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Change in Children's Physical Activity: Predictors in the Transition From Elementary to Middle School

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Abstract

Introduction: Interventions to promote physical activity in children should be informed by knowledge of the factors that influence physical activity behavior during critical developmental transitions. The purpose of this study is to identify, from a comprehensive, multidomain set of factors, those that are associated with change in objectively measured physical activity in children as they transition from elementary to middle school.

Methods: The study used a prospective cohort design, with children observed in fifth, sixth, and seventh grades. Growth curve analyses were used to examine associations between exposure variables measured at baseline and children's physical activity across three observations. A total of 828 children, aged 10.6 (SD=0.5) years at baseline provided physical activity data in fifth grade and at one or both follow-ups. Exposure variables assessed child characteristics, parent characteristics, home characteristics, social factors, school environment, and community characteristics. Physical activity was measured via accelerometry. Data were collected in two school districts in South Carolina in 2010–2013 and analyzed in 2017.

Results: Variables measured within the child, parent/home, and community domains were positively associated with children's physical activity as they transitioned from fifth to seventh grade. These included parent encouragement of physical activity, parental support for physical

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activity, child sports participation, parent's report of the child's physical activity level, the child's time spent outdoors, social spaces for physical activity in the community, and the number of physical activity facilities that were proximal to the child's home.

Conclusions: Interventions designed to increase children's physical activity should include strategies that target multiple domains of influence.

INTRODUCTION

Physical activity provides important health benefits to children and youth,[1,2] and the *Physical Activity Guidelines for Americans* recommend that young people engage in 60 or more minutes of moderate to vigorous intensity physical activity (MVPA) per day.[3] However, most U.S. youth do not meet that guideline, and it is well documented that the percentage of youth meeting the guideline declines with age.[4,5] The National Health and Nutrition Examination Survey (2003–2004) observed that, on average, children aged 6–11 years engaged in more than 75 minutes of MVPA per day, but youth aged 12–15 years engaged in only 25 (girls) to 45 (boys) minutes per day.[4] Clearly, one strategy for increasing the prevalence of children and youth meeting the federal physical activity guideline is to reduce the rate at which PA declines during the transition from childhood to adolescence.

Interventions to reduce the age-related decline in PA in children should be informed by a thorough understanding of the factors that influence change in PA as young people grow and develop. However, those factors are not well understood. Craggs et al.[6] performed a systematic review of 46 studies to assess evidence regarding determinants of change in PA. Few of the variables studied were consistently associated with change in PA, due in part to the different measures of PA and the frequent use of self-reported PA (31 of 46 studies).

Much of the previous research on factors that influence PA in youth has been based on a social ecologic model of health behavior.[7] This model posits that PA behavior is influenced by a complex set of personal, social, institutional, and community factors.[7] Research based on this model has identified numerous individual factors that associate with PA in young people.[8–10] To date, however, few studies of children have examined factors that represent multiple domains of the social ecologic model, while using a longitudinal study design and objective measurement of PA.[9,11] Accordingly, the purpose of this study is to identify, from a comprehensive set of child, parent/home, social, school, and community factors, those that are associated with change in objectively measured PA in children as they transition from elementary to middle school.

METHODS

This study employed a longitudinal, observational research design in which children were measured on up to three occasions as they transitioned from elementary to middle school (aged 10.6 [SD=0.5]–12.5 [SD=0.5] years). The primary outcome variable was PA measured objectively via accelerometry. Exposure variables were conceptualized using the social ecologic model and were selected from four domains: child, parent/home, school, and community. These variables were measured at baseline when the children were in the fifth

grade, and growth curve analysis was used to identify the variables that were associated with PA during 2 years of follow-up.

Study Sample

Participants were students drawn from 21 elementary schools and who subsequently enrolled in 12 middle schools in two school districts in South Carolina. Once per year, data were collected in the school setting. During an initial data collection session, students completed a questionnaire and anthropometric measurements and received an accelerometer. During a second session, students returned the accelerometer. A parent/guardian also completed a questionnaire; 87% of responding parents were mothers. Prior to data collection, parent/guardian consent and child assent were obtained. Data were collected in 2010–2013 and analyzed in 2017. The IRB at the University of South Carolina approved the protocols.

