009**	**0.003**	< **0.0001**

Abbreviations
SP: Sports participation, TG: Triglycerides, TC: Total cholesterol, HDL-C: High-density lipoprotein cholesterol, LDL-C: Low-density lipoprotein cholesterol, SBP: Systolic blood pressure, DBP: Diastolic blood pressure

As seen in Figure 3.1, body fat increased for all sports participation groups and both races over time ($p < 0.0001$). However, a three-way interaction between sports participation, race and time point ($p < 0.0001$) indicated that the relationship between sports participation and body fat over time was different for Black and White girls. When the association between sports participation and body fat was examined by race, the interaction between sports participation and time was not significant for Black ($p=0.56$) or White ($p=0.69$) girls, however, the main effects of sports participation and time remained significant for both. Overall, the Black girls who were the most involved ($\geq$20 MET times/wk) in sports had a lower body fat percentage than Black non-participants ($p=0.002$), and there was a tendency for them to be lower than those with moderate (4-19.99 MET times/wk) and low ($<$ 4 MET times/wk) participation as well (unadjusted $p \leq 0.03$). For White girls, non-participants had significantly higher body fat than those with moderate sports participation ($p=0.006$), and the difference between non-participants and those most involved in sports approached statistical significance (unadjusted $p=0.01$).

a. White



b. Black

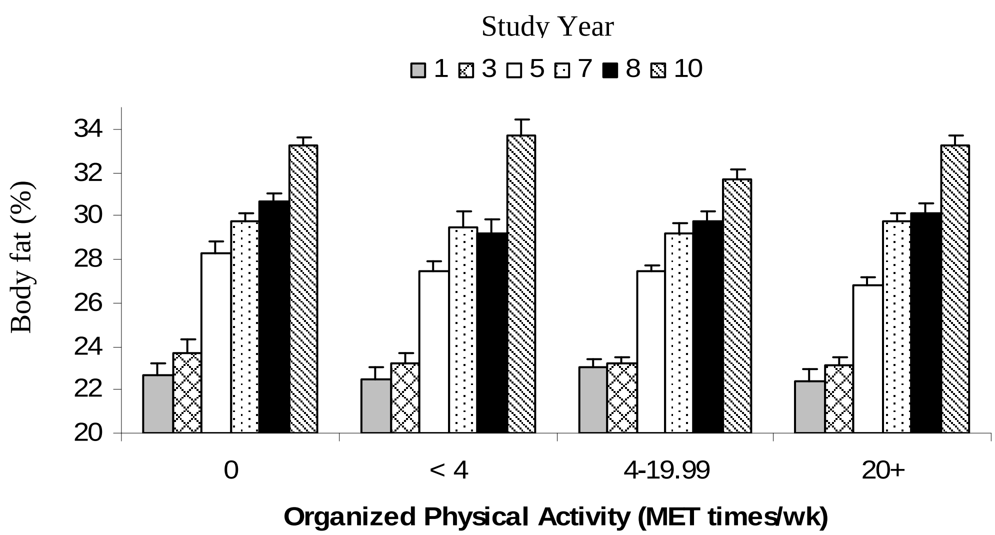
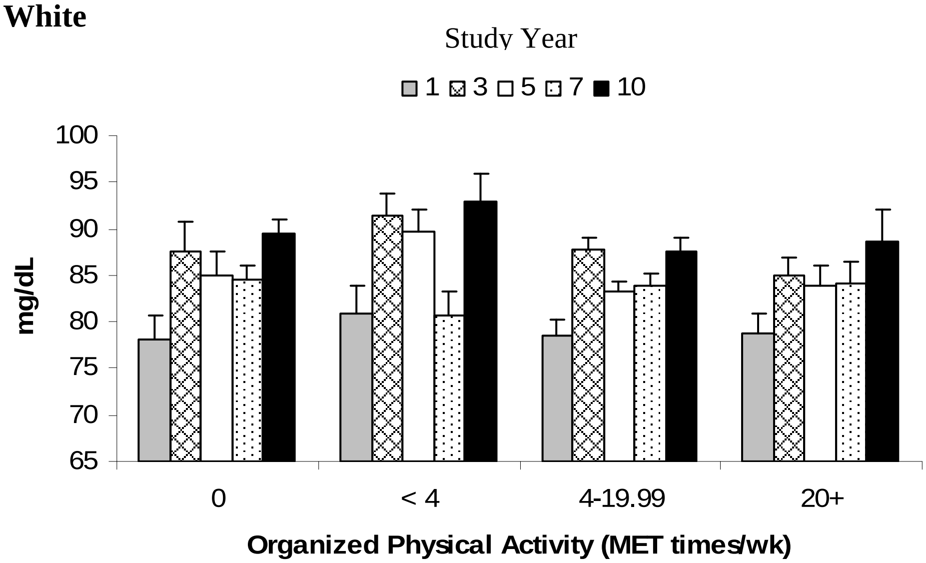


Figure 3.1. Time trend in body fat by race and organized physical activity

The three-way interaction between sports participation, race, and time point was also significant for TG, SBP, and DBP. When the association between sports participation and TG was examined by race (Figure 3.2), neither the main effect of sports participation nor the interaction between sports participation and time were significant for Black or White girls, and the main effects of time remained significant for both. For Black girls, the increase in TG between 9-10y and 11-12y approached significance (unadjusted p=0.01), and there was a significant decrease between 11-12y and 13-14y (p=0.03). For White girls, there was a significant increase in TG between baseline and 11-12y (p < 0.0001) and again between 15-16y and 18-19y (p=0.003). Black girls consistently had lower TG levels than White girls (p < 0.0001).

