Directly Observed Physical Activity Levels in Preschool Children

Russell R. Pate, PhD[a]
Kerry McIver, MA[b]
Marsha Dowda, DrPH[c]
William H. Brown, PhD[d]
Cheryl Addy, PhD[e]

ABSTRACT

BACKGROUND: Millions of young children attend preschools and other structured child development programs, but little is known about their physical activity levels while in those settings. The purpose of this study was to describe the physical activity levels and demographic and school-related correlates of physical activity in children attending preschools, using a direct observation measurement system.

METHODS: The Observational System for Recording Physical Activity in Children-Preschool Version was used to measure physical activity levels and related factors in four hundred ninety-three 3- to 5-year-old children in 24 preschools. A minimum of six hundred 30-second observation intervals were recorded for each child. Physical (height/weight) and demographic data also were collected.

RESULTS: Children engaged in moderate-to-vigorous physical activity (MVPA) during less than 3% of the observation intervals and were sedentary during more than 80% of the observation intervals. Boys were more likely than girls to engage in MVPA ($p = .01$), and 3-year-old boys were more active than 4- and 5-year-old boys ($p = .01$). The preschool that a child attended explained 27% of the variance in activity levels.

CONCLUSIONS: The study indicates that young children are physically inactive during most of their time in preschool. The preschool that a child attended was a stronger predictor of physical activity level than any other factor examined. Additional research is needed to identify the characteristics of preschools in which children are more active.

Keywords: preschool; physical fitness and sport; public health.

Citation: Pate RR, McIver K, Dowda M, Brown WH, Addy C. Directly observed physical activity levels in preschool children. J Sch Health. 2008; 78: 438-444.

[a]Professor, (rpate@gwm.sc.edu), Department of Exercise Science, University of South Carolina, 921 Assembly St, Columbia, SC 29208.

[b]Doctoral Student, (mciverkl@mailbox.sc.edu), Department of Exercise Science, University of South Carolina, 921 Assembly St, Columbia, SC 29208.

[c]Biostatistician, (mdowda@gwm.sc.edu), Department of Exercise Science, University of South Carolina, 921 Assembly St, Columbia, SC 29208.

[d]Professor, (bbrown@gwm.sc.edu), College of Education, University of South Carolina, 801 Sumter St, Columbia, SC 29208.

[e]Associate Professor, (caddy@gwm.sc.edu), Department of Epidemiology and Biostatistics, University of South Carolina, 800 Sumter St, Columbia, SC 29208.

Address correspondence to: Russell R. Pate, Professor, (rpate@gwm.sc.edu), Department of Exercise Science, University of South Carolina, 921 Assembly St, Columbia, SC 29208.

This study was funded by a grant from the National Institute of Child Health and Human Development. The authors thank Nazeema Kapacee and Rebecca Polizzotto for collecting the observational data and Gaye Groover Christmus, MPH, for editorial assistance in the preparation of the manuscript.

Preschool-age children often are perceived to be highly physically active, and previous studies have shown that 3- to 5-year-olds are more physically active than children in older age groups. However, a few studies suggest that very young children are not as active as many people believe.[1-4] In addition, national surveys show that obesity rates in American children and youth have increased dramatically in recent decades,[5] and this alarming trend is evident in preschool children as well as older children and youth.[5,6] Between 1999 and 2004, the percentage of preschool-aged children (2-5 years old) that was observed as overweight or obese increased from 22.0% to 26.2%.[6] The causes of the population trend in childhood obesity have not been identified definitively. However, it seems likely that reduced physical activity and increased participation in sedentary behaviors are important contributing factors.[7-9]

Approximately 5 million American preschool-age children currently attend preschools and other structured child development programs, a number which has increased markedly over the past 2 decades.[10] On average, a child attending a preschool or day care center will spend 30 hours per week at the facility.[10] With the increase in the number of children attending structured programs and the amount of time they are spending in these settings, it is likely that the amount of physical activity children accumulate while in preschools and child development centers influences energy balance and risk of overweight.

