Correlates of Objectively Measured Physical Activity in Preadolescent Youth

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Objective: The purpose of this study was to identify the psychosocial and environmental correlates of objectively measured physical activity behavior in a diverse sample of sixth-grade students.

Design: Cross-sectional.

Participants and Setting: One hundred ninety-eight sixth-grade students from 4 public middle schools in Columbia, South Carolina. The study group was 52.0% female, 55.1% African-American, with a mean age of 11.4 ± 0.6 years.

Main Outcome Measures: Time spent in moderate physical activity (MPA) and vigorous physical activity (VPA) was assessed using a uniaxial accelerometer (CSA WAM 7164) (Computer Science and Applications Inc., Shalimar, FL). Determinant variables included: age, gender, race/ethnicity (demographic); physical activity self-efficacy, social norms related to physical activity, and beliefs regarding physical activity outcomes (psychosocial); and perceived physical activity habits of parents and peers, involvement in community physical activity organizations, involvement in community-based sports programs, access to fitness/sporting equipment at home, and self-reported hours spent watching television or playing video games (environmental).

Results: For boys, physical activity self-efficacy, social norms related to physical activity, and involvement in community physical activity organizations were salient predictors of MPA and VPA. Among girls, only physical activity self-efficacy emerged as a clear predictor of objectively measured physical activity.

Conclusions: These findings are consistent with previous studies using self-reported physical activity and suggest that interventions to increase physical activity in preadolescent youth should endeavor to boost physical activity self-efficacy by offering a wide selection of enjoyable, developmentally-appropriate physical activity options.

Medical Subject Headings (MeSH): exercise, sports, health promotion, physical fitness, behavioral medicine, child (Am J Prev Med 1999;17(2):120–126)

Introduction

Regular participation in physical activity is an important component of a healthy lifestyle. Among adults, higher levels of physical activity are associated with reduced risk of coronary heart disease, hypertension, type II diabetes mellitus, obesity, certain cancers, as well as some mental health problems.[1,2] Emerging evidence indicates that physical activity is also beneficial to the health of children and adolescents.[1,3] Among youth, physical activity is inversely associated with a number of cardiovascular disease risk factors, including elevated blood lipids, hypertension, obesity, and cigarette smoking, while positively associated with physical fitness, HDL cholesterol, bone mass, and psychological well-being.[3,4] Moreover, because physical activity habits developed early in life may persist into adulthood,[5,6] adequate participation in physical activity during childhood and adolescence may be of critical importance in the prevention of chronic disease later in life. Despite the health benefits of regular physical activity, survey data from the United States, as well as other developed countries, indicate that sizeable percentages of the youth fail to meet established guidelines for participation in physical activity. Data from the 1995 Youth Risk Behavior Survey (YRBS) indicate that approximately 25% of

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adolescent males and approximately 50% of adolescent females fail to meet guidelines for participation in sustained vigorous physical activity.[7] Moreover, adolescence appears to be a period characterized by marked declines in physical activity. Data from the 1992 National Health Interview Survey (NHIS) indicate that, by age 21, only 42.2% and 30.2% of U.S. males and females, respectively, report participating in 3 or more vigorous physical activity sessions in the week preceding the survey.[1] These findings reinforce the need for physical activity intervention programs for children and adolescents.

To guide the development and implementation of such programs, it is important to understand the psychosocial and environmental factors that influence activity behavior in youth.[8] Presently, however, our knowledge concerning the determinants of youth physical activity is limited. Previous investigations have identified physical activity self-efficacy,[9–13] enjoyment,[14,15] parental influences,[16–18] attitudes or beliefs about physical activity outcomes,[19–21] access to equipment and programs,[12,13,22] and time spent outdoors[22,23] as significant correlates of physical activity behavior. However, the strengths of these associations are weak, accounting for only 5% to 25% of the variance in youth physical activity behavior.