a. White



b. Black

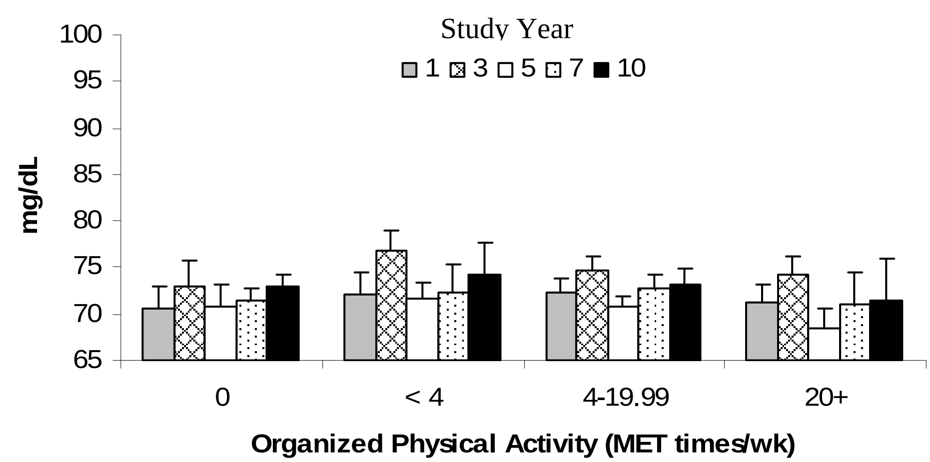
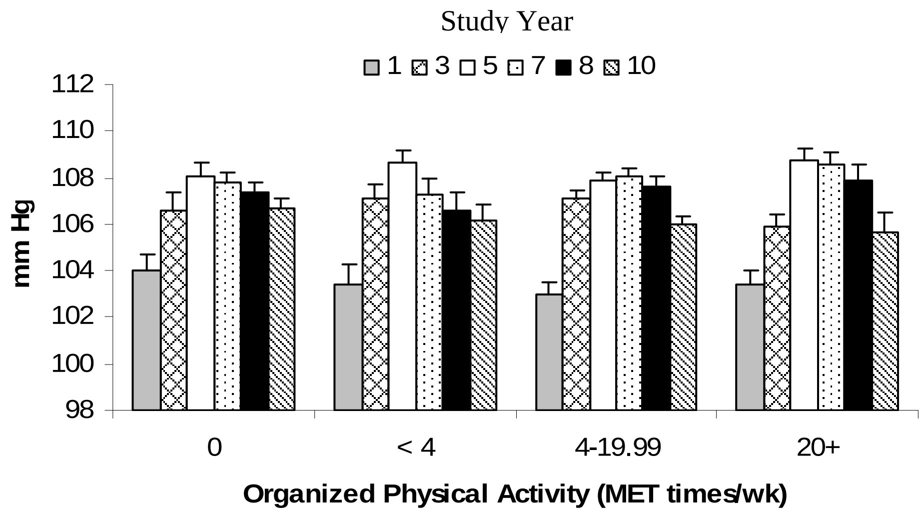


Figure 3.2. Time trend in triglyceride level by race and organized physical activity

Similarly, for both BP values, sports participation alone and the interaction of sports participation with time were not significant for either race. The pattern of change over time was different by race. For SBP (Figure 3.3), Black girls increased between baseline and 11-12y, thereafter maintaining. The White girls showed a significant increase until 13-14y, followed by a gradual decrease, such that 18-19y was significantly lower than 13-14y ($p < 0.0001$), 15-16y ($p < 0.0001$), and 16-17y ($p = 0.007$), yet still higher than baseline ($p=0.02$).

Figure 3.4 show the trends for DBP. The Black girls' DBP increased significantly between baseline and 11-12y ($p < 0.0001$) and again between 13-14y and 15-16y ($p < 0.0001$). For White girls, DBP increase significantly between time points from baseline until 15-16y ($p \leq 0.001$), then decreased between 15-16y and 16-17y ($p < 0.0001$).

a. White



b. Black

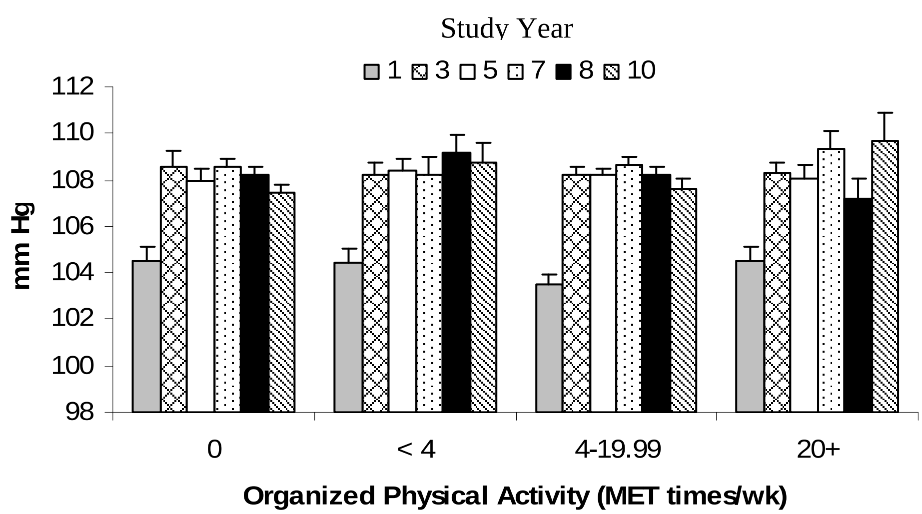
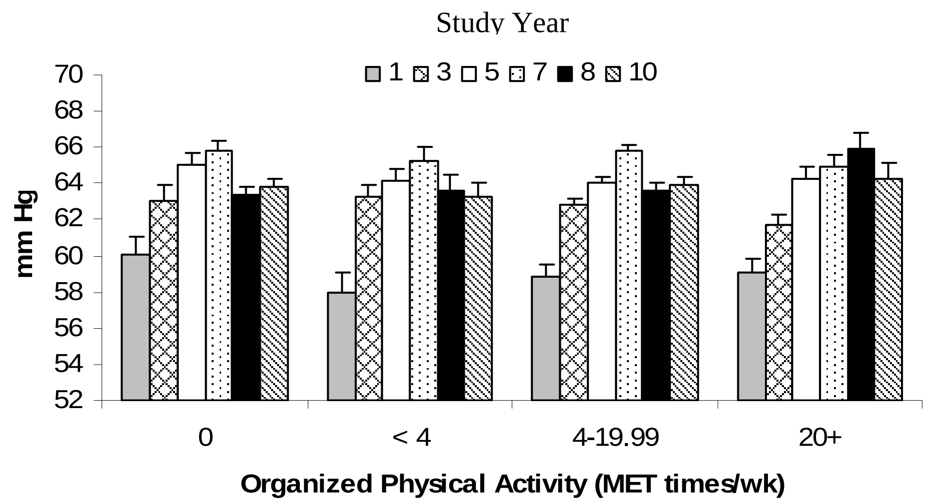