Relatively little is known about the physical activity levels of children while they attend preschools or about how activity levels vary across preschools. Valid measurement of physical activity in young children is challenging, in part because much of their activity is performed in very short spurts.[11] One preferred method for monitoring physical activity in young children is direct observation, a technique that allows detection of these short spurts of activity with minimal reactivity of the participants and no reliance on participant compliance.[12] The present study was designed to employ a direct observation measurement system to describe the physical activity levels of children attending preschools. In addition, the study described the demographic correlates of physical activity in preschoolers and determined the extent to which children's physical activity levels varied across schools.

METHODS

Participants

Participants in this study were recruited from 24 preschools in and around Columbia, SC. Preschools were recruited using a stratified random selection procedure. The pool of eligible preschools included all licensed preschools in Richland and Lexington counties with an enrollment of greater than or equal to forty-five 3- to 5-year-old children. Each school was assigned to 1 of 3 strata based on sponsorship and setting; preschools were classified as commercial, church-based, or Head Start programs. After placing schools in the 3 strata, a representative number of schools from each stratum (based on the distribution of enrollment across the 3 types) were invited to participate. If a school refused to participate, the next randomly selected school in that stratum was invited to participate. Of the preschools that were invited to participate, 8 declined participation for reasons that included lack of interest in the study and school policy prohibited participating in the study. Data were collected in 12 commercial, 8 church-based, and 4 Head Start preschools.

Parents of all 3-, 4-, and 5-year-old children who attended the 24 preschools were invited to enroll their children in the study. There were 2 rounds of data collection, separated by 13-19 months, at each preschool. The study's participant recruitment protocol called for including 18 children per preschool in the first round of data collection and 15 children per preschool in the second round. If the parents of more than the prescribed number of children provided informed consent, participants were selected at random from the pool of consented children. The number of participants ranged from 14 to 33 children per preschool, and a total of 539 children (51% males, 55% African American) were enrolled in the study. This sample was very similar to the population of children (51% males, 61% black) in the 24 preschools. Ninety-one percent of children enrolled in the study were observed (n = 493). After deletions for race other than African American or white (n = 38), race unknown (n = 9), insufficient data (n = 3), or missing age (n = 5), data from 438 children were available for analyses. Of this analysis sample, 59% were African American, and equal numbers were male and female. Each participating child's parent or guardian provided written informed consent. The study was approved by the University of South Carolina Institutional Review Board.

Assessment of Physical Activity

The Observational System for Recording Physical Activity in Children-Preschool Version (OSRAC-P)[12] was used to measure physical activity in the preschool setting. OSRAC-P is a focal child, momentary time sampling observation system with a 5-second observe interval followed by a 25-second record interval for each 30-second observation interval. The observational system assesses physical activity level and activity type (eg, running, sitting, walking, and riding), social environment (eg, initiator of activity, group composition), and nonsocial environment (ie, child location and activity contexts). Files from each child were merged

and summarized by calculating the frequency of each activity code across all observation sessions. Physical activity codes used in the OSRAC-P were modified from the Children's Activity Rating Scale,[13] and activity levels are scored on a 1-5 scale, with 1 indicating stationary or motionless and 5 indicating fast movement. Intervals coded as level 1 (stationary) or 2 (stationary with limb movement) were considered Sedentary activity. Intervals coded as level 3 (slow, easy movement) were considered Light activity. Intervals coded as levels 4 or 5 were considered Moderate and Vigorous activity, respectively. The Active category included all intervals coded as 3, 4, or 5, and moderate-to-vigorous physical activity (MVPA) included all intervals coded as 4 or 5. Data were collected in 30-minute sessions, and each child was observed for 10-12 sessions. Two observation intervals were coded each minute, for a total of 600-720 observation intervals per child. The observation sessions were randomly chosen from the hours that each child attended preschool and were spread across 10 days.

Each observer had extensive training using the OSRAC-P prior to data collection.[12] To assess interobserver reliability, 2 observers simultaneously coded during 1-3 observation sessions per day. Reliability was assessed during 12% of the total observations made over the course of the study (681 reliability sessions/5830 total observation intervals). Interobserver agreement (IOA) was good for every observation category (range of 83-100%), and Kappa scores indicated good interobserver reliability (range of scores: 0.80-0.95). The mean Kappa score for physical activity level was 0.82, and IOA was 91% for all reliability observation sessions. Data were collected using INTMAN software[14] with handheld Dell Axim X5 computers (Dell World Trade LP, Round Rock, TX).

