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Physical Activity Measures in the Healthy Communities Study

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Abstract

The risk of obesity is reduced when youth engage in recommended levels of physical activity (PA). For that reason, public health organizations in the U.S. have encouraged communities to implement programs and policies designed to increase PA in youth, and many communities have taken on that challenge. However, the long-term effects of those programs and policies on obesity are largely unknown. The Healthy Communities Study (HCS) is a large-scale observational study of U.S. communities that is examining the characteristics of programs and policies designed to promote healthy behaviors (e.g., increase PA and improve diet) and determining their association with obesity-related outcomes. The purpose of this paper is to describe the methods used to measure PA in children and the personal and community factors that may influence it. The study used both self-reported and objective measures of PA, and measured personal, family, and home influences on PA via three constructs: (1) PA self-schema; (2) parental support; and (3) parental rules regarding PA. Neighborhood and community factors related to PA were assessed using three measures: (1) child perceptions of the neighborhood environment; (2) availability of PA equipment; and (3) attributes of the child's street segment via direct observation. School influences on children's PA were assessed via three constructs: (1) school PA policies; (2) child perceptions of the school PA environment; and (3) school outdoor PA environment. These measures will enable examination of the associations between characteristics of community PA programs and policies and obesity-related outcomes in children and youth.

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Introduction

Physical activity (PA) has long been recognized as a critical health behavior in children. In the late 19th century, medical and education professionals acknowledged its importance by advocating for physical education (PE) programs in American schools.¹ In the mid-20th century, the significance of youth PA was highlighted by President Eisenhower, who founded the President's Council on Physical Fitness.² And in the 21st century, the importance of PA to the health of American youth was formally recognized in the first federally approved Physical Activity Guidelines for Americans (PAG).³ These include a specific recommendation that youth engage in moderate-to-vigorous PA for at least 60 minutes per day.³ A federal advisory committee's review of the scientific literature on PA and health in children and youth served as the basis for the PAG recommendation.⁴

The advisory committee recognized that a reduced risk of overweight and obesity is a key health benefit of higher levels of PA. A recent review reinforced this conclusion, finding that PA was one of the few factors consistently associated with preventing excessive weight gain in prospective observational studies of youth.⁵ Such reports, along with the well-documented impact of PA on energy expenditure,⁶ have prompted researchers and health organizations to recommend increasing PA as a key strategy in efforts to reduce the prevalence of overweight and obesity in young people. These groups have consistently emphasized the importance of community programs and policies (CPPs) aimed at increasing PA in youth.⁷⁻⁹

Although promoting PA through implementing targeted CPPs is a widely accepted strategy for reducing childhood obesity, the scientific evidence supporting the effectiveness of this approach is limited. The recent PAG Mid-Course Report reviewed a wide range of interventions to promote PA in youth and concluded that only school-based strategies have consistently increased children's PA.¹⁰ The report also noted that the long-term effects of such programs on weight status in youth are largely undocumented.¹⁰ Accordingly, the design and protocol for the Healthy Communities Study (HCS) places a major emphasis on PA programs and policies. The purpose of this article is to describe the methods used to measure PA and related personal and community factors in children.

Methods

Details on study protocols and procedures are included in Arteaga et al.¹¹ and John and colleagues¹² in this issue.

Conceptual Framework for Physical Activity Measures

The HCS is examining the characteristics of CPPs designed to promote healthy behaviors (e.g., increase PA and improve diet) and determining their association with obesity-related outcomes.^{11,12} The PA component of the HCS protocol was designed to measure variables viewed as central to detecting the effects of community-based obesity prevention initiatives that focus on promoting PA in children and adolescents. Figure 1 presents the conceptual framework that guided the selection of the PA measures. A key focus of the protocol was measurement of child- and parent-reported child participation in the types of physical

activities and PA programs that are most often implemented in community-based obesity prevention initiatives. In addition, the protocol included measures of key hypothesized community-level influences on child PA, including school characteristics and relevant neighborhood factors. Further, selected child social–cognitive factors and parental/home variables were measured. The HCS also collected information about community initiatives designed to support PA, using key informant interviews conducted by Community Liaisons (CLs). CLs were selected from existing Battelle staff; additional information about the community measures is described in Fawcett et al.¹³