Figure 3.3. Time trend in systolic blood pressure by race and organized physical activity

a. White



b. Black

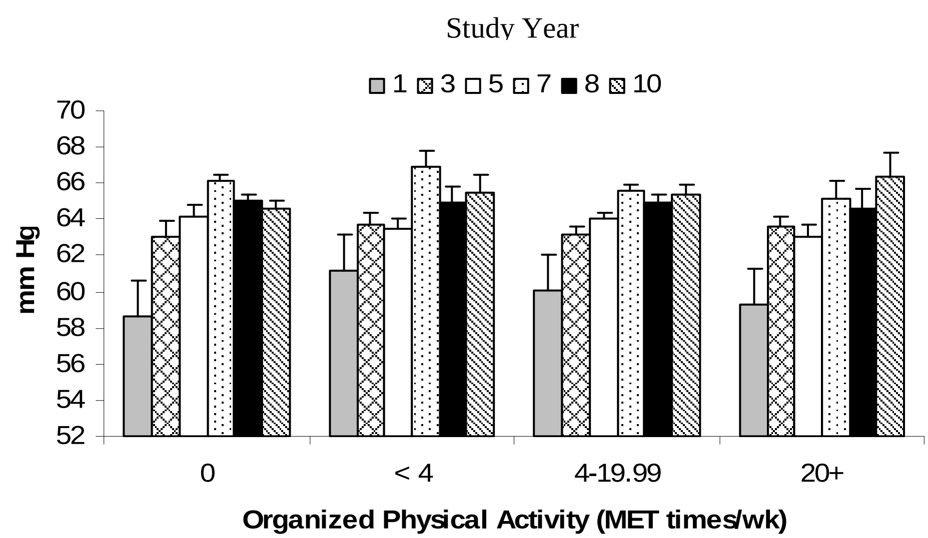


Figure 3.4. Time trend in diastolic blood pressure by race and organized physical activity

There was a significant two-way interaction between sports participation and race for insulin (Figure 3.5). When examined by race, Black non-participants had significantly higher fasting insulin than White non-participants as well as the White girls who participated in 4-19.99 MET times/wk and at least 20 MET times/wk of organized activity ($p < 0.02$).

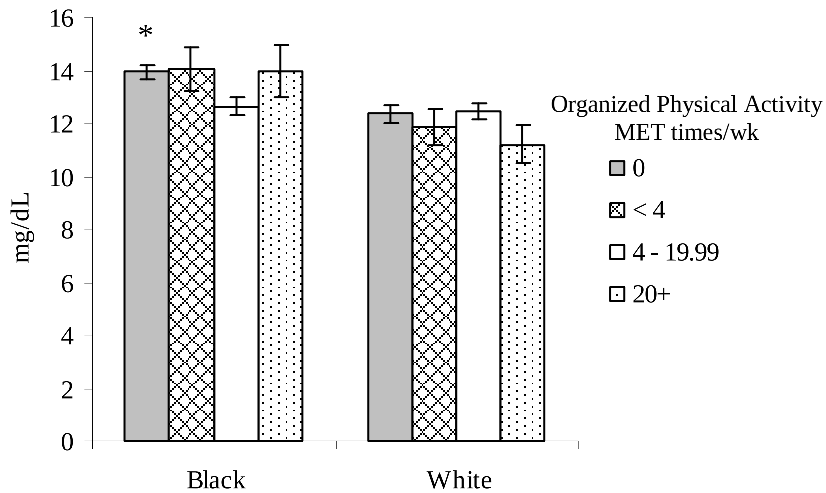


Figure 3.5. Insulin level by race and organized physical activity

* Significantly higher than White girls in 0, 4-19.99, and 20+ groups

Accumulated organized physical activity. Girls who had complete HAQ data for Years 1, 3, 5, and 7 (n=1670) were included in an analysis of the association between years of accumulated sports participation and outcomes at 18-19y. Baseline organized activity volume, body fat, BP, and lipids, and 18-19y body fat were similar for those with and without complete data. Missing data were more common in White and lower income participants ($p \leq 0.01$). As previously mentioned, for each of the four years, girls were categorized as participants if they had at least 4 MET times/wk of organized PA. As shown in Table 3.4, the distribution across these categories was different for Black and White girls ($\chi 2 = 95.02$, $p < 0.0001$). Although similar proportions of girls never participated (~4%), a larger proportion of White than Black girls were sports participants at all four time points (33.8 vs. 15.5%).

Table 3.4

Years of Accumulated Sports Participation by Race

	Black	White
	N=879	N=791
Years of participation*[a]	**%**	**%**
0	4.4	4.1
1	16.4	10.9
2	32.3	19.1
3	31.4	32.2
4	15.5	33.8

*Distribution significantly different between races ($p < 0.0001$)

[a] Girls were categorized as a sports participant if they had an average of at least 4 MET times/wk

As seen in Figure 3.6, those girls who reported organized PA participation at all four time points had lower body fat at 18-19y than girls who never reported any participation ($p = 0.038$). Accumulated sports participation groups did not differ on insulin, glucose, TG, TC, HDL-C, LDL-C, SBP or DBP at 18-19y ($F < 2.4$, $p \geq 0.05$; Table 3.5).

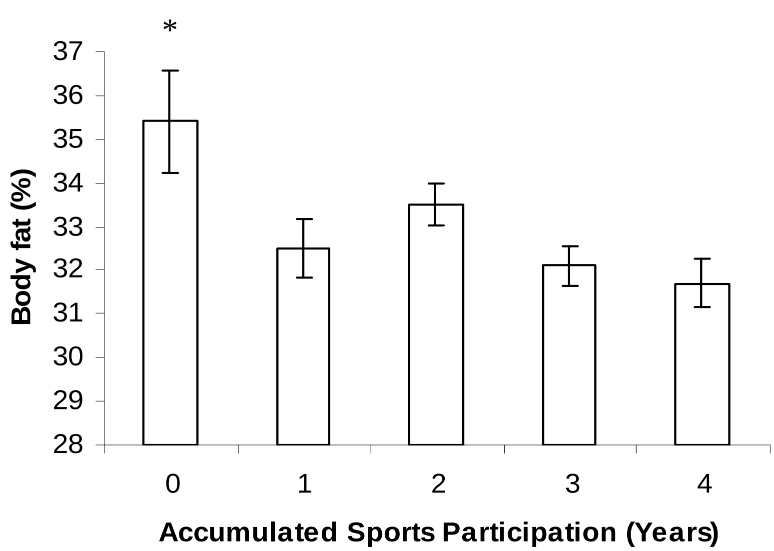


Figure 3.6. Body fat at 18-19y by accumulated sports participation

* Significantly different than 4 years (p=0.038)

Table 3.5

Cardiovascular Disease Risk Factor Outcomes at 18-19y by Accumulated Sports Participation