Other Measurements

Parents completed a survey which included the child's age, gender, and race/ethnicity and the parents' level of education. Children were grouped into 2 age categories, with 3-year-olds in 1 category and 4- and 5-year-olds in the other. Height was measured to the nearest 0.1 cm using a portable stadiometer (Shorr Productions, Olney, MD). Weight was measured to the nearest 0.1 kg using an electronic scale (Seca, Model 770, Hamburg, Germany). The average of 2 measurements was used for both height and weight. Body mass index (BMI) was calculated and expressed as kg/m^2.

Statistical Analyses

All statistical analyses were performed using SAS 9.1 software (SAS Institute, Cary, NC). Three-way analyses of variance (ANOVAs) (sex, race, and age group) were calculated for main effects using Proc Mixed with preschool as a random variable and adjusting for BMI. Two-way and 3-way interactions were also tested. Because all the preschools scheduled a nap during each day, and because children were required to be sedentary during nap periods, ANOVAs were run with and without the observations where the type of activity observed was nap. Regression analyses (all intervals) were also conducted for percent of observations that were MVPA and Active (codes 3-5). Three sets of analyses were performed for each outcome variable. The first regression model included age, gender (male = 1, female = 0), BMI, and race (white = 1, black = 0). The second included the demographic variables and type of preschool (church-based or Head Start, with commercial as the reference group). The third regression model included the demographic variables and a block of 23 dummy variables representing the effect of each preschool. Statistical significance was set at an α level of .05.

RESULTS

Mean age of the children was 4.2 (SD = 0.7) years; 41% were in the 3-year-old group and 59% were in the 4- to 5-year-old group (Table 1). Over 50% of the parents were college graduates or higher. Forty-six percent of the children attended commercial preschools, 21% attended Head Start programs, and 33% attended church-based preschools.

Table 1. **Characteristics of 438 Preschool Children**

Characteristic	Mean (SD) or Percent
Age	4.2 (0.7)
BMI	16.5 (2.6)
Sex	
Males	50.0%
Females	50.0%
Race	
Black	58.7%
White	41.3%
Highest parent education	
≤High school graduate	16.8%
Technical school/some college	29.4%
College graduate or higher	53.8%
24 preschools	Range: number = 11-26 students Observations/student = 594.3-710.8 Sessions/student = 9.9-11.8 sessions
Type of preschool	
Commercial	
Percent of students	46.1%
Mean observations/student	678.4
Mean sessions/student	11.3
Head Start	
Percent of students	20.6%
Mean observations/student	598.7
Mean sessions/student	10.0
Church-based	
Percent of students	33.3%
Mean observations/student	655.1
Mean sessions/student	10.9

Table 2. **Mean (SD) Percent of Observation at Levels of Physical Activity**

	Mean (SD) Percent	
Level	**All Intervals**	**Nap Removed**
1 (stationary)	55.6 (12.5)	46.4 (12.5)
2 (stationary with limb movement)	31.7 (9.4)	37.0 (9.1)
3 (slow, easy movement)	8.1 (3.6)	10.5 (4.4)
4 (moderate activity)	0.8 (0.8)	1.1 (1.0)
5 (vigorous activity)	1.8 (1.4)	2.3 (1.9)
Sedentary (levels 1 and 2)	87.3 (5.5)	83.4 (6.9)
Light (level 3)	8.1 (3.6)	10.5 (4.4)
MVPA (levels 4 and 5)	2.6 (1.9)	3.4 (2.5)
Active (levels 3-5)	10.7 (5.1)	13.9 (6.3)

Table 2 presents the mean percent of observations at the 5 levels of physical activity. More than 80% of the observations were coded as Sedentary. Eight to ten percent of observations (with and without nap periods included) were coded as Light activity, and approximately 3% were coded as MVPA.

Results of the 3-way ANOVA (sex, race, and age group) are presented in Tables 3 and 4. After removing intervals that occurred during nap periods, the percentage of intervals coded as Light, MVPA, and Active were higher than when intervals including nap were included. The 4- to 5-year-olds had significantly more intervals coded as Sedentary and were observed less frequently in Light, MVPA, and Active codes than the 3-year-olds. Males were observed in significantly more MVPA than females and, after removal of nap periods, males had significantly more observations in Active codes. An age × sex 2-way interaction was borderline significant for MVPA for the model with nap included (Figure 1). Three-year-old males were observed in more MVPA than 4- and 5-year-olds (3.2% vs. 2.5% of observed time spent in MVPA, respectively; p = .01), but there was no difference among the females.

