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PAPER

Physical activity in overweight and nonoverweight preschool children

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OBJECTIVE: To compare the physical activity levels of overweight and non overweight 3- to 5-y-old children while attending preschool. A secondary aim was to evaluate weight-related differences in hypothesized parental determinants of child physical activity behavior.
DESIGN: Cross-sectional study.
SUBJECTS: A total of 245, 3- to 5-y-olds (127 girls, 118 boys) and their parent(s) (242 mothers, 173 fathers) recruited from nine preschools. Overweight status determined using the age- and sex-specific 85th percentile for body mass index (BMI) from CDC Growth Charts.
MEASUREMENTS: Physical activity during the preschool day was assessed on multiple days via two independent objective measures—direct observation using the observation system for recording activity in preschools (OSRAP) and real-time accelerometry using the MTI/CSA 7164 accelerometer. Parents completed a take-home survey assessing sociodemographic information, parental height and weight, modeling of physical activity, support for physical activity, active toys and sporting equipment at home, child's television watching, frequency of park visitation, and perceptions of child competence.
RESULTS: Overweight boys were significantly less active than their nonoverweight peers during the preschool day. No significant differences were observed in girls. Despite a strong association between childhood overweight status and parental obesity, no significant differences were observed for the hypothesized parental influences on physical activity behavior.
CONCLUSIONS: Our results suggest that a significant proportion of overweight children may be at increased risk for further gains in adiposity because of low levels of physical activity during the preschool day.
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Introduction

The prevalence of overweight and obesity among children and adolescents is increasing at an alarming rate. Data from the 1999 US National Health and Nutrition Examination Survey (NHANES) indicate that 13% of children between the ages of 6–11 y and 14% of adolescents between the ages 12–19 y are obese, an increase of 2–3% from NHANES III (1988–1994).[1] Similar increases have been reported in the UK,[2] Canada,[3] and Australia.[4] The global rise in childhood obesity rates represents a critical public health problem. Not only are obese children at increased risk for adult obesity,[5] they are more likely than non obese children to experience significant short-term health problems such as hyperlipidemia, hypertension, insulin resistance, respiratory problems, and orthopedic complications.[6]

The preschool years have been identified as a crucial time to study the determinants of childhood obesity.[7] Not only is it a time when eating and physical activity habits are becoming established,[8] it is also a time period immediately preceding the upswing in body mass index (BMI) known as adiposity rebound.[7,9] Indeed, an expert panel organized by the Centers for Disease Control and Prevention recently recommended that the relation between physical activity and obesity in preschool children be better characterized.[10]

Previous studies involving preschool-aged children have shown physical activity to be protective of accelerated weight gain and inversely associated with change in body fatness.[11,12] However, to date, no previous study has examined the physical activity levels of overweight and

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nonoverweight children during the preschool day. It has been previously shown that overweight children find sedentary activities more reinforcing than active pursuits.[13] Therefore, it is reasonable to hypothesize that, in discretionary situations, overweight preschool children may elect to participate in sedentary or low-intensity activities over more active forms of play. Importantly, low levels of physical activity during the preschool day may contribute to a state of positive energy balance and place overweight children at risk for further gains in adiposity.

In addition, research on the mediators of familial patterns of overweight and obesity suggests that overweight parents tend to create environments that promote overweight among their children.[14] Therefore, it is possible that parents of overweight children may exhibit activity-related behaviors, and parenting practices that consciously or unconsciously discourage their children from participating in physical activity at preschool or other behavioral settings. We are aware of no other studies that have examined the effects of parental influences on child physical activity participation during the preschool day.

To fill these important gaps in the research literature, the purpose of this study was to compare the physical activity levels of overweight and nonoverweight 3- to 5-y-old children while attending preschool. A secondary aim was to evaluate potential weight-related differences in hypothesized parental determinants of child physical activity behavior such as modeling of physical activity, support for physical activity, and sporting/fitness equipment at home. To overcome many of the difficulties associated with obtaining valid and reliable measures of physical activity in preschool-aged children,[10,15] we employed two independent objective measures of physical activity behavior—direct observation and real-time accelerometry.

Methods

Sample

Subjects for this study were recruited from nine preschools operating in the Columbia, SC metropolitan area. Prior to selection, all preschools with an enrollment of 60 or more children were identified and classified as either privately operated (private), church-based (church), or predominantly government funded (Head Start). From each of these three strata, three preschools were randomly selected. If a preschool refused participation or could not provide a sufficient number of participants, a replacement preschool was randomly selected from the appropriate stratum.