	Insulin	**Glucose**	**TG**	**TC**	**HDL-C**	**LDL-C**	**SBP**	**DBP**
			mg/dL				mmHg	
Sports participation [a] (years)								
Overall	11.0 (8.8)	87.7 (13.8)	81.3 (31.0)	164.5 (24.3)	53.7 (9.0)	98.3 (22.3)	108.6 (8.6)	65.7 (8.6)
0	14.4 (16.6)	87.2 (6.7)	86.1 (49.1)	171.3 (37.4)	53.7 (12.8)	104.4 (30.3)	110 (9.5)	66 (10.7)
1	12.0 (9.0)	86.5 (7.4)	80.4 (45.7)	165.7 (31.4)	55.7 (12.6)	97.4 (28.2)	109 (9.3)	66 (9.4)
2	12.5 (12.2)	90.2 (27.1)	78.7 (39.9)	166.0 (31.4)	54.0 (11.9)	99.9 (29.5)	109 (9.7)	66 (8.9)
3	9.9 (7.6)	86.5 (12.0)	80.4 (40.2)	164.0 (31.0)	53.7 (12.2)	97.9 (28.3)	109 (9.0)	66 (8.7)
4	9.2 (8.2)	87.2 (23.2)	86.1 (39.7)	167.6 (33.5)	53.5 (11.3)	100.8 (31.4)	108 (8.5)	66 (9.1)

Data are presented as Mean (SD)
[a] Girls were categorized as a sports participant if they had an average of at least 4 MET times/wk

Abbreviations
TG: Triglycerides, TC: Total cholesterol, HDL-C: High-density lipoprotein cholesterol, LDL-C: Low-density lipoprotein cholesterol, SBP: Systolic blood pressure, DBP: Diastolic blood pressure

The prevalence of the CVD risk cluster factors at 18-19y ranged from 4.5% with high fasting glucose to 25% with low HDL-C (Table 3.6). Over half of the girls did not display any of these risk factors at their final follow up, and 105 (6.3%) were defined "at risk" with three or more unfavorable factors. The distribution of those at risk and not at risk across years of accumulated sports participation can be seen in Table 3.7. There was no significant difference in the distribution by sports participation ($\chi 2=4.02$, $p=0.4$). Additionally, years of accumulated sports participation was not found to significantly contribute to the odds of being at risk (OR=1.05, 95% CI=0.87-1.27, p=0.59).

Table 3.6

Cardiovascular Disease Risk Factor Prevalence

Factor	**Cutpoint**	**Percent at risk**[d]
Systolic blood pressure [a]	> 120 mmHg	9.3
Diastolic blood pressure [a]	> 80 mmHg	4.6
Total cholesterol [b]	> 200 mg/dL	8.4
HDL cholesterol [b]	< 50 mg/dL	25.0
LDL cholesterol [b]	> 130 mg/dL	9.1
Triglycerides [b]	≥ 130 mg/dL	6.9
Fasting glucose [c]	≥ 100 mg/dL	4.5

[a] Hsia et al. (2007)
[b] Thompson et al. (2007)
[c] American Diabetes Association (2007)
[d] N=1670 with complete sports participation data

Table 3.7

Clustered Risk by Years of Accumulated Sports Participation

Sports participation [a] **(years)**	**< 3 risk factors** N (%)	**≥ 3 risk factors** N (%)
Overall [b]	1565 (93.7)	105 (6.3)
0	66 (4.2)	5 (4.8)
1	222 (14.2)	8 (7.6)
2	403 (25.8)	32 (30.5)
3	497 (31.8)	34 (32.4)
4	377 (24.1)	26 (24.8)

[a] Girls were categorized as a sports participant if they had an average of at least 4 MET times/wk
[b]N=1670 with complete sports participation data

Discussion

Previous work with this cohort has shown a steep decline in PA throughout adolescence accompanied by increased body fat, and has established an association between the two (Kimm et al., 2005). The current study was designed to examine the association between organized PA participation and body fat and other CVD risk factors. The main finding of this study was that organized PA was related to the development of body fat such that regular participants did not reach body fat levels as high as their non-participating counterparts. The association was expressed differently in Black and White girls. As seen in Figure 3.1, for White girls, the non-participants were different than the other groups, while in Black girls, the most involved participants were the group with the most differentiation from the others and the non-participants were separated from the two intermediate groups to a lesser extent.

Although a cross-sectional relationship between sports participation and weight status has been indicated (Ara et al., 2007; Ara et al., 2004; Boreham et al., 1997; Dowda et al., 2001; Kawabe et al., 2000; Ribeyre et al., 2000; Sirard et al., 2008), longitudinal studies are less common, particularly those comparing levels of sports participation. A three-year study of prepubertal boys (Tanner stage 1-2 at baseline) found that total body fat mass increased less in sport participants than non-participants, and at the end of the period, total body fat tended to be lower in the sport participants than the non-participants (Ara et al., 2006). Sports participation is recognized as a positive influence on total PA (Harrison & Narayan, 2003; Katzmarzyk & Malina, 1998; Pfeiffer et al., 2006; Ribeyre et al., 2000) and can potentially provide a significant number of bouts of moderate-to-vigorous PA. Longitudinal studies have suggested total PA as an important factor in slowing obesity development (Gordon-Larsen, Adair, Nelson, & Popkin, 2004; Kettaneh et al., 2005; McMurray, Harrell, Creighton, Wang, & Bangdiwala, 2008; Menschik, Ahmed, Alexander, & Blum, 2008; Stevens et al., 2004; Twisk, Kemper, van Mechelen, Post, & van Lenthe, 1998).

This study indicated that organized PA in early adolescence had a significant association with body fat at 18-19y. Girls who never reported participation in organized activity by 15-16y had the highest body fat at 18-19y. Although other participation groups (1, 3 years) tended to have lower body fat than non-participants, the difference was only significant for four-year participants. It is possible that girls who participated in organized PA maintained a more active lifestyle. While correlations tend to be low to moderate, several studies, primarily in the United Kingdom and Scandinavia, have shown a positive association between past sports participation and continuing PA such that those adolescents who participate in sports are more likely to continue to be physically active in later adolescence and adulthood than those who do not participate in sports (Aarnio, Winter, Peltonen, Kujala & Kaprio, 2002; Aaron, Stroti, Robertson, Kriska, & LaPorte, 2002; Alfano, Kleges, Murray, Beech, & McClanahan, 2002; Dovey, Reeder, & Chalmers, 1998; Kjonniksen, Anderssen, & Wold, 2009; Kjonniksen, Torsheim, & Wold, 2008; Pfeiffer et al., 2006; Richards, Williams, Poulton, & Reeder, 2007; Tammelin, Nayha, Hills, & Jarvelin, 2003; Tammelin, Nayha, Laitinen, Rintamaki, & Jarvelin, 2003; Telama, Laakso, & Yang, 1994; Telama, Leskinen, & Yang, 1996; Telama, Yang, Hirvensalo, & Raitakari, 2006; Telama, Yang, Laakso, & Viikari, 1997; van Mechelen, Twisk, Post, Snel, & Kemper, 2000). If early participants are more likely to be consistently and currently active, a decreased risk of becoming overweight would be expected. This was the finding in a study of young adult (18-39 years) Black and White women in which their history of sports participation in adolescence was related to their current BMI as well as total and sport activity level (Alfano et al., 2002).