Table 5 presents results of regression analyses to predict percent of Active and MVPA categories among preschool children. The first set of models with sex, age, BMI, and race resulted in R^2 of .10 and .08 for Active and MVPA, respectively. In the second set of models, type of preschool was added to the model with commercial as the reference. The R^2 increased to .18 for Active and to .09 for MVPA. In the third set of models, individual preschools were added to models after the addition of the demographic variables. This resulted in R^2s of .37 for Active and .22 for MVPA.

DISCUSSION

This is the first large-scale study to apply a direct observation system in describing the physical activity

Table 3. **Results of 3-Way ANOVA With Preschool as a Random Variable (Main Effects Only) Using All Intervals***

	Independent Variables								
Dependent Variables	**Sex**	**Mean (SE) % Time**	**p**	**Race**	**Mean (SE) % Time**	**p**	**Age Group**	**Mean (SE) % Time**	**p**
Sedentary	Male	87.1 (0.7)	.40	Black	87.8 (0.7)	.14	3	86.6 (0.7)	.01
	Female	87.4 (0.7)		White	86.7 (0.8)		4 and 5	87.9 (0.6)	
Light	Male	8.3 (0.5)	.26	Black	7.9 (0.5)	.35	3	8.6 (0.5)	.003
	Female	8.0 (0.5)		White	8.4 (0.5)		4 and 5	7.7 (0.5)	
MVPA	Male	2.8 (0.2)	.01	Black	2.5 (0.2)	.36	†	†	†
	Female	2.4 (0.2)		White	2.7 (0.2)				
Active	Male	11.1 (0.6)	.06	Black	10.5 (0.7)	.55	3	11.4 (0.6)	<.003
	Female	10.3 (0.6)		White	10.9 (0.7)		4 and 5	10.1 (0.6)	

*All analyses adjusted for BMI.
†Sex × age interaction (see text and Figure 1).

Table 4. **Results of 3-Way ANOVA With Preschool as a Random Variable (Main Effects Only) Intervals for Nap Removed***

	Independent Variables								
Dependent Variables	**Sex**	**Mean (SE) % Time**	**p**	**Race**	**Mean (SE) % time**	**p**	**Age Group**	**Mean (SE) % Time**	**p**
Sedentary (1 and 2)	Male	83.1 (0.8)	.45	Black	83.3 (0.9)	.95	3	82.3 (0.8)	.001
	Female	83.5 (0.8)		White	83.3 (1.0)		4 and 5	84.3 (0.8)	
Light (3)	Male	10.7 (0.6)	.23	Black	10.6 (0.6)	.71	3	11.1 (0.6)	.001
	Female	10.3 (0.6)		White	10.3 (0.6)		4 and 5	9.8 (0.5)	
MVPA (4 and 5)	Male	3.8 (0.2)	.01	Black	3.4 (0.3)	.98	3	3.7 (0.3)	.01
	Female	3.1 (0.2)		White	3.5 (0.3)		4 and 5	3.2 (0.2)	
Active (3-5)	Male	14.4 (0.8)	.05	Black	14.2 (0.8)	.44	3	14.8 (0.8)	.001
	Female	13.4 (0.8)		White	13.5 (0.9)		4 and 5	12.9 (0.8)	

*All analyses adjusted for BMI.

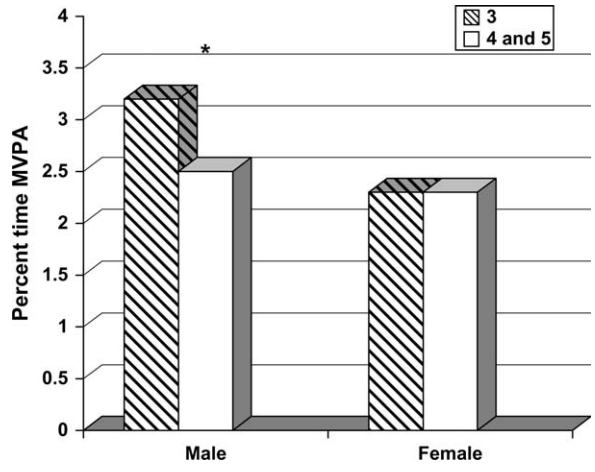
Table 5. **Results of Regression Analysis for Prediction of Percent Time in Active and MVPA Among Preschool-Aged Children**