A total of 281 children and their families were recruited into the study. The number of participants from each center ranged between 22 and 30 (mean 27.4 ± 3.1). After deletions for missing BMI ($n = 14$), child physical activity data ($n = 8$), and parental survey data ($n = 14$), the sample size was reduced to 245 child participants (127 girls, 118 boys), and their parent(s) (242 mothers, 173 fathers). Approximately 60% of the families participating in the study were African American, and just over half of the parents (51.1%) did not have a college education. The study was approved by the University of South Carolina Institutional Review Board, and parents of participating children provided written informed consent.

Child weight status

Height and weight assessments were conducted in a private setting with children dressed in light clothing. Height was measured to the nearest 1.0 cm using a portable stadiometer. Weight was measured to the nearest 0.1 kg using high precision electronic scales (Seca Corp, Birmingham, UK). BMI was calculated as body mass in kilograms divided by height in meters squared (kg/m^2). Children were classified as overweight if their BMI was equal to or greater than the sex- and age-specific 85th percentile from the Centers for Disease Control and Prevention's Growth Charts.[16]

Assessment of physical activity

Direct observation. Physical activity level was quantified using an instrument called OSRAP—the observation system for recording activity in preschools. This system was modified from the Children's Activity Rating Scale (CARS).[17] A research assistant observed the activity of a child continuously for 15 s, followed by 15 s of recording. Physical activity within each 15 s observation period was rated on five-point scale with (1) *stationary/motionless* and (5) *fast movement* serving as end points. In addition to activity level, observers recorded the child's physical location, the structure or context of the observed behavior, the type of activity being performed, the presence or absence of interactors, and the frequency of activity-related prompts from interactors. All data were entered directly into a Palm Vx hand-held computer with the aid of a customized database form.

Participants were observed for 1-h on three separate days. To avoid bias related to the time of day, participants were randomly assigned to observation periods corresponding to different segments of the day. Participants were not observed during scheduled meal times or rest periods. All observations were completed by two research assistants, who, prior to formal data collection duties, completed over 20 h of theoretical and practical training. Interobserver agreement at the midpoint of the study was assessed by simultaneous field observations of the same child. Intraclass correlations for the mean activity rating ranged from 0.91 to 0.98. Percent agreement for the five activity categorizations was substantial to excellent, ranging from 75 to 99%.[18]

For the present study, the physical activity variables of interest were the mean activity rating over the 1-h observational period (Mact), and the percentage of observations with an activity rating of three or greater (%MVPA). Mact and %MVPA scores for the three observation days were each

averaged to provide an index of daycare physical activity participation.

Accelerometry. In addition to direct observation, physical activity was quantified using the Manufacturing Technologies Inc. (MTI) (formerly CSA) 7164 uniaxial accelerometer.[19] Since the typical 1-min sampling interval may mask the short intermittent bursts of activity characteristic of young children,[20] a 15-s sampling interval was used. The number of days and the length of time children wore the activity monitor each day varied according to the child's receptivity to wearing the monitor and school's policy regarding use of the monitor. The number of monitoring days ranged from 1 to 11 days (mean 6.6 ± 2.3) and the monitoring time on each day ranged from 0.4 to 7.8 h (mean 4.4 ± 1.3 h). For the present study, only those participants with at least 3 days of monitoring data were included in the analyses. The MTI/CSA 7164 has been shown to provide valid assessments of physical activity in preschool-aged children.[21]

Data reduction. Activity counts for each 15-s interval were uploaded to a visual basic data reduction program for the determination of total counts per hour, number of vigorous intervals per hour, and the number of moderate to vigorous intervals per hour. Age-specific count cutoffs corresponding to the moderate (3–5.9 METs) and vigorous physical activity ($\geqslant$6 METs) were derived from the MET prediction equation developed by Sirard *et al*.[22]

$$\text{METs} = 1.43 + 0.00399\,(\text{counts}) - 0.14882\,(\text{age})\ (R^2 = 0.79)$$

In a different sample of 23 3–5-year olds, the correlation between OSRAP mean activity rating and number of vigorous and moderate to vigorous intervals per hour was 0.67 and 0.52, respectively ($P<0.05$).

Parental measures

Parents completed a brief questionnaire assessing sociodemographic information, height, weight, and previously studied parental determinants of physical activity behavior including parental modeling, parental support for physical activity, park visitation, perceived competence of their child, time permitted for television watching, and number of active toys and sports equipment in the home. The items appearing on the questionnaire were adapted from those used in the International Life Sciences Institute national phone survey[23] and the Amherst Health and Activity Study.[24]

Statistical analyses

All statistical analyses were conducted using SAS (Version 8.0). Differences in the physical activity variables were tested using two-way ANCOVA. Within each linear model, sex and weight status served as the grouping variables with parent education serving as a covariate. For the observation-derived dependent variables, percentage of time observed in an indoor or outdoor play area was included as an additional covariate. The least-squares means procedure was used to evaluate the significance of preplanned contrasts between overweight and non-overweight boys and girls, respectively. Group differences in proportions were tested using two-way contingency tables and Fisher's exact tests. Statistical significance was set at an alpha level of 0.05.