The CVD risk factor levels in this cohort have been reported elsewhere (Morrison et al., 2005; Morrison, Sprecher, Barton, Waclawiw, & Daniels, 1999; Thompson et al., 2007). Risk factor prevalence increased over time for both Black and White girls, with the exception of TG for Black girls (Morrison et al., 2005). Examining the changes by sports participation status over time did not add meaningful information. Previous reports have indicated a strong influence of overweight status on SBP, DBP, HDL-C, and TG (Morrison et al., 2005; Thompson et al., 2007). In the current analyses, body fat percentage was a significant covariate in all models, and race and maturation were significant for several risk factors (Table 3.3). With these associations accounted for, sports participation had little to no influence. There were interactions between sports participation, race, and time for TG, SBP, and DBP, however, when the variables were examined by race, it was determined that the most meaningful differences were from race effects. Clustered risk at 18-19y was also not associated with previous sports participation.

Observational studies such as the Young Hearts Project (Boreham et al., 1997), the Bogalusa Heart Study (Myers et al., 1996), Danish Youth and Sport Study (Andersen et al., 2004; Brage et al., 2004), the Québec Family Study (Katzmarzyk, Malina, & Bouchard, 1999), and the European Youth Heart Study (Ekelund et al., 2009; Ekelund et al., 2007) have found associations between PA and CVD risk factors in youth. However, correlations are generally weak for individual risk factors and significant findings vary across studies. Relationships are more apparent at the extremes and for boys (Eisenmann, 2004). Stronger associations have also been reported when clustered risk or metabolic syndrome was assessed (Steele, Brage, Corder, Wareham, & Ekelund, 2008). Since these associations have been difficult to establish in girls, and our sample had low prevalence of high risk factor levels and used a sub-component of a self-report PA instrument, the limited findings of the longitudinal analyses are not completely unexpected.

Previous studies isolating sports participation in relation to CVD risk are scarce, and it is difficult to compare results because of differences in study design. In general, there is no clear indication of a relationship between girls' overall sports participation and BP or lipids, and relationships with insulin and glucose have yet to be reported. In the Young Hearts Project (Northern Ireland), sports participation was associated with fitness in 12- and 15-year-old girls; however, both sports participation and PA were unrelated to any biological CVD risk factor at either age (Boreham et al., 1997). Like the sports participants in our study, a sample of trained runners (girls and boys) demonstrated lipid development similar to the general population (Eisenmann, Womack, Reeves, Pivarnik, & Malina, 2001). The athletes were only superior to the general population in their HDL-C levels; however, this difference no longer remained after early adolescence.

Measurement of sports participation is a possible cause for the lack of relationship between and CVD risk factors. For example, in the European Youth Heart Study, even though objectively measured PA was associated with clustered metabolic risk, self-reported sports participation was not (Ekelund et al., 2009). Self-report questionnaires are often used to assess participation, and questions tend to be limited in information gathered. Most commonly, intensity information is lacking. Assumptions can be made based the sport type (e.g., soccer versus softball); however, there is wide variation between participants due to individual factors such as motivation, athletic position or competitive level. Intensity of PA may play an important role in its relationship with CVD (Craig, Bandini, Lichtenstein, Schaefer, & Dietz, 1996; Steele et al., 2008). For example, in a study of high school males, those who participated in “highly dynamic” exercise (e.g., distance running, basketball, rowing), had healthier profiles, even compared to other athletes (Kawabe et al., 2000). In the current study, organized PA was derived from the HAQ; participants were not asked to provide the duration of their activities, and intensity level was assigned by activity reported. It is possible that girls did not participate for a sufficient amount of time or intensity to significantly impact their CVD risk profile. Alternatively, girls with little organized PA may have been sufficiently active in other pursuits to maintain a healthy profile.

Additionally, prevalence of “at risk” levels of BP, lipids, glucose, and insulin and clustered risk were low. When the girls were 18-19y, prevalence rates were 4.5-9.3% for most risk factors, and 6.3% had clustered risk. Similar rates were reported for individual risk factors in 11-17 year olds in the Bogalusa Heart Study (Freedman, Dietz, Srinivasan, & Berenson, 1999) as well as clustered risk in 9-18 year olds in the Québec Family Study (Katzmarzyk, Tremblay, Perusse, Despres, & Bouchard, 2003). We observed obesity development, but it may take several more years for the impact of low PA to become apparent in other CVD risk factors. Even with low risk factor prevalence, the association between obesity and risk factors has been established in this cohort (Morrison et al., 2005; Morrison et al., 1999; Thompson et al., 2007). Furthermore, the categorization of the independent variable (sports participation) may have weakened the ability to detect a relationship between organized PA and CVD risk factors.

It is important to note that NGHS was conducted from 1987 to 1997. Obesity and diabetes prevalence have both increased in recent years (Eisenmann, 2004). It is possible that prevalence of other CVD risk factors has increased as well. Additionally, as children develop overweight at younger ages, the impact of obesity may be seen in younger populations currently and in the future.

NGHS did not include a measure of cardiovascular fitness, which may have shown a stronger association with risk factors than organized PA. Low cardiorespiratory fitness is associated with elevated CVD risk factors, particularly clustered risk or metabolic syndrome, in children and adolescents (Andersen et al., 2004; Carnethon, et al., 2005; Ekelund et al., 2009; Ekelund et al., 2007; Ondrak, McMurray, Bangdiwala, & Harrell, 2007; Wedderkopp et al., 2003). This association has been found to be independent of body fat (Eisenmann et al., 2005; Eisenmann, Welk, Ihmels, & Dollman, 2007; Eisenmann, Welk, Wickel, & Blair, 2007; Ondrak et al., 2007) and PA (Ekelund et al., 2009; Ekelund et al., 2007; Katzmarzyk et al., 1999).

Sports participation may increase cardiorespiratory fitness. Cross-sectional data of European children generally show that those who are physically active through sports have better fitness performance (Ara et al., 2007; Ara et al., 2004; Boreham et al., 1997) than those who are not active. High school girls who did at least one school sport performed better on the aerobic shuttle run test than girls who did not participate (Beets & Pitetti, 2005). Observational longitudinal studies have also found sports participation to be related to fitness (Ara et al., 2006; Pfeiffer et al., 2007).

Organized PA may then have a very important role in maintaining a healthier body composition and fitness level, thereby contributing to a decreased risk of CVD. These relationships need to be further evaluated in study designs that can better address the sports participation variables, such as frequency, intensity, and duration, as well as fitness and body composition.