Measures

PA (minutes/hour) was measured using accelerometers (ActiGraph GT1M and GT3X models). Each child wore an accelerometer for 7 consecutive days, except while bathing, swimming, or sleeping. Accelerometer counts in the vertical plane were collected and stored in 60-second epochs and reduced using methods previously described.[12] PA was defined as ≥100 counts/minute and included light, moderate, and vigorous intensity PA. To adjust for differences in accelerometer wear-time PA was expressed as minutes of PA per hour of wear time. Data for Sundays were not used because of poor wear rates (<8 hours) and low reliability. Missing values for children with >2 days of ≥8 hours of wear each day were estimated by multiple imputation using Proc MI in SAS, version 9.3. A total of five data sets were imputed and then averaged for each variable. Prior to imputation, most children in the analysis sample had ≥4 qualifying days (80% at fifth grade, 75% at sixth grade, and 67% at seventh grade). On average, 73% of total possible records from Monday to Saturday were available over the 3 years.

Children's standing and seated heights were measured to the nearest 0.1 cm using a portable stadiometer. Leg length, used in calculating maturity offset, was estimated by subtracting seated height from standing height. Weight was measured to the nearest 0.1 kg using an electronic scale. The average of two measurements was used for both height and weight, and BMI was calculated (kg/m^2). To assess maturational status, maturity offset was calculated using sex-specific equations from Mirwald and colleagues[13] as revised by Malina and Koziel.[14]

The student questionnaire included assessments of personal, social, and home environment variables. Child-reported personal variables included PA self-efficacy,[15–17] perceived barriers,[18] self-schema,[19,20] and motives for PA,[21] including enjoyment, competence, appearance, fitness, and social subscales. Social variables included perception of parent support,[22,23] perception of parent encouragement, peer support, and number of active friends. Home environment variables included perceived environment[23] and availability of PA equipment at home.[22,24–26]

Parent-reported personal variables included perception of the child's PA levels and importance of the child's participation in sports/PA. Social variables included parent's perception of his/her support of child's PA,[22] parent's enjoyment of PA, and parent's participation in leisure-time PA and sports.[27] Home environment variables included access to PA and sedentary equipment at home, rules about sedentary behavior in the home, and number of adults in the home.[24,25]

A school administrator and a physical education teacher at each participating school completed surveys. These surveys included items from the School Health Policies and Programs Study,[28] including recess minutes per week, physical education minutes per year, and intramural activities.

A Windshield Survey[29] was completed for the street segment (i.e., cross street to cross street not to >0.5 miles) for each child's home address. Three scales were created from the windshield data: physical incivilities (e.g., litter, graffiti), territoriality (e.g., fences or barriers), and social spaces (e.g., presence of yards). Also, facilities that provide PA opportunities and resources were identified in each community by searching internet resources and databases for churches, commercial facilities, trails, parks, and schools/colleges. Trained staff confirmed facility offerings and completed a Physical Activity Resource Assessment[30] for each facility. The Physical Activity Resource Assessment includes information on facility features (e.g., baseball fields), amenities (e.g., drinking fountains), and incivilities (e.g., graffiti). For each resource the authors created an index and summed this index across all the facilities within a 2-mile buffer around a participant's home.

Statistical Analysis

Growth curve analysis, performed in SAS Proc Mixed, was used to identify factors that were associated with PA in children as they transitioned from elementary to middle school.[31] In all analyses, time was included as a random variable and children were nested in schools. Time was coded according to grade level as an ordered categorical variable (0, 1, 2) using procedures described by Singer and Willett.[31] Exposure variables were examined as main effects and as interactions with time. Data were analyzed in 2017.

Initially, eight preliminary exploratory growth curve analyses were performed to identify exposure variables for inclusion in comprehensive, multidomain models. Missing values for 21 selected exposure variables were replaced by multiple imputation data augmentation using SAS Proc MI. The longitudinal relationships between PA and the exposure variables identified in exploratory analyses were then examined by constructing two additional growth curve models. The first examined only the influence of time on PA. The second included the 21 variables selected from the preliminary exploratory analyses and variable by time interactions. Maturity offset was included in this model to adjust for children's maturational status. All models included time, sex, race/ethnicity, parent education, and poverty index. Continuous variables were centered by subtracting the grand mean of the variable. Goodness-of-fit for each model was estimated by three statistics: deviance, Akaike Information Criteria, and Bayesian Information Criteria.