	% Time Active (3-5)				% Time MVPA (4 and 5)			
	β	F	p Value	R^2	β	F	p Value	R^2
Model 1								
Intercept	0		<.001		0		.01	
Gender (0 = female, 1 = male)	−.08	2.77	.10		−.13	7.38	.01	
Age	−.14	8.82	.003		−.09	3.60	.06	
BMI	.16	12.10	.001		.16	12.27	.001	
Race (1 = white, 0 = black)	.24	26.78	<.001		.17	13.99	<.001	
Total model		11.77	<.001	.098		8.84	<.001	.076
Model 2								
Intercept	0		<.001		0		.03	
Gender (0 = female, 1 = male)	−.09	4.30	.04		−.13	8.29	.004	
Age	−.16	14.03	<.001		−.10	4.78	.03	
BMI	.18	16.12	<.001		.17	13.86	<.001	
Race (1 = white, 0 = black)	.33	45.70	<.001		.21	17.07	<.001	
Preschool type								
Religious	.18	14.07	<.001		.09	3.31	.07	
Head Start	.31	38.08	<.001		.14	6.62	.01	
Total model		15.56	<.001	.178		7.27	<.001	.092
Model 3								
Intercept	0		<.001		0		.01	
Gender (0 = female, 1 = male)	−.08	3.47	.06		−.11	6.13	.01	
Age	−.11	7.08	.01		−.06	1.35	.25	
BMI	.17	15.41	<.001		.14	9.08	.003	
Race (1 = white, 0 = black)	−.07	0.73	.39		−.14	2.32	.13	
Preschool (23)	−.27 to .15	7.87*	<.001		−.21 to .18	3.25*	<.001	
Total model		9.09	<.001	.374		4.23	<.001	.218

*Sum of all preschools.

levels of children attending preschools. More than 400 children in 24 preschools were observed for an average of more than 5 hours. Our major finding was that children were engaged in MVPA during only 2.6% of observation intervals. Even after deleting nap periods, children were observed to perform MVPA during only 3.4% of the remaining observations. In contrast, the children were completely stationary during 55.6% of observations, and they were engaged in stationary activity with limb movement during another 31.7% of observations. These findings indicate that young children are physically inactive during most of their time in preschool.

Figure 1. **Sex × Age Interaction for MVPA, All Intervals (p = .07)**



Adjusted for race, BMI, and with preschool as a random variable. *p = .01.

Given that, on average, children who attend preschools spend 30 hours per week at school, our findings suggest that 25 hours of this time is spent in sedentary activities and less than 1 hour is spent in MVPA. A common perception among parents and teachers is that young children are much more active than indicated by our data. In a study conducted in Canada, parents reported that their preschool child was getting an average 3-4 hours of daily physical activity.[15] In another study, parents indicated that they thought children were very active when in day care but qualified this by indicating that it depends on the weather and opportunities provided.[16] Given that parents think that their child is highly active while in preschool or day care, parents may be less likely to provide opportunities for or encourage physical activity behaviors in other settings, thus leading to reduced levels of activity over the total day.

While children were inactive most of the time, we did find that children's overall activity levels varied considerably across the 24 preschools included in the study. Preschool attended accounted for substantially

more variance in child-level physical activity than did demographic characteristics such as gender, age, and race/ethnicity. Results from this study using direct observation as the measure of physical activity are similar to those of a previous study by our group that measured physical activity using accelerometry.[1] In the current study, preschool accounted for an additional 27.6% of the variance for Active and an additional 14.2% of the variance in predicting MVPA. In the accelerometry study, preschool accounted for an additional 43.3% and 30.9% of the variance in predicting MVPA and VPA, respectively. Similar to the current study, Finn et al found that childcare center accounted for 46% of the variation in activity counts during the school day and accounted for more than 50% of the variation in total daily activity.[17] Research conducted with a university preschool and a Head Start program indicated that children in the university preschool setting were 2.5 times more active than those in Head Start.[18] While these differences are probably not attributed to center type alone, the authors did note the disparity in space allocation between the 2 centers, with the university preschool having approximately twice as much classroom and playground space.