Limitations

A few limitations must be considered while interpreting the results of the current study. As previously mentioned, the HAQ did not include duration of activity, and participants were not asked to judge their intensity in activities. Additionally, some assumptions were made in defining organized PA. With regards to classes/lessons, anything active in nature was included while activities such as music or art were not. In the case of "sports and other physical activities" addressed by another section of the HAQ, only activities generally performed with a group, team, or leader were included in the definition of organized PA. Activities such as running or biking were excluded. It is possible that misclassifications were made in both directions (inaccurately including as well as erroneously excluding organized PA); however it is assumed they were minimal.

The HAQ was subject to recall bias, especially in the earlier years when the girls were relatively young. The instrument was designed to minimize the age-related limitations (Kimm et al., 2000), however, the HAQ may have been difficult since children were asked to recall the prior year and estimate how much of the year they were active in each setting. While this was likely an issue, it is expected to be relatively uniform across same-age participants, and age was used as a covariate to minimize the impact.

Girls were allowed to participate in NGHS without consenting to a blood draw. Therefore, there was more missing data for glucose, insulin, and lipids than other variables. Additionally, glucose and insulin were only analyzed at two of the three study sites. In order to minimize the effect of missing data, values were imputed. Finally, glucose and insulin were only available for Years 7 and 10, limiting the timeframe for examination of changes.

For analyses with accumulated sports participation, complete data were available for 70% of the sample. Although this subsample had more Black and higher income girls, PA and CVD variables were similar between those with and without complete data.

Conclusion

In conclusion, sports participation was found to be related to body fat for both Black and White girls, however, participation alone was not associated with healthier insulin, glucose, lipid, or BP. Although the relationships with positive health outcomes were limited in this study, organized PA participation is still a suggested pursuit for adolescent girls. Sports participation can make an important contribution to total PA and may help attenuate body fat gain in adolescence. Both of these factors are pathways for the influence of organized PA on CVD risk. Additionally, consistent sports participation may be of sufficient intensity to increase cardiorespiratory fitness which may also help maintain healthy insulin, glucose, lipid, and BP profiles. The relationships between organized PA, weight status, fitness and cardiovascular risk profiles in adolescent girls are complex, and more exploration of these constructs with American youth is needed.

Chapter 4: Dissertation Discussion

Participation in organized PA lessons and sport teams is very common for American youth. However, the effects of this specific type of PA have been understudied. As we strive to prevent inactivity and obesity, it is important to examine specific activity types that may be valuable tools. Structure, leadership, social support, and skill development are components of organized PA that may lead to substantial benefits for health and behavior. These issues are especially important for adolescent girls who are less likely to meet PA guidelines than younger children or their male peers (Caspersen, Pereira, & Curran, 2000; Eaton et al., 2006; Eaton et al., 2008; Kahn et al., 2008; Nader, Bradley, Houts, McRitchie, & O'Brien, 2008; Pate et al., 2009; U.S. Department of Health and Human Services, 1996; Ward et al., 2006). This dissertation project aimed to increase knowledge about the impact of organized PA on total daily PA, body fat, and CVD risk factors in adolescent girls.

This chapter will highlight the findings, as well as the strengths and limitations of the project and considerations for future research.

Dissertation conclusions

Girls who participate in regular organized physical activity are more active than non-participants. At a given time point throughout adolescence, those girls who did at least 20 MET times/wk of organized activity had the highest PA on their three-day diary. These cross-sectional data established a clear relationship between sports participation status and daily PA, such that the most involved girls were significantly more active than most other girls. This relationship was particularly salient for White girls, where in every year until age 18-19y, the most involved group was more active than each of the other groups (0, <4, 4-19.99 MET times/wk).

Organized physical activity is a significant factor for change in daily physical activity during adolescence; however, the relationship is expressed differently in Black and White girls. Although over the study period, a decline in daily PA was evident for all groups of girls, organized PA participation did have a positive association. Regular and consistent participation appears to offer some protection against the pattern of PA decline, particularly in White girls. The time trend was notably different between Black and White girls; the most involved (≥20 MET times/wk) Black girls declined less than their peers, where as White participants demonstrated better maintenance of PA over time. Additionally, White girls with a moderate level of participation (4-19.99 MET times/wk) were more active over time than girls with little or no participation. For both race groups, girls who reported the most involvement in organized activity accumulated approximately 30 minutes more moderate PA per day than girls who had little or no participation.

The association between organized and daily physical activity is long-lasting. At age 18-19y, girls who had never participated in organized PA were significantly less active than those who had reported participation at least one time between the ages of 9-10y and 15-16y. Only a single year of participation, as early as 9-10y, was necessary to find this difference, therefore, it appears that activity patterns and habits may begin to be established at this young age.

Organized physical activity is a significant factor for change in body fat during adolescence. As had been shown with total habitual PA in this cohort (Kimm et al., 2005), there was a relationship over time between girls' level of organized PA involvement and development of body fat. Organized PA was associated with healthier body fat for both Black and White girls, however, there was an interaction involving race, such that a different participation group emerged as a stand out for Black and White girls. In the Black girls, those who were the most involved in organized PA (≥20 MET times/wk) had a lower body fat than non-participants, and a tendency to have lower fat than those with moderate (4-19.99 MET times/wk) and low (< 4 MET times/wk) participation. This suggests that in this group, it took regular and consistent participation to dampen the development of obesity. However, for White girls, all the participation groups were more similar, and the non-participants stood out as the most at-risk, with the highest body fat percentage.

Consistent participation in organized physical activity has an association with the development of body fat. Girls who reported participation at four time points between 9-10y and 15-16y had lower body fat at 18-19y than girls who never reported organized PA. Although other participation groups (1, 3 years) tended to have lower body fat than non-participants, the difference was only significant for four-year participants. These girls were probably more likely to maintain higher PA levels between 15-16y and 18-19y than girls who did not participate or participated sporadically. This is consistent with others who have found sports participants more likely to continue an active, healthy lifestyle (Aarnio et al., 2002; Aaron et al., 2002; Alfano et al., 2002; Dovey et al., 1998; Kjonniksen et al., 2009; Kjonniksen et al., 2008; Pfeiffer et al., 2006; Richards et al., 2007; Tammelin, Nayha, Hills et al., 2003; Tammelin, Nayha, Laitinen et al., 2003;

Telama et al., 1994; Telama et al., 1996; Telama et al., 2006; Telama et al., 1997; van Mechelen et al., 2000).