RESULTS

A total of 1,080 children (501 boys, 579 girls) were recruited into the study as fifth graders, and 992 of these children provided baseline accelerometer data for assessment of PA. The analytic sample included 828 children who provided PA data in the fifth grade and again in the sixth, or seventh, or both sixth and seventh grades. This sample was diverse (53.9% girls, 38.3% white, 35.1% African American, 9.5% Hispanic). Table 1 provides descriptive data for the analysis sample. The group included in the analysis was similar to the group excluded; however, the analysis sample included a greater proportion of white children and fewer Hispanics than the excluded group (p=0.001). Parental education was higher in the analytic sample than in the excluded group (p=0.02).

As shown in Table 2, exposure variables were selected in eight categories. Within each category a backward elimination analysis was performed to identify variables that were associated with PA (p<0.20). Across the eight categories 21 variables, of a total of 36, were identified as associated with PA at the specified level.

Table 3 presents the findings for the composite growth curve analyses. Model 1 is the unconditional growth model with time. This model shows that there was a significant decline in PA as children progressed from fifth to seventh grade (p<0.05). Model 2, presented in Table 3, examined the influence of the 21 exposure variables identified in the first phase of the analysis on PA as it changed between fifth and seventh grades. This model controlled for parent education, poverty rate, sex, race, and maturational status. The following variables were found to be positively associated with PA as main effects across the three time points: parental support for PA (child reported), rating of child PA (parent reported), child time spent outdoors on weekends (parent reported), child sports participation (parent reported), intramural activities (teacher reported), and number of proximal community PA facilities (Physical Activity Resource Assessment weighted score; p<0.05). The multivariate model accounted for 41% of between-child variance in PA averaged across fifth through seventh grades (variance of the model intercept was 7.23 minutes/hour of PA compared with 12.35 minutes/hour in the unconditional model).

Three variables were significantly associated with change in PA. Two of these variables were positively associated with change in PA: parent encouragement of PA (child reported) and social spaces for PA in the neighborhood (p<0.05). The number of school-based intramural programs was negatively associated with change in PA (p<0.05). The multivariate model accounted for 54% of between-child variance in the decline in PA from fifth grade through seventh grade (variance of the model slope was 0.52 minutes/hour of PA compared with 1.14 minutes/hour in the unconditional model). To verify that the assumptions underlying linear mixed model regression were met, the authors examined mixed procedure residual diagnostic plots for the model presented in Table 3. These plots indicated constant variance and linearity.

DISCUSSION

The major finding of this study was that factors drawn from multiple domains of the social ecologic model were associated with PA in children as they transitioned from elementary school to middle school. The social ecologic model holds that health behaviors, such as PA, are influenced by an interactive constellation of personal, social environmental, physical environmental, community, and societal characteristics.[32,33] This model has been widely used by public health researchers[34] and practitioners.[35,36] The findings of the present study are consistent with this theory in that factors measured in the child, parent/home, and community domains were found to be longitudinally associated with children's objectively measured PA.

Both child and parent social cognitive variables were related to PA and change in PA. Child-reported parental support of PA was positively associated with the child's PA across the observation period, and parental encouragement of PA was positively associated with change in child PA. These observations advance knowledge of the impact of parenting behavior on children's PA, because few related observational studies have used a longitudinal design,[37,38] and very few have used a device-based measure of PA.[37] The few previous studies that used methodologies similar to those of the present study have yielded inconsistent findings.[39,40] These findings indicate that parental support and encouragement, as perceived by the child, are important influences on children's PA during the critical transition from childhood to adolescence. Parents can encourage, co-participate, and provide opportunities and transportation to PA programs.[41,42]