One possible explanation for this lack of explanatory power is the difficulty associated with measuring physical activity behavior in children and adolescents.[24] Previous determinant studies have quantified physical activity behavior using self-report methods that are subject to recall limitations and have limited reliability and validity among younger children.[25,26] Importantly, imprecision and/or inaccuracy in the measurement of physical activity behavior can severely attenuate or even obscure its relationship to a given determinant variable.

A potential solution to this problem is to use objective measures of physical activity such as heart rate monitors and accelerometer devices. Such devices not only provide objective information on the amount of activity performed, but also provide reliable information on the intensity and patterning of physical activity. These features make objective measures particularly well suited for determinants studies involving preadolescent youth. To date, however, no study has used objective monitoring devices to examine the psychosocial and environmental correlates of physical activity behavior in healthy, free-living children.

The purpose of this study was to identify the psychosocial and environmental correlates of physical activity behavior in a diverse sample of sixth-grade children. To avoid the limitations associated with self-reported physical activity, we employed a state-of-the-art uniaxial accelerometer to directly assess participation in moderate and vigorous physical activity over a 7-day period.

Methods

Subjects

Subjects for this study were 213 sixth-grade students from 4 public middle schools in Columbia, South Carolina. The study group was 51.6% female, 55.9% African-American, with a mean age of 11.4 ± 0.6 years. After deletions for incomplete physical activity data ($N = 11$) or missing questionnaire data ($N = 4$) the final sample consisted of 198 students (103 females, 95 males). The descriptive statistics for this group (52.0% female, 55.1% African-American, mean age of 11.4 ± 0.6) indicated that the demographic characteristics remained unchanged by the exclusion of these participants. Prior to participation in the study, written informed consent was obtained from each student and his or her primary guardian. The study was approved by the University of South Carolina Institutional Review Board.

Determinants of Physical Activity

Students completed a questionnaire designed to measure hypothesized demographic, psychosocial, and environmental determinants of physical activity. The determinant variables were selected on the basis of Social Cognitive Theory[27] and the Theory of Reasoned Action.[28] The questionnaire was administered in a classroom setting by the primary author who read the items to students using a standardized script. At each administration, an assistant moved around the classroom to answer any questions and check for students who had problems. Prior to data collection, the questionnaire was pilot tested to ensure that the reading level and response format was appropriate for sixth-grade students.

Psychosocial Variables. Hypothesized psychosocial determinants of physical activity included physical activity self-efficacy, social norms regarding physical activity, and beliefs regarding physical activity outcomes. The physical activity self-efficacy, social norms, and beliefs scales were modeled on the measurement scales developed by Saunders and coworkers.[29] A brief description of these scales and their associated reliability coefficients (Cronbach's alpha) are provided in Table 1.

Environmental Variables. Students completed a series of single items designed to measure hypothesized environmental determinants of physical activity behavior. Consistent with Bandura's concept of the physical and social environment,[27] these included perceived physical activity of parents and friends, access to sporting and/or fitness equipment at home, involvement in community physical activity organizations, participation in community sports teams, and self-reported hours spent watching television or playing video games. These items were modified from measures used in the Na-

Table 1. Scales used to measure hypothesized psychosocial determinants of physical activity and their reliability coefficients

Scale	Cronbach's Alpha	Concept/sample items
Self-efficacy (16 items, range 1–3)	0.71	*Perceived confidence in ability to be active* • I think I can be physically active even if I could watch television or play video games instead. • I think I can be physically active even if it is very hot or cold outside. • I think I can be physically active even if I have a lot of homework.
Social norms (10 items, range 1–3)	0.72	*Influence of family members, friends, and teachers on physical activity behavior* • My mother thinks I should be physically active. • The students in my class think I should be physically active. • My best friend thinks I should be physically active.
Beliefs/outcomes (16 items, range 1–3)	0.67	*Beliefs about consequences of being physically active* If I were to be physically active during my free time in the next two weeks it would: • Get or keep me in shape • Make me more attractive • Be fun

tional Children and Youth Fitness Study[30] and the 1990 Centers for Disease Control and Prevention's Youth Risk Behavior Survey.[31] The psychometric properties of these measures have been reported elsewhere.[32,33]