Organized activity is not strongly related to single cardiovascular disease risk factors or clustering of risk factors. In this cohort, sports participation was not significantly related to the change over time of CVD risk factors. Additionally, the odds of finding clustered risk at 18-19y was not related to previous organized PA participation. Although many hypothesize that PA in organized settings, particularly sustained over time, would be beneficial, previous work has also noted that relationships are inconsistent and weak for females (Boreham et al., 1997; Eisenmann, 2004). It may take more sophisticated PA measures or a longer timeframe to expose this relationship in females.

Implications for practical application

Girls who do not participate in organized activity are a high risk group for inactivity and obesity. Special attention is needed to promote PA in this group, because they do not appear to be active in other pursuits. In this sample, participation in organized PA as early as 9-10y was associated with more daily PA 10 years later. Girls who reported participation in organized PA at least once by the time they were 15-16y also tended to have lower body fat at 18-19y. This suggests the importance of early exposure to and involvement in sports or other organized PA.

This study also indicated that non-participation in organized PA increases with age in adolescent girls. Those who are becoming non-participants by high school age may do so because of lack of interest, ability, or available programs. For example, if a girl enjoyed playing basketball, but did not have the ability or time to join the high school competitive team, she may not have another opportunity to continue with that activity. These girls need to be exposed to and informed on other activities they can do to maintain PA, as well as provided with opportunities for recreational participation in the activities they enjoy but do not have the competitive ability to continue high-level participation. Additionally, at high school age, girls may be involved in more social or work activities, and feel they have less time for PA. Promotion efforts for PA should include behavior modification techniques. Ideally, an active lifestyle would be a topic covered in high school health, PE, and science curriculums.

Although this study did not examine the effects of PE participation, it is one form of organized PA. These results provide further support for the maintenance of quality PE offerings and requirements throughout the school years. These offerings need to include exposure to non-competitive, lifelong activities in addition to sports skills.

A multi-level approach for increased involvement in organized PA is necessary. At the intrapersonal level, girls need to experience different activities and learn skills to improve their actual and perceived competence for physical activity. The importance and value of positive, skill-building opportunities needs to be understood by teachers, instructors, and parents. Additionally, schools and the community are responsible for providing opportunities for activity that are appropriate for age, skill, and culture, as well as accessible and affordable, interesting, safe, and fun. It is important to note that it cannot be assumed that inactive girls would be interested in sports activities, particularly competitive, even if provided with the opportunity. Therefore, non-competitive activities in which girls have shown interest should be included. For example, in this cohort Double Dutch jump rope and aerobic dance were popular activities.

Intervention research will be necessary to examine the effects of these multi-level changes. Individual factors such as perceived competence, self-efficacy, and value beliefs for PA, social factors such as attitudes, beliefs, and support of family and friends, as well as changes in girls' school and community environments should be assessed and linked to possible changes in PA behavior.

Dissertation strengths and weaknesses

The main strength of this dissertation project was the large, bi-racial sample with an extended follow up period and excellent retention. There was a limited amount of missing data, and it was able to be imputed via mean replacement.

In general, measurement of PA is difficult with self-report measures in young children. Their understanding of time and intensity is limited, and therefore, the PA instruments and available data were limited in this regard as well. Additionally, there was no instrument specifically developed to examine organized PA.

The longitudinal analyses allowed for girls to be changing sports participation categories over time, however, different patterns of participation were not able to be examined. From analyses of accumulated participation, it appears that the "never participants" were the group who are significantly different than others, however, it could be important to detect differences in those who moved in and out of sports and those who were consistently involved.

Due to confidentiality concerns, it is the policy of the NGHS data distribution not to provide study site in the limited access dataset. Therefore, possible regional differences between California, Ohio, and Washington, D.C. could not be controlled for or examined in analyses. This also limited analyses to those that did not require subjects to be "nested" within study site.

NGHS did not include a measure of cardiorespiratory fitness, which may mediate the relationship between organized PA and CVD risk factors. While this study included a measure of volume of organized activity, it is possible that the duration and intensity of activities varied greatly within sports participation categories. Sufficient organized PA may increase cardiorespiratory fitness, and fitness or the combination of PA and fitness may be important for these relationships (Eisenmann, 2004; Steele et al., 2008).

Finally, the age of dataset is an issue to be considered. NGHS was conducted from 1987-1997. We do not expect that relationships between organized PA and health outcomes would be different now, unless the delivery of PA in these programs has changed over time. However, it is possible that the magnitude of these findings could be significantly different in a more recent sample, particularly concerning body fat and CVD risk factors. Childhood obesity and diabetes prevalence have both increased in recent years (Eisenmann, 2004). As children develop overweight at younger ages, the impact of obesity may be seen in younger populations. For example, CVD risk factors may be more prevalent in late adolescence for girls who have been overweight since early childhood compared to those who developed obesity during puberty. Additionally, racial differences found in this sample may have strengthened or weakened.

Suggestions for future research

Continue this research focus in representative American youth. Most importantly, more research concerning the impact of organized PA in American youth is necessary. Outcomes of special focus should include CVD risk factors, in particular those related to metabolic risk such as insulin, glucose, and specific fat patterning. Intervention studies would allow for discussion of cause and effect relationships between organized PA and outcomes. Studies would also be strengthened by longitudinal data collection with children growing up in the present time, with substantial racial representation, and robust methods. The measures for the outcome of body fat can be strengthened by using current, race-specific skinfold equations (Loftin et al., 2007) or DEXA to determine fat patterning. Additionally, instruments addressing this specific component of PA should be used.

Examine how outcomes are related to different long-term participation patterns. Recommendations for organized PA participation would also be strengthened if we could examine the influence of different participation patterns over time. This study showed that one year of participation in late childhood/early adolescence was sufficient to see PA differences several years later. Future questions should address the impact of consistent participation, as well as what happens to girls who participate and then drop out or "age out", and if there is a critical timeframe for participation.

Determine the mediators between sports participation and physical activity. Pathways between sports participation and PA, such as perceived and actual competence, social support, and self-efficacy, should be examined. This would help provide intervention approaches.

Additionally, the "experience" of organized PA needs to be better understood. The factors of a "good" experience that has a positive influence on future PA behavior need to be identified, as negative experiences may actually be a factor leading to a decreased likelihood of continued activity. Factors such as activity type (lesson/class, recreational, competitive, team/individual sport), coach/instructor style, and social environment should be addressed.

Examine the physical activity habits of non-sports participants. In order to really understand the PA habits of non-participants, specific research within this subgroup of children is needed. Questions to be addressed include: What are they doing for PA? Do they really have very low activity levels, or are different PA instruments needed? Are the questionnaires adequate to capture their activities? Is there a group of "active, non-participants" and what is different about them from both inactive, non-participants and sports participants? These topics need to be examined throughout childhood ages as it is possible that different patterns exist at different stages.