Results

Descriptive statistics for the overweight (OW) and nonoverweight (NOW) participants are shown in Table 1. Apart from the expected differences in BMI and body mass, there were no significant group differences for age or proportion of children who were African American. NOW girls were significantly taller than OW girls, while OW boys were significantly taller than NOW boys.

Group means for the physical activity variables are shown in Table 2. Relative to NOW boys, OW boys exhibited significantly lower scores for the observational activity variables and exhibited significantly fewer counts per hour, MVPA intervals per hour and VPA intervals per hour. No weight-related differences were observed among girls.

Group comparisons with respect to the hypothesized parental determinants of physical activity are shown in Table 3. No significant differences were noted for the level of parental modeling, parental support, active toys or sporting equipment at home, television watching, perceived level of

Table 1 Descriptive statistics for overweight and nonoverweight girls and boys

	Girls		*Boys*	
	OW (n = 35)	*NOW (n = 92)*	*OW (n = 25)*	*NOW (n = 93)*
Age (y)	3.9 ± 0.08	4.1 ± 0.12	4.3 ± 0.14	4.0 ± 0.07
Height (cm)	107.0 ± 0.7	$112.8 \pm 1.1^{*}$	112.2 ± 1.3	$108.6 \pm 0.7^{*}$
Body mass (kg)	24.1 ± 0.5	$17.5 \pm 0.3^{*}$	22.2 ± 0.6	$18.1 \pm 0.3^{*}$
BMI (kg/m^2)	18.8 ± 0.2	$15.2 \pm 0.1^{*}$	$17.6 \pm 0.2^{*}$	$15.3 \pm 1.0^{*}$
% African American	68.6	59.1	60.0	54.8

*Significant difference between overweight and nonoverweight children within gender group $P<0.05$.

Table 2 Group differences with respect to the physical activity variables (Mean ± s.d.)

	Girls		*Boys*	
	OW (n = 35)	*NOW (n = 92)*	*OW (n = 25)*	*NOW (n = 93)*
Mean activity rating	2.50 ± 0.19	2.49 ± 0.20	2.40 ± 0.20	2.60 ± 0.19*
% Time in MVPA	42.2 ± 12.8	41.6 ± 12.5	39.0 ± 12.5	47.6 ± 12.7*
Total counts/h × 10^3	51.9 ± 15.8	52.1 ± 15.7	50.5 ± 14.4	60.0 ± 14.5*
MVPA interveral/h	28.3 ± 10.8	28.5 ± 11.1	27.2 ± 10.5	33.7 ± 8.5*
VPA intervals/h	4.7 ± 3.0	5.6 ± 3.7	4.9 ± 3.1	6.7 ± 2.8*

*Significant difference between overweight and nonoverweight children within gender group ($P < 0.05$).

Table 3 Group differences with respect to hypothesized parental influences on physical activity

	Girls		*Boys*	
	OW (n = 35)	*NOW (n = 92)*	*OW (n = 25)*	*NOW (n = 93)*
Parental support[1]	3.5 ± 0.1	3.5 ± 0.7	3.7 ± 0.1	3.6 ± 0.6
Home equipment[2]	8.2 ± 0.5	7.4 ± 0.3	8.0 ± 0.6	7.4 ± 0.3
TV watching [3]	2.4 ± 0.2	2.5 ± 0.1	2.9 ± 0.3	2.6 ± 0.2
Park visitation[4]	2.5 ± 0.2	2.2 ± 0.1	2.3 ± 0.2	2.0 ± 0.1
Perceived competence[1]	3.3 ± 0.1	3.3 ± 0.1	3.6 ± 0.1	3.5 ± 0.1
Parent active %	22.2	23.2	45.0	29.7
Parent obese %	54.3	23.9*	68.0	25.8*

*Significant difference between overweight and nonoverweight children within gender group ($P < 0.05$). 1 = rating on a Likert scale ranging from 1 to 5—higher rating represents a greater amount of the attribute being measured; 2 = Number of items in the home; 3 = TV hours per day; 4 = park visits per month.

competence, and frequency of park visitation. Child OW status was significantly associated with parental obesity. Compared to their NOW counterparts, OW boys and girls were 6.1 (95% CI: 2.3–16.0) and 3.8 (95% CI: 1.7–8.7) times more likely to have at least one obese parent or adult caregiver at home, respectively.