Measurement of Physical Activity

Instrumentation. Objective assessments of physical activity were obtained using the Computer Science and Applications Inc. (CSA) 7164 activity monitor (Shalimar, Florida). Briefly, the CSA 7164 is a uniaxial accelerometer designed to detect vertical acceleration ranging in magnitude from 0.05 to 2.00 G's with frequency response of 0.25 to 2.50 Hz. These parameters allow for the detection of normal human motion and will reject high frequency vibrations encountered in activities such as operation of a lawn mower. The filtered acceleration signal is digitized and the magnitude is summed over a user-specified time interval. At the end of each interval, the summed value or activity "count" is stored in memory and the integrator is reset.[34] For the present study, a 1-minute sampling interval was used. The CSA 7164 has been shown to be a valid and reliable tool for assessing physical activity in children aged 10 to 14.[35]

Protocol. Students were outfitted with a single activity monitor immediately after completing the determinants questionnaire. Consistent with previous studies, monitors were attached to adjustable elastic belts and worn over the right hip. After receiving detailed instructions regarding the care and use of the monitors, students were instructed to wear the CSA monitor during the waking hours for 7 consecutive days. At the time of distribution, students were given a 7-day log sheet to record the times the monitor was not worn and to provide information about any swimming, cycling, or weight training performed over the 7-day monitoring period. Upon removal of the activity monitor the following week, stored activity counts were downloaded and saved to a personal computer for subsequent data reduction and analysis.

Data Reduction. Minute-by-minute activity counts were uploaded to a QBASIC data reduction program for determination of time spent in moderate (3–5.9 METs), vigorous (6–8.9 METs), and very vigorous physical activity (≥ 9 METs) during each 60-minute segment of the 7-day monitoring period. The age-specific count ranges corresponding to the aforementioned intensity levels were derived from the energy expenditure prediction equation developed by Freedson and co-workers.[36] Daily totals for participation in MPA (3–5.9 METs) and VPA (≥6 METs) were calculated by summing the MPA and VPA totals from the 60-minute time blocks between 9:00 a.m. and 9:00 p.m. The 12-hour time interval was selected to replicate previous monitoring studies[37–39] and to control for individual differences in time spent wearing the monitors. None of the participants was involved in physical education classes prior to 9:00 a.m. MPA and VPA scores recorded for each day of the monitoring period were averaged to produce an estimate of usual VPA and MPA. Students with less than 4 days of complete monitoring data were excluded from the analyses.

Statistical Analyses

All statistical analyses were conducted with SAS (version 6.12). Means and standard deviations were calculated

Table 2. Means and standard deviations for the physical activity and determinant variables

Variable	All	Boys	Girls
Moderate activity (min/day)	74.6 ± 35.4	80.2 ± 36.1	69.4 ± 34.0*
Vigorous activity (min/day)	11.3 ± 9.5	12.5 ± 9.4	11.1 ± 9.7
Age (years)	11.4 ± 0.6	11.4 ± 0.6	11.3 ± 0.5
Self-efficacy	2.6 ± 0.3	2.6 ± 0.3	2.5 ± 0.3
Social norms	2.4 ± 0.4	2.4 ± 0.5	2.3 ± 0.4
Beliefs/outcomes	2.5 ± 0.3	2.6 ± 0.3	2.5 ± 0.2
Mother's activity	2.5 ± 0.8	2.5 ± 0.8	2.5 ± 0.7
Father's activity	2.5 ± 0.7	2.6 ± 0.7	2.5 ± 0.7
Best friend's activity	2.6 ± 0.7	2.6 ± 0.7	2.6 ± 0.7
Home equipment	7.3 ± 3.0	7.5 ± 3.2	7.0 ± 2.6
Community sports	2.2 ± 1.3	2.6 ± 1.4	1.9 ± 1.1*
Community organizations	5.0 ± 0.8	5.1 ± 0.8	4.8 ± 0.8*
TV/Video games (hrs/day)	3.4 ± 1.0	3.4 ± 1.0	3.5 ± 1.0

