

# Factors associated with physical activity in preschool children

Kevin Finn, PhD, Neil Johannsen, and Bonny Specker, PhD

**Objective:** Our purpose was to identify factors associated with the physical activity in young children.

**Study design:** Participants were 214 children (aged 3-5 years) enrolled in 10 childcare centers who were monitored for physical activity with an accelerometer during 2 continuous days (48 hours). Mean daily activity counts, activity counts between 9 AM and 5 PM, and percentage of time spent in vigorous activity were determined. The factors investigated were age, childcare center, season, sex, body mass index (BMI), history of preterm birth, participation in organized activities, parental BMI, and parental educational level. Regression analyses were used to identify factors associated with each of the activity measures.

**Results:** A statistical model including sex, history of preterm birth, childcare center, and father's BMI accounted for 22%, 37%, and 23% of the variance in total daily counts, counts between 9 AM and 5 PM, and percentage of time spent in daily vigorous activity, respectively. Childcare center was the highest individual predictor of activity. Boys were more active than girls in all activity measures except counts between 9 AM and 5 PM. Children born preterm were less active than children born at term, and high activity levels in the child were associated with a low BMI in fathers.

**Conclusion:** The findings indicate that sex, history of preterm birth, childcare center, and father's BMI influence the daily physical activity of young children. (J Pediatr 2002;140:81-5)

It has been hypothesized that the recent increase in childhood obesity is linked to physical inactivity. Understanding the factors associated with physical inactivity may help establish

better intervention to promote more physical activity. Sallis et al<sup>1</sup> evaluated 55 studies that investigated the relationships between activity levels in children aged 4 to 12 years. Unfortu-

nately, there were limited data on preschool-aged children. Five of the 12 studies found boys were more active than girls, and 3 studies found that time spent outdoors resulted in higher activity levels. A few studies reported seasonal differences in activity levels, a correlation between the child's and parent's activity levels, and inverse relationships between the child's activity level, their body mass index (BMI), and parental weight. The authors suggested that additional studies were needed to confirm the findings and explore additional factors that may influence a child's activity behavior.

---

**See related article, p 86.**

---

BMI Body mass index  
CARS Children's Activity Rating Scale

The time spent in childcare situations can be extensive when both parents are working; 40% of children aged 3 to 4 years whose mothers are employed spend more than 35 hours per week in nonparental care,<sup>2</sup> with the largest percent of the child's care coming from center-based care.<sup>3</sup> The purpose of this study was to identify factors associated with physical activity levels of preschool-aged children, and in particular, during the time usually spent in childcare centers. The data were collected as part of the baseline measurements obtained in the South Dakota Children's Health Study, a randomized trial of physical activity and calcium supplementation in 3- and 4-year-old children conducted in the childcare setting.

*From the School of HPELS, University of Northern Iowa, Cedar Falls, and Ethel Austin Martin Program in Human Nutrition, South Dakota State University, Brookings.*

Supported by National Institutes of Health grant No. R01 AR45310.

Submitted for publication June 6, 2000; revisions received May 3, 2001, and Sept 5, 2001; accepted Sept 27, 2001.

Reprint requests: Kevin Finn, School of HPELS, WRC 203, University of Northern Iowa, Cedar Falls, IA 50614-0241.

Copyright © 2002 by Mosby, Inc.

0022-3476/2002/\$35.00 + 0 9/21/120693

doi:10.1067/mpd.2002.120693

**Table 1.** Characteristics of study population by sex

Variable	Girls (n = 108)	Boys (n = 106)	P value
Age (y)	3.90 ± .06	3.95 ± .06	NS
Height (cm)	101.1 ± .6	102.9 ± .6	.03
Weight (kg)	16.2 ± .2	17.1 ± .2	.01
BMI	15.8 ± .1	16.1 ± .1	NS
Race (white/other)	98/10	102/4	NS
Premature at birth (no/yes)	93/15	91/15	NS
Season (fall/winter/spring/summer)	25/17/30/36	35/22/21/28	NS
Child in organized activities (no/yes/unknown)	72/16/20	67/21/18	NS
Mother's BMI	26.0 ± .6	25.2 ± .4	NS
Father's BMI	26.6 ± .4	27.9 ± .4	.02
Parental education (y)	14.9 ± .2	14.7 ± .2	NS
Mean daily sensor counts (×10,000)	26.3 ± .7	28.5 ± .8	.03
Mean sensor counts (9 AM-5 PM)(×10,000)	14.1 ± .5	15.3 ± .5	NS
Daily counts between 9 AM and 5 PM (%)	53.0 ± 1.1	53.3 ± 1.1	NS
Time in vigorous activity (%)	4.5 ± .2	5.2 ± .2	.02

Mean ± SEM.