Measurement Procedures

Child PA measures were completed as part of the HCS household interview (HHI), which was self-administered on tablet computers during home visits. For the child-report sections of the HHI, children aged 9–15 years were the primary respondents, with parents/guardians asked to assist children aged 9–11 years as needed. For children aged 4–8 years, parents/guardians responded to the questions. School PA measures, including the PE teacher interview and Physical Activity Resources Assessment (PARA), were administered by the CLs in and around participating schools. Both existing instruments and instruments developed for this study were included in the PA measures. The study was approved by the Battelle Memorial Institute IRB, and parents provided written informed consent for their child's participation. A description of the human subjects protections is included in John and colleagues.¹²

Self-Report of Physical Activity

Physical activity was measured in the full sample of child participants using self-report of participation in selected forms of PA that are hypothesized to be influenced by or intervened on through CPPs. The 7-day Physical Activity Behavior Recall (PABR-7) instrument is designed to elicit information about participation in 14 activities. These include PE, after-school programs, non-school sports, active classes or lessons, and active transport. Using a computer-assisted interview, children or parents/guardians indicated whether or not the child participated in each activity during the past week, the days on which they did the activity, and the average intensity of the activity (light, moderate, hard, very hard). To help with intensity rating, participants viewed cards with gender- and age-specific pictures depicting sample activities at the various intensities.

After answering questions about the 14 activities, participants then responded to additional items about activities completed on the previous day: the duration of the activity (minutes), the intensity, where they did the activity, with whom they did the activity, and the specific activity that was performed. Where, with whom, and specific activity answers were selected from predefined lists with options most common for the specific activity, with the option of adding an “other” response. Selected PA variables and operational definitions are presented in Table 1. Approximately 10% of families completed an enhanced protocol, which included accelerometry as an objective measure of child PA. These participants also responded to a previous-day PABR (PABR-1) during the second home visit. The PABR-1 matched the PABR-7 in layout and administration except that all questions refer to activities performed on the previous day. The PABR-7 and PABR-1 instruments were designed to meet the

specific needs of the HCS, and the psychometric properties of the instruments have not been established previously.

Self-Report of Sedentary Behavior

The PABR-7 and PABR-1 instruments also included four forms of sedentary behavior. The procedure for reporting sedentary behaviors was similar to that used with the physical activities. Selected sedentary behavior variables and definitions are presented in Table 1.

Objective Measurement of Physical Activity and Sedentary Behavior

Children who completed the enhanced protocol wore an ActiGraph GT3X+ accelerometer for up to 7 days. The accelerometer was attached to a belt and worn around the waist with the monitor over the right hip during all waking hours. The Field Data Collectors (FDCs) asked parents/guardians and children to remove the monitor only when sleeping at night or when it might get wet (swimming, bathing, and showering). Wear during naps and brief exposure to water (sweat or splashes) was acceptable and encouraged.

The accelerometers were initialized to collect triaxial data at an 80-Hz sampling rate beginning at midnight of the day of the first home visit. Accelerometry data will be reduced to daily minutes of light and moderate-to-vigorous intensity PA, as well as daily minutes of sedentary behavior. Operational definitions of PA and sedentary behavior variables are presented in Table 2. Times spent in selected PA intensity categories will be determined by applying the age-specific accelerometry count cut-points used in the National Health and Nutrition Examination Survey (ranges presented in Table 2).¹⁴

Personal, Family, and Home Influences on Youth Physical Activity

Studies have identified significant social cognitive and social environmental correlates of youth PA,¹⁵ which have been used to guide interventions to assist young people to maintain or increase PA.^{15,16} They may also serve as important mediators of the effects of CPPs to promote PA in youth. Important correlates identified in the literature include PA self-schema, parental support for PA, and parental rules related to PA and sedentary behavior.

Physical activity self-schema, self-identification as an active or fit person or one who exercises regularly, was assessed with a single item that asked each child to rate your level of PA compared to others of the same age and gender. Responses were recorded on a 5-point Likert scale with endpoints of *much less than others* to *much more than others*. This item was adapted from the Amherst Health and Activity Study.¹⁷

Parental support for PA was assessed as the weekly frequency with which a member of the child's household provided transportation so the child could participate in PA. This measure was taken from the International Life Sciences Institute national phone survey¹⁸ and the Amherst Health and Activity Study.¹⁷ The 1-week test-retest reliability for this measure has been shown to be high ($r = 0.81$).¹⁹

Items on parental rules were adapted from the Activity Support Scale for Multiple Groups (ACTS-MG).²⁰ The ACTS-MG has been shown to be a valid measure in several racial/ethnic populations.²⁰⁻²² Parents were asked whether their child is allowed to play outside

without adult supervision. Three additional items asked parents if they limited access to sedentary activities (e.g., is the child allowed to play video or computer games as much as he or she would like?). Parental responses were recorded on a 4-point Likert scale ranging from *strongly disagree* to *strongly agree*.