Higher scores on the social spaces scale in this study were associated with less decline in PA over time. Social spaces in neighborhoods have been identified as vital places that support health.[43] The social spaces scale from this inventory has also been associated with decreased odds of excessive weight gain in pregnant women.[44] Furthermore, many of the individual characteristics that constitute the social spaces scale, (e.g., people outside, homes with yards, homes with porches, at least one park), have been associated with higher PA levels primarily in adult studies. For example, availability of parks[45–47] and presence of sidewalks[48,49] have been consistently associated with higher PA levels. The presence of homes with porches has been theorized to provide for "eyes on the streets" and promote social capital, both of which can facilitate PA.[50,51] The presence of porches as well as the number of people in the area (both factors in the social spaces scale) have been associated with walking to work in previous research.[52] Finally, the availability of yards has been shown to support PA levels in children.[53]

Children in the U.S. are spending less time outdoors compared with previous generations,[54] and this appears to be negatively affecting their PA. A recent systematic review found that children tend to have more PA when they are outdoors than indoors.[55] Results of the present study support the importance of outdoor time as an influence on children's PA. Parent-reported time that children spent outdoors was positively associated with PA. Another longitudinal study found that weekend outdoor time was significantly associated with higher levels of MVPA.[56] These findings suggest that actions to increase children's outdoor time may be effective in increasing their PA.

The findings of this study provide important guidance to professionals who seek to increase the PA levels of children and adolescents. To address the increased prevalence of obesity in U.S. youth, healthcare providers, educators, and public health specialists have been called upon to adopt policies and practices to promote PA in young people.[57,58] In response to these recommendations, some health systems have implemented protocols for assessing PA behavior and for counseling children and their parents regarding strategies for increasing PA.[59,60] Comprehensive, multicomponent school-based PA interventions have been shown to be effective,[61] and some community-level interventions have increased children's PA.[62] The findings of the present study are consistent with a multidomain approach to promoting increased PA in young people. This approach would include elements aimed at helping children experience forms of PA that they enjoy and will be motivated to continue, assisting the parent in adopting behaviors that support the child's PA, and linking the child to community-based resources to support his/her PA.

Strengths of the study include the use of an objective measure of PA, repeated observations of large cohort of boys and girls followed for 3 years, and application of growth modeling, which uses each student's trajectory of change to estimate the typical change across students in PA and the variance of those changes, while also adjusting for initial fifth grade values. This approach permits a fuller test of correlated changes across time than prior longitudinal approaches, which may have failed to detect significant associations among similar variables when analysis was limited to less precise estimates of change across just 2 years.[9,63]

Limitations

Limitations include data collection in only two school districts in one state, only two follow-up data points, surveys of only one parent (primarily mothers), and only self-reported parent PA.

CONCLUSIONS

This study employed a comprehensive, multidomain approach in identifying factors that are associated with children's PA levels as they transitioned from elementary to middle school. A comprehensive set of child, parent/home, social, school, and community factors were measured when children were fifth graders. The findings were consistent with the social ecologic model of health behavior in that variables in the child, parent/home, social, and community domains were found to be associated with children's PA when it was measured in the fifth, sixth, and seventh grades. The results of this study demonstrate that characteristics of children and their environment, observed when the children were in fifth grade, were associated with their PA levels over the next 2 years. These findings suggest that interventions aimed at increasing children's PA should begin early in childhood and should include strategies targeting multiple domains of the social ecologic model.

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Table 1.

Baseline characteristics of children in the analysis sample

	Analysis sample, n=828	
Characteristic	**n**	**% or mean (SD)**
Sex		
Males	382	46.1%
Females	446	53.9%
Race		
White	317	38.3%
African American	291	35.1%
Hispanic	79	9.5%
Other	141	17.0%
Age	828	10.6 (0.5)
Maturity offset, 5th grade	828	−1.62 (1.1)
Physical activity		
5th grade PA, minute/hour	828	28.2 (4.6)
Parent education		
High school or less	343	41.4%
Greater than high school	485	58.6%
Mother completed questionnaire		
Yes	665	87.3%
No	97	12.7%

PA, physical activity.

Table 2.