## METHODS

Preschool children (n = 239) from 10 childcare centers in southeastern South Dakota were enrolled in the study. The South Dakota State University Human Subjects Committee approved all procedures, and parental written informed consent was obtained.

Physical activity levels were determined by movement counts with the Actiwatch Model AW16 activity monitor (Mini Mitter Co, Sun River, Ore). This activity monitor contains a sensor capable of detecting acceleration in 2 planes. Sensitive to .01 gravity (.098 m×s<sup>-2</sup>), this type of sensor integrates the degree and speed of motion and produces an electrical current that varies in magnitude. An increase in speed and motion produces an increase in voltage. The monitor stores this information as activity counts.<sup>4</sup> This monitor is similar to other second-generation accelerometers (CSA 7164, TriTrac-R3D) in regard to data storage capabilities. However, it is slightly different in the number of planes that can detect motion (2), and the sensitivity is greater than the other accelerometers mentioned. This device was selected because of its compact size (27 × 26 × 9 mm), weight (17 g), and

durable casing. To assess the validity of this device, 6 hours of direct observation using the Children's Activity Rating Scale (CARS) were scored on a subset of these children (n = 40) and compared with 1-minute activity counts obtained from the accelerometer.<sup>5</sup> A significant association ( $P < .001$ ) was found between the 2 activity measures with a median-within-child correlation of .74 (range, .03-.92).

For the baseline measurements, activity sensors were programmed to store total activity counts per minute for a 48-hour period beginning at 9 AM. Before 9 AM on the first day of the assessment period, the sensors were placed in a belt on the waist of each participant, with the base of the instrument positioned against the lumbar spine. The position on the torso has been shown to provide a better measure of reliability compared with wearing a similar type of movement-sensing device on the wrist or ankle.<sup>6</sup> The placement on the lower back was selected because it tends to minimize the time children play with the sensor. Parents and childcare providers were instructed on the proper sensor placement and asked to ensure correct repositioning of the sensor if it was accidentally removed. All sensors

were worn continuously and removed only if the child was submerged in water (ie, bathing or swimming). After the 48-hour period, sensor data were downloaded onto a computer file with an interface reader that was directly connected to a computer. Each participant's data file was reviewed to identify possible sensor malfunctioning, and data (24-hour) were omitted from the analysis if it appeared that the sensor had been removed or if there was a sensor malfunction. Of the 239 children enrolled in the study, 214 (90%) had at least 24 hours of sensor data (202 had a complete 48 hours of data). The day-to-day coefficient of variation calculated as the SD of the difference between the 2 days of counts divided by the overall mean daily counts was 21%. The correlation coefficient for the total daily counts on day 1 versus day 2 was .56 ( $P < .001$ ). This correlation coefficient is slightly higher than day-to-day reliability coefficients of .42 (95% CI, .27-.60) reported for children aged 7 to 15 years.<sup>7</sup>

Activity counts were recorded every minute for the 48-hour period. A cutoff of 1000 counts was defined as a minute involving vigorous activity. This cutoff count was the approximate mean count

that corresponded to a CARS score of 3 (unpublished data). In the subset of children ( $n = 40$ ) who had 6-hour direct observation of activity, we found that 75% of the minutes (666/886) with an average CARS score of  $\geq 3$  had at least 1 period of vigorous activity (CARS level of 4 or 5). The CARS scoring classifies physical activities by preschool-aged children into 5 levels according to a rating system developed by Puhl.<sup>8</sup> The level 1 activities are sedentary. The level 2 activities are sedentary but include movement of the limbs or torso. Levels 3 through 5 activities are labeled as translocation (moving the body from one location to another). The CARS score is obtained by averaging all levels of physical activity (and inactivity) in 1 minute. In addition to percent time in vigorous activity, we also calculated the average total daily counts as well as the average counts between 9 AM and 5 PM. The time period of 9 AM to 5 PM was assumed to represent the period that most children were present at the childcare center.