Several hypotheses can be advanced regarding why childcare centers or preschool settings are so influential in a child's physical activity levels. Space constraints, lack of equipment for physical activity, and lack of scheduled times for freeplay and outdoor play may be important factors. Research has shown that being outdoors is one of the most powerful correlates of physical activity in children.[19] Policies regarding teacher education and training related to physical activity programming and teacher and staff modeling and encouragement of physical activity are possible staffing discrepancies that directors should address. Dowda et al[20] found that children in preschools that had more college-educated teachers spent more time in MVPA while on the playground compared to children in schools where fewer teachers had college degrees.

Consistent with previous studies,[4,17,21,22] boys were more active than girls, as indicated by the proportion of intervals they were engaged in activity in the MVPA and Active categories. Similar to a previous study investigating age differences with regard to physical activity, we found that younger children (3-year-olds) spent less time in sedentary activities and more time in Light, MVPA, and VPA compared to older children (4- and 5-year-olds). Although the differences in active time between boys and girls and older and younger children were small, the additive effects of slightly higher rates of activity can lead to significantly higher accumulations of physical activity over a week. It is hypothesized that as children get closer to school attendance, the structured, preacademic activities of the older preschool child's classroom outweigh the freeplay typically seen in classrooms of younger children. Studies of race and ethnicity in relation to preschoolers' physical activity have been limited,[23,24] and these previous studies show inconsistent results.[1,4,22] The findings of this paper did not indicate any race differences in directly observed physical activity. Hence, these mixed results with preschoolers are at times inconsistent with findings with older elementary school children, in which black children have been less active than their white peers.[25,26]

This study had several strengths and some limitations that should be noted. First, the study sample was relatively large, and was racially and socioeconomically diverse. The use of a reliable direct observation system to measure physical activity provided information regarding the sporadic behaviors of children across the entire school day with minimal reactivity by the participants. Most importantly, the preschools from which the sample was drawn represented a variety of preschool settings including commercial, religious, and Head Start programs. The generalizability of the findings may be limited, however, because all the preschools were located in a single metropolitan area. It is also possible that the study sample was not perfectly representative of the population of children who attended the preschools. In addition, the information provided regarding children's physical activity is limited to the school day. No conclusions can be drawn regarding the total or overall physical activity levels of preschool-aged children.

In summary, based on analysis of over 2000 child-hours of systematic, direct observation, we found that children attending preschools were engaged in MVPA during only 2.6% of observation intervals. During over 85% of intervals, children were engaged in either very light activity or sedentary behaviors. Though generally low, the physical activity levels of the children were strongly associated with the school attended. These findings indicate that there is a need to increase physical activity levels of young children while they are in the preschool setting. Further, we conclude that characteristics of the preschool exert a greater influence on physical activity of students than do the students' demographic characteristics. Future research should be directed toward identifying the characteristics of schools that exert the greatest influence on children's physical activity.

REFERENCES

1. Pate RR, Pfeiffer KA, Trost SG, Ziegler P, Dowda M. Physical activity among children attending preschools. *Pediatrics*. 2004; 114(5):1258-1263.
2. Reilly JJ, Jackson DM, Montgomery C, et al. Total energy expenditure and physical activity in young Scottish children: mixed longitudinal study. *Lancet*. 2004;363(9404):211-212.
3. Fisher A, Reilly JJ, Kelly LA, et al. Fundamental movement skills and habitual physical activity in young children. *Med Sci Sports Exerc*. 2005;37(4):684-688.