Neighborhood/Community Physical Environment

Numerous studies have demonstrated that attributes of the neighborhood environment (e.g., availability of PA facilities, safety) are correlated with PA in young people, though contrary evidence also exists.^{23–25} To measure children's perceptions of their neighborhood environments, 12 items selected from related studies^{17,26} were included. These items have been shown to have fair to acceptable test–retest reliability.²⁷ All items were measured on a 4-point scale from *disagree a lot* to *agree a lot*. Availability of PA equipment in the home (e.g., basketball hoop, bicycle) also has been shown to positively influence child and adolescent PA.²⁸ Parental reports of availability of equipment in the home and availability of equipment and facilities in the neighborhood were obtained using 11- and 13-item checklists modified from a previous study.²⁹

Attributes of each child's street segment were documented through direct observation using five items from the Neighborhood Attribute Inventory.^{30,31} The items utilized in the HCS (e.g., measures of physical disorder, including the presence of litter) were chosen because they represent constructs important for PA and have acceptable to high reliability.^{32,33} To collect the data, an FDC drove a vehicle down the participant's street segment and documented specific attributes of the street segment.

School Influences on Youth Physical Activity

School PA policies and practices were assessed by questionnaire.³⁴ PE teachers responded to questions about PE and fitness testing practices, recess policies, intramural clubs and sports programs, facilities for PA, and professional development. They also reported on the following school policies and practices:

1. time spent in PE, standards for PE, and physical fitness testing;
2. school recess requirements and the time spent each day in recess;
3. types of physical activities in intramural and interscholastic sports programs;
4. availability of and access to school facilities (e.g., gym, indoor track);
5. access to school PA facilities by local groups (e.g., recreation department); and
6. PA professional development opportunities offered to teachers (e.g., information about monitoring PA, fitness testing, and individual PA plans).

An objective of the study is to evaluate whether perceptions of one's environment impact the association between CPPs and children's PA and obesity-related outcomes. Children spend a great deal of time at school, and the school environment may influence the PA behavior of students. Therefore, children's perceptions of their school's PA environment were assessed using four questions in the self-administered PA component of the child survey, which was

part of the household interview. Using a 4-point Likert scale, respondents rated their level of agreement/disagreement with the following questions:

1. My school has non-sports programs for students to be physically active (step team, dance, walk/run club, etc.).
2. My school has sports teams that you have to try out for.
3. My school has sports teams where everyone can participate (no try-outs).
4. I enjoy PE classes at my school.

Respondents had the option to indicate that the PE classes question was not applicable to them. Enjoyment of PE will be treated as a single item.³⁵ The three school activities/sports items were summed to create a school PA index in which a higher score is indicative of a perceived PA-promoting school environment.

The features and quality of outdoor facilities at schools are important for increasing PA levels during school hours^{36–38} and for increasing use of school grounds outside of school hours.³⁹ To assess the variety and quality of school ground features and amenities and to document evidence of unsociable behaviors (i.e., incivilities), CLs evaluated all outside areas at participating schools using a modified version of the PARA.⁴⁰ Specifically, observers documented:

1. the presence or absence and quality of 11 features (e.g., baseball fields);
2. the presence or absence and quality of 11 amenities (e.g., lighting);
3. the presence or absence of ten incivilities (e.g., evidence of drug use); and
4. facility hours, capacity, and size; cost of facility use; and the presence or absence of signs with rules and hours of operation.

Staff Training and Quality Control

The FDCs were responsible for collecting data during a visit to a participating family's home. They were trained to administer the household interview as part of a weeklong in-person session. The training covered interview skills, use of the study's information management system (IMS) and information on each section of the household interview. FDCs completed practice interviews and were certified on all components prior to data collection. Times to complete the interview components were recorded through the IMS and reviewed weekly by the University of South Carolina (USC) Quality Control (QC) lead. Short and long times to complete were flagged, and the Battelle Survey Operations Center followed up with the FDCs. The USC QC team developed monthly summary tables for all PA variables data and reviewed them for out-of-range responses and general spread of the data. The QC team notified the Survey Operations team of any issues it identified, and refresher training for FDCs was delivered as needed. During the initial weeks of data collection, QC leads or staff observed FDCs and provided additional training as needed.

CLs were trained to conduct the PE teacher interview as part of their standardized training on conducting interviews with community personnel. For the PARA, CLs were trained and certified by an investigator at USC who served as the “gold standard.” During in-person

training, CLs completed practice observations and certification observations at schools. All CLs were certified at an 80% agreement with the gold standard. During the initial months of data collection, all CLs were visited by a QC lead and observed for inter-rater reliability. All CLs showed >80% agreement with the QC lead during these observations. Additionally, PE teacher and PARA data were reviewed on a monthly basis by the USC QC lead for data completeness, out-of-range responses, and missingness.