*denotes significant difference between boys and girls, $P < 0.05$

for all physical activity and determinant variables. Crude associations between daily MPA and VPA and the hypothesized determinant variables were assessed using Pearson-Product-Moment correlation coefficients. To determine whether demographic, psychosocial, and environmental variables were independently associated with participation in MPA and VPA, a series of hierarchical multiple regression analyses were conducted. Age and ethnicity were entered in the first step. Psychosocial variables with significant zero-order correlations with the activity variables were entered in the second step. Environmental determinant variables with significant zero-order correlations with the activity variables were entered in the third step. In order to examine potential gender differences in the determinants of activity, separate analyses were performed for girls and boys. In all analyses, statistical significance was set at an alpha level of 0.05.

Results

Means and standard deviations for the determinants variables are shown in Table 2. On average, the participants accumulated approximately 75 minutes per day of MPA and just over 10 minutes per day of VPA. Relative to girls, boys exhibited significantly greater participation in MPA; however, no significant gender differences were observed for daily participation in VPA. On average, boys and girls scored similarly on each of the determinant variables with the exception of participation in community-based sports teams and involvement in community-based physical activity organizations for which boys scored higher than girls.

Zero-order correlation coefficients between each of the determinant variables and MPA and VPA are shown in Table 3. For boys, physical activity self-efficacy, social norms regarding physical activity, perception of mother's activity level, and involvement in community-based physical activity organizations were significant correlates of VPA. For girls, physical activity self-efficacy and beliefs regarding physical activity outcomes were significant correlates of VPA.

With respect to MPA, social norms regarding physical activity, perception of father's activity level, and involvement in community-based physical activity organizations were significant correlates among boys. For girls, physical activity self-efficacy, beliefs regarding physical activity outcomes, and access to sporting and/or fitness equipment at home were significant correlates of MPA.

Results of the hierarchical regression analyses for boys and girls are shown in Tables 4 and 5, respectively. For boys, physical activity self-efficacy, social norms regarding physical activity, and involvement in community-based physical activity organizations were significantly associated with daily participation in VPA. The final model containing all of the variables was significantly associated with VPA [$F(6, 88) = 3.06$; $P = .009$], explaining 12% of the variance. For daily MPA, social norms regarding physical activity and involvement in community-based physical activity organizations were significant correlates, explaining 13% of the variance. The final model containing all of the variables was

Table 3. Pearson-Product-Moment correlation coefficients for the determinant variables and physical activity behavior

	VPA		MPA	
	Boys	Girls	Boys	Girls
Self-efficacy	0.27*	0.33*	0.18	0.24*
Social norms	0.24*	0.03	0.23*	0.10
Beliefs/outcomes	0.10	0.25*	0.14	0.24*
Mother's activity	0.21*	0.08	0.14	0.09
Father's activity	0.15	0.10	0.21*	0.13
Best friend's activity	0.09	0.10	0.11	0.08
Home equipment	0.10	0.15	0.04	0.19*
Community sports	0.07	0.06	0.01	0.04
Community organizations	0.28*	0.04	0.26*	0.01
TV/Video games	−0.10	−0.01	−0.03	−0.06

VPA = vigorous physical activity (≥6 METs), MPA = moderate physical activity (3–5.9 METs).
*denotes statistically significant $P < 0.05$

Table 4. Results of the hierarchical multiple regression analyses to explain VPA and MPA in boys ($N = 95$)