Conclusion

In conclusion, this dissertation examined the relationship between organized PA participation and health outcomes such as daily PA, body fat, and CVD risk profile. The results indicate that girls who are never involved in organized PA are at an increased risk for low levels of PA and the development of high body fat levels. Few associations between participation and CVD risk factors were established in this cohort. However, participation was an important factor for daily PA and body fat development in Black and White girls throughout adolescence. Those girls who were most active in lessons and sports were more active and had healthier levels of body fat than other girls. Therefore, it is imperative to provide structured PA opportunities that are accessible and appealing to young girls as one approach to improving their health.

Appendix A. Activities included in definition of organized physical activities

CLASSES/LESSONS		SPORTS	
ACROBATICS	ICE HOCKEY	ACROBATICS	ICE HOCKEY
AEROBICS	ICE SKATING	AEROBICS	ICE SKATING
ARCHERY	JAZZ EXERCISE	BADMINTON	JAZZ EXERCISE
BADMINTON	JUDO	BALLET	JUDO
BALLET	KARATE	BASEBALL	KARATE
BASEBALL	KICKBALL	BASKETBALL	KICKBALL
BASKETBALL	LACROSSE	CHEERLEADING	LACROSSE
BATON	RACQUETBALL	DANCE	ROWING
BOWLING	ROLLERSKATE	*JAZZ*	RUGBY
BOXING	SAILING	*TAP*	SCHOOL SPORT
CANOEING	SKIING (DOWNHILL)	*POINTE*	SOCCER
CHEERLEADING	SOCCER	DIVING	SOFTBALL
CIRCLE GAMES	SOFTBALL	DOUBLE DUTCH JUMP ROPE	SWIM TEAM
DANCE	SQUASH	FENCING	SYNCHRONIZED SWIMMING
JAZZ	SWIMMING	FIELD HOCKEY	TEE BALL
TAP	SWIM TEAM	FLAG FOOTBALL	TENNIS
DIVING	TENNIS	FOOTBALL	TRACK
DOUBLE DUTCH JUMP ROPE	TRACK	GOLF	VOLLEYBALL
EXERCISE	VOLLEYBALL	GYMNASTICS	WRESTLING
FIELD HOCKEY	WATERSKIING	HANDBALL	
FOOTBALL	WEIGHT LIFTING	HORSEBACK	
GOLF	UNICYCLE		
GYMNASTICS			
HANDBALL			
HIKING			
HORSEBACK			

Appendix B. Decisions made regarding methods

Inclusions and exclusions in classes and lessons category

The Habitual Activity Questionnaire (HAQ) addressed classes and lessons with the following questions: *When you are not in school, do you take any classes or lessons such as dance, gymnastics, or swimming (during the school year or during the summer)? If yes, What are these classes or lessons that are taught by an instructor outside of school or during the summer?* Because the questionnaire specifically addressed supervised classes and lessons, anything active in nature was included. Activities included team sports and games as well as competitive, recreational, or fitness-related individual activities. When a sedentary activity, such as board games or homework, was given as a response, it was not included in the calculation of organized PA. A complete list of included activities is in Appendix A.

Inclusions and exclusions in sports category

The HAQ addressed sport activities with the following questions: *During the summer, what sports or physical activities (other than classes or lessons) do you do? During the school year, what sports or other physical activities (other than classes or lessons) do you do? This includes activities before school, after school, and on weekends.* As this question addressed all physical activity outside of classes or lessons, and the primary interest of the study was activities performed in an organized setting, several reported activities were excluded. Activities typically done without instruction or leadership for fitness or recreational purposes were excluded. These activities included playing, walking, jogging, hiking, and biking. Some activities that could be either organized or recreational in nature had different codes, and those were used to include or exclude the activity. For example, swimming and swim team responses were differentiated, therefore, swimming was excluded and swim team was included. Similarly, while running was excluded, track was included. Team sports activities were always included with the assumption that in this age group, they would almost always be organized in nature. Other activities that typically require access to a facility, and likely an instructor, such as judo, gymnastics, horseback riding, and fencing were included. There was a group of activities that were borderline in definition (badminton, golf, rowing, wrestling); these activities were examined for frequency of participation, and it was determined that few girls reported these activities. Therefore, they were included, as they were possibly performed in an organized setting, and due to the small numbers, would not have a large impact on the results if this was an incorrect assumption. A complete list of included activities is in Appendix A.

Categorization of sports participants (0, < 4, 4-19.99, ≥20 MET times/wk)

The independent variable in the study was categorized to describe between-group differences by level of sports participation. Bases on prior research, it was known that those who reported no organized PA would be one defined group (non-participants; 0 MET times/wk). The distribution of organized PA was examined with tertile, quartile, and quintile breakdowns. One issue with these breakdowns is that they changed from year to year. Additionally, the cutpoints didn't necessarily have a meaningful translation. This measure had been previously defined with 10 MET times/wk as the equivalent of moderate activity for 30 minutes, 2.5 times/wk and 20 MET times/wk being five 30-minute sessions of moderate activity (Kimm et al., 2005). I also looked at what weekly participation in one activity would look like in terms of MET times/wk, and found that a participation in one hour of a moderate intensity activity (e.g., ballet or gymnastics) per week consistently over the year would be 4 MET times/wk. Therefore, the cutpoint of 4 MET times/wk was chosen to denote girls who did less than this equivalent. Additionally, I wanted to group the girls who met the standard of 20 MET times/wk. This resulted in the intermediate group of girls who had 4-19.99 MET times/wk.

Accumulated sports participation

There were two issues of note in determining accumulated sports participation. The first was the decision not to impute organized PA values, thereby limiting analyses with this variable to a subsample with complete data, and the second was the cutpoint used to denote participants versus non-participants. Each year, the mean volume of organized PA would have categorized all girls with missing data in the third group (4-19.99 MET times/wk). Doing this would have inflated this group, rather than "smooth out" the data as when mean imputation is used with continuous variables. Additionally, the mean level of organized PA misrepresents this sample because the data were significantly skewed, particularly in later study years. For example, by age 15-16y, the median total PA from the HAQ was 0 MET times/wk for Black girls (Kimm et al., 2002). Therefore, only girls with complete HAQ data for Years 1, 3, 5, and 7 (n=1670; 70%) were included in analyses using this variable.

I started looking at this variable by defining girls who reported 0 MET times/wk of organized PA as non-participants. However, this breakdown resulted in only 8 (0.48%) girls who never participated in the four years of interest. Because previous analyses had suggested that girls with less than 4 MET times/wk had similar activity levels to non-participants, I decided to define non-participation as less than 4 MET times/wk.

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