Discussion

The protocol for measurement of PA variables in the HCS includes a unique method for assessment of child-level PA behavior. The HCS investigators developed a PA recall instrument for use in this study because the protocol required a focus on forms of PA participation that are typically targeted by CPPs designed to prevent obesity in children and youth. Accordingly, the primary method for assessing child PA involved the child (or a parent/guardian) responding *yes* or *no* to queries regarding the child's participation, during the previous seven days, in 14 specific forms of physical activities. For activities performed in the previous week, the child (or parent) reported additional information regarding frequency and intensity of participation. For any activities performed on the previous day, they provided additional contextual and duration information. It is anticipated that the data collected through administration of this protocol will be used in two major ways. First, it will be used to assess, among children in each community, the prevalence of participation in forms of PA. Second, it will be reduced to create metrics that reflect child-level PA behavior (Table 1). The validity of this new instrument has not been established previously. However, because the HCS enhanced protocol provides accelerometry data for approximately 10% of participating children, it will be possible to examine the validity of the new self-report instrument versus objectively measured PA.

The HCS PA protocol also draws heavily on instruments that have been used successfully in previous large-scale studies of PA behavior in youth.^{41,42} These include several measures of school and neighborhood characteristics that are related to children's PA. The school and neighborhood constructs were included in the protocol because of their hypothesized roles as potential mediators and moderators of the effects of community policies and programs on child PA. Through a combination of interviews with school personnel, self-reports by children and parents, and objective assessments of the built environments of the school and neighborhood, the HCS protocol provides a comprehensive assessment of key school and community characteristics.

In summary, the HCS PA protocol includes important strengths and some limitations. A major strength is the selection of measures that collectively allow testing of study hypotheses in a manner that is consistent with the conceptual framework that guided design of the study. However, resource limitations and the need to avoid excessive staff and participant burden precluded inclusion of some potentially useful measures. Among the various child-level social cognitive variables that have been associated with PA, only measures of PA self-schema, parental social support, and parental rules were included in the HCS protocol. Objective assessments of the built environment are limited to observations of school grounds and residential street segments and do not include observations of parks or

other community PA resources. However, it is an important strength that the enhanced protocol includes accelerometry, which will provide the basis for comparison of the HCS sample with national norms and with findings of other large-scale studies in which accelerometry has been used as an objective measure of PA.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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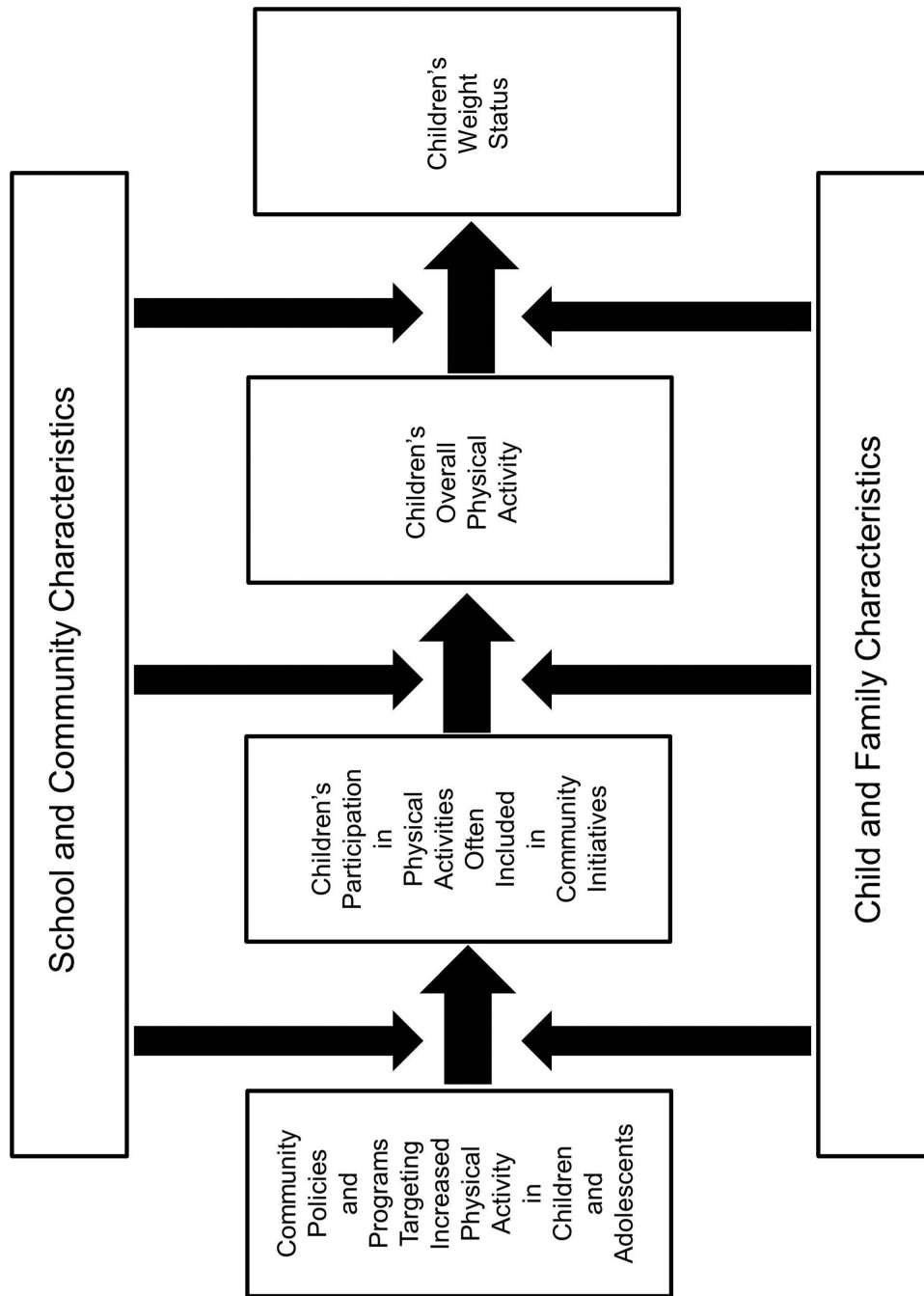