Step	Variable in model	Std Beta	*p* value	Δ Adj. R^2	Model R^2
Associations with daily vigorous activity					
1.	Age	0.02	0.16	0.01	0.01
	Race/ethnicity	0.12	0.22		
2.	Self-efficacy	0.22	0.03	0.08	0.09
	Social norms	0.20	0.01		
3.	Community organizations	0.21	0.04	0.03	0.12
	Mother's activity	0.06	0.56		
				F (6,88) = 3.06; P = 0.009	
Associations with daily moderate activity					
1.	Age	0.18	0.08	0.04	0.04
	Race/ethnicity	0.14	0.17		
2.	Social norms	0.24	0.01	0.05	0.09
3.	Community organizations	0.18	0.04	0.04	0.13
	Father's activity	0.15	0.13		
				F (5,89) = 3.89; P = 0.003	

significantly associated with MPA [F (5,89) = 3.89; P = .003]. Age and race/ethnicity were not significantly associated with physical activity in both regression models.

For girls, physical activity self-efficacy emerged as the only significant predictor of daily VPA. The final model consisting of age, race/ethnicity, physical activity self-efficacy, and beliefs regarding physical activity outcomes was significantly associated with daily VPA [F (4,98) = 3.66; P = .008], explaining 10% of the variance. For daily MPA, the model consisting of age, race/ethnicity, physical activity self-efficacy, beliefs regarding physical activity outcomes, and access to sporting and/or fitness equipment at home was significantly associated with MPA [F (5,97) = 2.83; P = .02], explaining 8% of the variance. However, no single determinant variable was significantly associated with MPA at the 0.05 level of significance. Similar to the boys, age and race/ethnicity were not significantly associated with physical activity.

Discussion

The present study is unique in that it employed an objective measure of physical activity to study the correlates of physical activity behavior in a diverse group of sixth-grade children. Our key overall finding was that, in agreement with previous studies utilizing self-reported physical activity, psychosocial and environmental influences such as physical activity self-efficacy, beliefs about physical activity outcomes, social norms regarding physical activity, and involvement in community-based physical activity organizations were associated with objectively measured physical activity behavior. In all cases the associations were in the expected directions.

An important finding of the present study was the significant association between physical activity self-efficacy and objectively measured physical activity behavior. With the exception of moderate activity in the

Table 5. Results of the hierarchical multiple regression analyses to explain VPA and MPA in girls ($N = 103$)

Step	Variable in model	Std Beta	*p* value	Δ Adj. R^2	Model R^2
Associations with daily vigorous activity					
1.	Age	0.03	0.79	0.00	0.00
	Race/ethnicity	0.01	0.95		
2.	Self-efficacy	0.29	0.007	0.10	0.10
	Beliefs/outcomes	0.13	0.22		
				F (4,98) = 3.66; P = 0.008	
Associations with daily moderate activity					
1.	Age	0.10	0.31	0.02	0.02
	Race/ethnicity	0.14	0.16		
2.	Self-efficacy	0.19	0.07	0.06	0.08
	Beliefs/outcomes	0.14	0.19		
3.	Home equipment	0.12	0.22	0.00	0.08
				F (5,97) = 2.83; P = 0.002	

boys, physical activity self-efficacy was the strongest independent predictor of daily participation in moderate and vigorous physical activity. Previous investigations have shown physical activity to be associated with, or predictive of, self-reported physical activity.[9–13] However, this is the first study to report a significant association between self-efficacy and objectively measured physical activity behavior in children. The consistency of this finding across study populations, study designs, and activity measurement protocols underscores the fundamental importance of efficacy beliefs in the development of physical activity habits. According to Bandura,[27] self-efficacy perceptions are derived from four principal sources of information: past performances, vicarious experiences (modeling), verbal persuasion, and physiological state. Therefore, to increase physical activity self-efficacy, school and community-based intervention programs should: (1) provide enjoyable, developmentally appropriate activities that enable all participants to experience success; (2) create opportunities for youth to observe influential others (e.g., teachers, coaches, parents, and peers) perform physical activity; (3) verbally encourage children to participate in physical activity (i.e., you can do it); and (4) reduce any anxiety associated with participation in physical activity by significantly reducing or eliminating competition from planned activities.