Summaries and psychometric properties of variables hypothesized to associate with children's physical activity

Variable	Number of items	Possible Range	Cronbach' s α	n	Observe d range	Mean (SD) or %	Estimate (95% CI), $p<0.20$
Child characteristics, child reported							
Self-efficacy	8	1–4	0.77	828	1–4	3.3 (0.5)	0.56 (−0.12, 1.14)
Perceived barriers	5	1–4	0.49	828	1–3.6	1.7 (0.4)	−0.59 (−1.24, 0.07)
Self schema	6	1–48	N/A	815	2.3–37.3	25.7 (9.2)	0.06 (0.03, 0.09)
Enjoyment motivation	4	1–4	0.74	828	1–4	3.6 (0.5)	
Competence motivation	4	1–4	0.72	828	1–4	3.5 (0.6)	
Appearance motivation	6	1–4	0.86	828	1–4	3.1 (0.8)	0.37 (0.01, 0.73)
Fitness motivation	3	1–4	0.65	828	1–4	3.7 (0.5)	−0.78 (−1.44, − 0.11)
Social motivation	3	1–4	0.64	828	1–4	3.1 (0.8)	
Child characteristics, parent reported							
Parent rating of child's PA	3	1–5	0.75	774	1–5	3.1 (0.8)	1.09 (0.70, 1.48)
Sport/classes participation, Yes/No	1	0–1	N/A	736	1–5	Yes, 65.4%	0.79 (0.18, 1.39)
Weekday outdoor hours	1	N/A[a]	N/A	756	0–4	2.1 (1.2)	
Weekend day outdoor hours	1	N/A[a]	N/A	758	0–8	4.3 (2.2)	0.19 (0.05, 0.32)
Walk/bike to school	1	0–1	N/A	726	0–1	Yes, 50.7%	
How important that child is active	1	1–4	N/A	767	1–4	3.6 (0.6)	0.61 (0.10, 1.12)
Parent characteristics, parent reported							
Parent-reported support	4	1–5	0.76	771	1–5	2.8 (0.8)	1.12 (0.76, 1.48)
Parent leisure time	4	N/A[a]	0.42	759	1–4.8	2.5 (0.7)	−0.58 (−1.12, − 0.14)
Parent sports	4	N/A[a]	N/A	772	0.7–6.4	2.1 (0.8)	
Parent enjoys PA	1	1–5	N/A	764	1–5	3.2 (0.8)	
Home environment, child reported							
Perceived environment	9	1–4	0.73	828	1–4	2.9 (0.6)	0.51 (0.08, 0.95)
Equipment	1	1–4	NA	824	1–4	3.3 (1.0)	0.18 (−0.09, 0.45)
Home characteristics, parent reported							
Rules on sedentary equipment	3	1–4	0.84	773	1–4	1.9 (0.7)	−0.30 (−0.69, 0.09)
Sedentary equipment in child's bedroom	3	0–3	N/A	763	0–3	1.3 (0.9)	
Sedentary items in home	4	0–25	N/A	761	1–25	9.5 (3.5)	
Access to active equipment	14	0–14	N/A	757	1–13	6.3 (2.6)	0.09 (−0.02, 0.20)
Number adults in home: single parent vs 2 or more adults	1	0–1	N/A	764	0–1	2 or more =78.9%	
Social factors, child reported							
Parent support	8	1–5	0.88	789	1–5	3.3 (1.0)	0.79 (0.43, 1.16)
Parent encouragement	2		0.65	790	1–5	3.7 (1.0)	−0.49 (−0.86, − 0.12)
Peer support	3	1–5	0.71	828	1–5	3.4 (1.0)	

Variable	Number of items	Possible Range	Cronbach' s α	n	Observe d range	Mean (SD) or %	Estimate (95% CI), $p<0.20$
Active friends	1	0–5	N/A	825	0–5	3.8 (1.3)	0.22 (−0.005, 0.43)
School environment, teacher or administrator reported							
Recess minutes/week, administrator	2	N/A[a]	N/A	828	75–200	100.5 (25.6)	
PE yearly minutes, teacher reported	2	N/A[a]	N/A	787	1,440–3,330	2,255 (631)	
Intramural activities, teacher reported	1	N/A[a]	N/A	828	0–6	1.3 (1.7)	0.35 (0.14, 0.56)
Community characteristics, directly observed							
Physical incivilities (windshield survey)	7	0–1	N/A	752	0–1	0.26 (0.4)	
Social spaces (windshield survey)	9	0–9	N/A	752	0–9	3.1 (1.0)	0.01 (−0.28, 0.30)
Territorial (windshield survey)	6	0–4	N/A	752	0–4	1.7 (0.9)	
PARA weighted score (2-mile buffer)	1	N/A[a]	N/A	821	0–148	25.2 (29.1)	0.01 (−0.001, 0.02)

[a]No range. Respondents reported an open-ended response.