Figure 1. Conceptual model guiding the selection of physical activity measures.

Table 1

Operational Definitions of Selected Physical Activity and Sedentary Behavior Variables Derived from the PABR-7

Variable	Operational Definition
Physical Activity	
Participation in specific types of physical activity	Count of activities
MVPA Index: Moderate-to-Vigorous PA (Self-report)	Number of moderate-to-vigorous activities reported * frequency of participation in those activities
VPA Index: Vigorous PA (Self-report)	Number of vigorous activities reported * frequency of participation in those activities
TPA Index: Total PA (Self-report)	Number of activities reported * frequency of participation in those activities
MVPA: Volume of Moderate-to-Vigorous PA (Self-report; previous day activities)	Frequency * duration of reported MVPA activities
VPA: Volume of Vigorous PA (Self-report; previous day activities)	Frequency * duration of reported VPA activities
TPA: Volume of Total PA (Self-report; previous day activities)	Frequency * duration of reported Total PA
Participation in physical activities in specified settings	Count of activities in each location
Participation in physical activities in specified social contexts	Count of activities by group composition (i.e., by self, with one other person, with many people, with class/team)
Sedentary Behavior	
Participation in specific types of Sedentary Behaviors	Count of activities
Sedentary Behavior Index	Number of sedentary activities reported * frequency
Volume of Sedentary Behavior (previous day activities)	Frequency * duration of reported sedentary activities
Participation in Sedentary Behaviors in specified settings	Count of activities in each location
Participation in Sedentary Behaviors in specified social contexts	Count of activities in each group setting

Table 2

Operational Definitions of Physical Activity and Sedentary Behavior Variables Derived from Accelerometry

Variable	Definition
Total activity	Daily vector magnitude sum from 3 axes
Total physical activity (min/day)	Sum of all wear min w/ Actigraph count values >100
Sedentary behavior (min/day)	Accumulated daily min w/ Actigraph count value 100
Light intensity physical activity (min/day)	Accumulated daily min w/ Actigraph count range 101 to age-adjusted value (1,400-2,780)
Moderate-to-vigorous activity (MVPA) (min/day)	Accumulated daily min w/ Actigraph count values age-adjusted cut-off (1,400-2,780)
Vigorous activity (min/day)	Accumulated daily min w/ Actigraph count values age-adjusted cut-off (3,758-6,007)
MET-weighted MVPA (MET-min/day) ^a	Daily MET-weighted minutes of MVPA

^a 1 MET=3.5 mL O₂ kg⁻¹ min⁻¹, which is the rate of energy expenditure at rest. MET-minutes (MET-min)=minutes spent in activity × MET level of the activity.