In compliance with recently published research recommendations,[1,8] the present study examined potentially important gender and intensity-related differences in the determinants of objectively measured physical activity. For boys and girls, respectively, parallel analyses were performed in which participation in moderate physical activity and vigorous physical activity served as dependent variables. The results of these analyses revealed striking gender differences in the determinants of physical activity. For boys, social norms regarding physical activity and involvement in community-based physical activity organizations were independently associated with daily participation in moderate and vigorous physical activity. Conversely for girls, beliefs about physical activity outcomes emerged as an independent predictor of daily participation in moderate and vigorous physical activity. Within gender groups, the determinants varied little by level of physical activity intensity. Collectively, these observations reinforce the need for public health practitioners and educators to consider salient gender differences in the determinants of activity behavior when designing and implementing interventions to promote physical activity in youth. For example, our findings suggest that one potentially effective way to increase physical activity in sixth-grade boys is to facilitate greater involvement in community-based physical activity organizations such as the YMCA, boy scouts, and boys clubs. On the other hand, for interventions directed at sixth-grade girls, it appears important to cultivate positive beliefs about physical activity by educating them about the proximal benefits associated with physical activity (i.e., spending more time with friends) and by providing them with physical activity experiences that meet their needs and interests.

Relative to some studies using self-reports of physical activity, the determinant variables accounted for a small percentage of the variance in objectively measured physical activity. This finding is consistent with previous studies that have employed both self-report instruments and objective monitoring devices to investigate the determinants of physical activity. Epstein and co-workers[40] compared the determinants of physical activity in obese children when activity was measured by self-report and 3-dimensional accelerometry. The determinant variables consisting of aerobic fitness, socioeconomic status, cognitions related to exercise, and selected psychological disorders explained more variance in self-reported physical activity than objectively measured physical activity. Of note, the determinants varied according to the method used to assess physical activity. Dishman and associates[41] compared the determinants of objectively measured activity and self-reported activity in college-aged men and women. Self-ratings of physical activity self-efficacy, outcome expectancies, and perceived barriers to exercise were associated with self-reported activity but were unrelated to objectively measured activity.

Considering that objective measures of physical activity should, in theory, reduce the overall level of measurement error,[24] the stronger associations observed for self-reported physical activity are difficult to explain. One possibility is that objective measures such as heart rate monitors and accelerometers have their own sources of measurement error that attenuate potential relationships with determinant variables. Depending on the types of activities being monitored (for example, walking versus cycling) and the population under study, such errors could be equal to, if not greater than, those associated with self-report methods. Alternatively, the stronger associations reported in self-report studies may be attributable to shared method variance. That is, self-reported thoughts and feelings about physical activity may correspond more closely to self-reported physical activity than objective assessments of activity.

The cross-sectional nature of this study design precluded us from inferring causal relationships between the hypothesized determinants and physical activity behavior. Furthermore, because we did not assess physical activity by self-report we were unable to directly compare the determinants of physical activity when measured by accelerometry and self-report. Nevertheless, within the limitations of our study design, our results provide meaningful new information about the determinants of physical activity in preadolescent youth. The correspondence of findings from previous

determinants studies provides strong empirical support for utility of social cognitive theory as a conceptual framework for designing and implementing intervention programs targeted at youth.

In summary, physical activity self-efficacy, social norms regarding physical activity, beliefs about physical activity outcomes, and involvement in community-based physical activity organizations were found to be significant independent correlates of objectively measured physical activity in a diverse sample of sixth-grade students. Of note, these findings are consistent with the results of previous determinants studies utilizing self-reported physical activity.

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