PA, physical activity; PE, physical education; PARA, Physical Activity Resource Assessment; N/A, not applicable.

Table 3.

Growth curve analyses for identification of variables longitudinally associated with physical activity in children[a]

Fixed effects	Model 1	Model 2	
	Estimate (95% CI)	Initial PA, estimate (95% CI)	Change in PA,[b] estimate (95% CI)
Intercept	28.03 (27.62, 28.44)	**27.22 (26.36, 28.07)**	
Time	−2.94 (−3.25, −2.63)	**−2.87 (−3.12, −2.62)**	
Sex, males		0.19 (−0.63, 1.00)	
Race			
Black		**1.19 (0.57, 1.80)**	
Hispanic		0.34 (−0.50, 1.18)	
Other		0.42 (−0.25, 1.08)	
White		ref	
Parent education, more than high school		**−0.99 (0.50, 1.47)**	
Percent poverty		−0.02 (−0.05, 0.02)	
Maturity offset, 5th grade		**−1.12 (−1.49, −0.75)**	
Self-efficacy		0.21 (−0.42, 0.85)	0.05 (−0.36, 0.45)
Perceived barriers		0.29 (−0.40, 0.98)	−0.17 (−0.59, 0.26)
Self schema		0.01 (−0.03, 0.04)	0.003 (−0.02, 0.03)
Appearance motivation		0.23 (−0.16, 0.62)	0.22 (−0.02, 0.46)
Fitness motivation		−0.35 (−1.05, 0.36)	−0.33 (−0.77, 0.10)
Parent rating of child's PA		**0.86 (0.42, 1.31)**	0.05 (−0.23, 0.32)
Sport/classes participation		**0.92 (0.25, 1.60)**	−0.07 (−0.49, 0.36)
Weekend day outdoor hours		**0.19 (0.05, 0.34)**	−0.03 (−0.12, 0.06)
How important that child is active		0.52 (−0.03, 1.07)	−0.21 (−0.55, 0.13)
Parent-reported support		0.16 (−0.27, 0.60)	−0.03 (−0.31, 0.24)
Parent leisure time		−0.45 (−0.92, 0.02)	0.02 (−0.27, 0.31)
Perceived environment		0.01 (−0.48, 0.51)	−0.11 (−0.42, 0.21)
Child-reported equipment		0.00002 (−0.29, 0.29)	−0.08 (−0.26, 0.11)
Rules on sedentary equipment		−0.11 (−0.52, 0.30)	0.03 (−0.22, 0.29)
Access to active equipment		−0.003 (−0.13, 0.12)	0.04 (−0.03, 0.12)
Child-reported parent support		**0.51 (0.10, 0.91)**	−0.05 (−0.31, 0.20)
Child-reported parent encouragement		**−0.54 (−0.90, −0.18)**	**0.27 (0.04, 0.49)**
Active friends		0.12 (−0.11, 0.35)	−0.02 (−0.16, 0.12)
Intramural activities, teacher reported		**0.32 (0.15, 0.50)**	**−0.28 (−0.42, −0.14)**
Social spaces (windshield survey)		**−0.34 (−0.64, −0.04)**	**0.32 (0.14, 0.51)**
PARA weighted score (2-mile buffer)		**0.01 (0.003, 0.02)**	−0.003 (−0.01, 0.004)
Goodness of fit			
Deviance	12,741.8	12,412.1	
AIC	12,757.8	12,526.1	

Fixed effects	Model 1	Model 2	
	Estimate (95% CI)	Initial PA, estimate (95% CI)	Change in PA,[b] estimate (95% CI)
BIC	12,765.8	12,582.8	

Note: Boldface indicates statistical significance ($p<0.05$).

[a]Variables were centered, and values reported are coefficients with 95% CI in parentheses estimated using full maximum likelihood.

[b]From 5th to 7th grade

PA, physical activity; PARA, Physical Activity Resource Assessment; AIC, Akaike's Information Criterion; BIC, Bayesian Information Criterion.