Discussion

To our knowledge, this is the first study to evaluate weight-related differences in physical activity during the preschool day. Our major finding was that overweight boys participated in significantly less physical activity than nonoverweight boys during the preschool day. Notably, no weight-related activity differences were observed in girls. While the cross-sectional nature of this study does not allow for conclusions concerning cause and effect, our findings in boys are consistent with the hypothesis that physical inactivity is an important contributing factor to the development and maintenance of childhood obesity.[25] They also suggest that a considerable percentage of overweight preschool children may be at risk for further gains in adiposity by virtue of their low levels of physical activity during the preschool day.

Contrary to our findings in boys, weight status was not associated with preschool physical activity in girls. This result is difficult to explain. It is possible that activity levels were sufficiently low in both groups of girls that overweight status was unable to exert a negative influence on physical activity behavior (ie, a floor effect). Alternatively, the types of activities engaged in by girls during the preschool day may be less influenced by excess adiposity than activities typically engaged in by boys. In support of this contention, observational studies of preschool children have shown that boys engage in more vigorous-intensity activities, play in larger groups in more open settings, engage in more risk-taking behavior, and play rougher games involving greater amounts of body contact than girls.[26–28] While it is not possible to provide a definitive explanation for our gender-specific findings, the large gender gap in physical activity observed in this and other studies of preschool children,[29–31] strongly supports the recommendation that efforts to promote physical activity in girls start early in life.[32,33]

Recent research has shown that familial patterns of overweight and obesity are mediated, in part, by parenting eating behaviors (parental energy intake, mother's dietary restraint, and disinhibition) and parental child-feeding practices (concern for child's weight, monitoring, and restriction of child's food intake).[34–38] In the present study, parental obesity was strongly associated with child weight status. For girls and boys, respectively, overweight children were approximately three and six times more likely than their nonoverweight counterparts to have at least one obese

parent or adult caregiver. However, in contrast to studies in which parental eating and food-related parenting practices were associated with child weight status, we observed no significant differences between overweight and nonoverweight children with respect to parental modeling of physical activity, support for physical activity, time allowed to watch television, frequency of park visitation, perceived level of coordination, and the amount of active toys and sporting equipment at home. On the surface, this suggests that the lower levels of physical activity exhibited by overweight boys during the preschool day may be associated with personal motivational factors and/or contextual factors at the preschool rather than activity-related parenting practices and behaviors at home. Nevertheless, additional studies utilizing prospective study designs and more rigorous measures of parental influence are required before the contribution of parental behaviors and practices to preschool physical activity can be fully or partially discounted.

A major strength of this study was the use of two independent objective measures to assess the quantity and intensity of physical activity during the preschool day. Direct observational methods are commonly used to measure physical activity in preschool-aged children; however, this is the first study to also use a state-of-the-art accelerometer to quantify participation in moderate- and vigorous-intensity physical activity during the preschool day. The fact that both measures of physical activity provided the same pattern of differences supports the validity of our findings. A further strength was our diverse sample. Participating families were recruited from a combination of private-, religious-, and government-subsidized preschools and approximately 60% of the child participants were African American. Moreover, just over half of the parents did not have a college education. The diversity of our sample is an important consideration as the majority of previous studies examining parental influences and weight status in children have been conducted with white, university-educated families.

The present study had several limitations that warrant consideration. First, the cross-sectional nature of this study precluded our ability to infer a causal relation between preschool physical activity level and weight status. Second, overweight status was based on an age- and sex-specific percentile for BMI ($\geqslant$85th percentile). While this approach is consistent with other studies, it should be recognized that weight for height indices are imperfect measures of adiposity, particularly among young children.[39] Third, our reliance on self-report methods to measure the parental influences, in particular, height and weight, raises the possibility of social desirability and recall bias. However, previously conducted population-based studies have reported high correlations (>0.90) between measured and self-reported height and weight.[40] Lastly, although the primary focus of the study was preschool physical activity, we did not examine physical activity at home or other settings as a potential mediator of weight-related difference in preschool physical activity behavior.

In summary, direct observation and real-time accelerometry showed overweight 3- to 5-y-old boys to be significantly less active than nonoverweight peers during the preschool day. No significant differences were observed in girls. Despite a strong association between childhood overweight status and parental obesity, previously studied parental influences of physical activity behavior such as parental modeling, parental support, and amount of active toys and sporting equipment at home did not differ significantly by child weight status. Our results suggest that a significant proportion of overweight children may be at increased risk for further gains in adiposity because of low levels of physical activity during the preschool day. Thus, additional prospective studies investigating the contribution of preschool physical activity level to weight status in young children, and the physical activity-related mediators of familial patterns of overweight and obesity are warranted.

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