4. McKenzie TL, Sallis JF, Nader PR, Broyles SL, Nelson JA. Anglo- and Mexican-American preschoolers at home and at recess: activity patterns and environmental influences. *J Dev Behav Pediatr*. 1992;13(3):173-180.
5. Hedley AA, Ogden CL, Johnson CL, Carroll MD, Curtin LR, Flegal KM. Prevalence of overweight and obesity among US children, adolescents, and adults, 1999-2002. *JAMA*. 2004;291(23):2847-2850.
6. Ogden CL, Carroll MD, Curtin LR, McDowell MA, Tabak CJ, Flegal KM. Prevalence of overweight and obesity in the United States, 1999-2004. *JAMA*. 2006;295(13):1549-1555.
7. Dennison BA, Erb TA, Jenkins PL. Television viewing and television in bedroom associated with overweight risk among low-income preschool children. *Pediatrics*. 2002;109(6):1028-1035.
8. Epstein LH, Paluch RA, Gordy CC, Dorn J. Decreasing sedentary behaviors in treating pediatric obesity. *Arch Ped Adolesc Med*. 2000; 154(3):220-226.
9. Gortmaker SL, Must A, Sobol AM, Peterson K, Colditz GA, Dietz WH. Television viewing as a cause of increasing obesity among children in the United States, 1986-1990. *Arch Ped Adolesc Med*. 1996;150(4):356-362.
10. National Center for Education Statistics. *Digest of Education Statistics, Tables and Figures 2001*. Washington, DC: Institute of Education Sciences, US Department of Education; 2001.
11. Bailey RC, Olson J, Pepper SL, Porszasz J, Barstow TJ, Cooper DM. The level and tempo of children's physical activities: an observational study. *Med Sci Sports Exerc*. 1995;27(7):1033-1041.
12. Brown WH, Pfeiffer KA, McIver KL, Dowda M, Almeida MJCA, Pate RR. Assessing preschool children's physical activity: an observational system for recording physical activity in children—preschool version (OSRAC-P). *Res Q Exerc Sport*. 2006; 77(2):167-176.
13. Puhl J, Greaves K, Hoyt M, Baranowski T. Children's Activity Rating Scale (CARS): description and calibration. *Res Q Exerc Sport*. 1990;61(1):26-36.
14. Tapp J, Wehby J. Observational software for laptop computers and optical bar code time wands. In: Thompson T, Felce D, Symons F, eds. *Behavioral Observation: Technology and Applications in Developmental Disabilities*. Baltimore, Md: Paul H. Brookes; 2000: 71-81.
15. Irwin JD, He M, Bouck LM, Tucker P, Pollett GL. Preschoolers' physical activity behaviours: parents' perspectives. *Can J Public Health*. 2005;96(4):299-303.
16. O'Connor JP, Temple VA. Constraints and facilitators for physical activity in family day care. *Aust J Early Child*. 2005;30(4):1-9.
17. Finn K, Johannsen N, Specker B. Factors associated with physical activity in preschool children. *J Pediatr* 2002;140(1):81-85.
18. Worobey J, Worobey HS, Adler AL. Diet, activity and BMI in preschool-aged children: differences across settings. *Ecology of Food and Nutrition* 2005;44(6):455-466.
19. Sallis JF, Owen N. Determinants of physical activity. In: Sallis JF, Owen N, eds. *Physical Activity and Behavioral Medicine*. Thousand Oaks, Calif: Sage Publications; 1998:110-134.
20. Dowda M, Pate RR, Trost SG, Almeida MJCA, Sirard J. Influences of preschool policies and practices on children's physical activity. *J Commun Health*. 2004;29(3):183-195.
21. Jackson DM, Reilly JJ, Kelly LA, Montgomery C, Grant C, Paton JY. Objectively measured physical activity in a representative sample of 3- to 4-year-old children. *Obes Res*. 2003;11: 420-425.
22. Baranowski T, Thompson WO, DuRant RH, Baranowski J, Puhl J. Observations on physical activity in physical locations: age, gender, ethnicity, and month effects. *Res Q Exerc Sport*. 1993;64(2): 127-133.
23. Pate RR. Assessment of physical activity and sedentary behavior in preschool children: priorities for research. *Pediatr Exerc Sci* 2001;13(2):129-130.
24. Fulton JE, Burgeson CR, Perry GR, et al. Assessment of physical activity and sedentary behavior in preschool-age children: priorities for research. *Pediatr Exerc Sci*. 2001;12:113-126.
25. Kimm SY, Glynn NW, Kriska AM, et al. Decline in physical activity in black girls and white girls during adolescence. *N Engl J Med*. 2002;347(10):709-715.
26. Sallis JF, Zakarian JM, Hovell MF, Hofstetter CR. Ethnic, socioeconomic, and sex differences in physical activity among adolescents. *J Clin Edpidemiol*. 1996;49(2):125-134.