The child's demographic data and selected parental information were obtained by questionnaire at enrollment. Height was determined with a fixed measuring tape and level with standard footings and recorded to the nearest .5 cm. The process was repeated twice and a third time if the 2 measurements differed by more than .5 cm. Weight was recorded to the nearest .1 kg with a digital scale (Seca, Hopkins Medical Products, Baltimore, Md) with the child dressed in light clothing. BMI (kilograms/meters<sup>2</sup>) was calculated for these data.

Participation in organized sports activities (yes, no, unknown) was included in the parent's questionnaire. Seasons were defined as spring, summer, fall, and winter.

Variables that were investigated in this study were the child's age, sex, BMI, history of preterm birth, season of the year, childcare center, child's participation in organized activities, mother's and father's BMI (as an indicator of parental fitness), and mean

parental educational level (as an indicator of socioeconomic status). Data were analyzed using JMP statistical software (SAS Institute, Cary, NC) and descriptive statistics were reported. Mean daily counts, counts between 9 AM and 5 PM, and percentage of time spent in vigorous activity were the measures used in the analyses. Mean daily counts approximated a normal distribution. A forward-backward stepwise regression analysis was used to identify variables that were significantly associated with the activity measures. Variables were allowed to enter the model at  $P \leq .25$  but had to have  $P \leq .05$  to remain in the model.

## RESULTS

Activity data were available for 214 of the 239 (90%) children enrolled in the study (Table I). Boys were slightly taller, heavier, and had a higher paternal BMI than girls. Boys also spent more time in vigorous activity and had higher total daily activity counts compared with girls. There were no sex differences in age, BMI, race, history of premature birth, child's participation in organized activities, maternal BMI, parental education, and mean sensor counts between 9 AM and 5 PM.

There were significant center differences in mean daily counts (range,  $23.0 \pm 1.2$ - $31.5 \pm 1.7$  [ $\times 10,000$ ],  $P = .002$ ), mean counts between 9 AM and 5 PM (range,  $10.1 \pm .8$ - $20.3 \pm 1.8$  [ $\times 10,000$ ],  $P < .001$ ), and percentage of time spent in vigorous activity (range,  $3.6 \pm .3\%$ - $6.0 \pm .8\%$ ,  $P = .002$ ). Children born preterm had lower mean daily counts ( $23.0 \pm 1.4$  vs  $28.1 \pm .6$  [ $\times 10,000$ ],  $P < .001$ ), mean counts between 9 AM and 5 PM ( $11.8 \pm 1.0$  vs  $15.1 \pm .4$  [ $\times 10,000$ ],  $P = .002$ ), and percentage of time spent in vigorous activity ( $3.7 \pm .4\%$  vs  $5.0 \pm .2\%$ ,  $P = .004$ ) compared with children born at term. The average daily sensor counts and percentage of time spent in vigorous activity were marginally associated with the father's BMI ( $r = -.13$ ,  $P = .07$  and

$r = -.12$ ,  $P = .09$ ). Although there were no seasonal differences in total daily counts ( $P = .28$ ) or percentage of time spent in vigorous activity ( $P = .35$ ), there were slightly higher counts between 9 AM and 5 PM in the fall ( $159.9 \pm 7.0$ ) compared with the summer ( $131.2 \pm 6.8$ ) ( $P < .05$ ). Neither average daily counts, counts between 9 AM and 5 PM, nor percentage of time spent in vigorous activity were associated with participation in organized activities ( $P = .9$ ,  $P = .4$ , and  $P = .8$ , respectively), child's BMI ( $P = .4$ ,  $P = .9$ , and  $P = .3$ , respectively), or maternal BMI ( $P = .18$ ,  $P = .2$ , and  $P = .2$ , respectively).

The influence of the significant variables on the activity measures were evaluated simultaneously with a multiple linear regression approach; 22% of the variation in mean daily sensor counts was explained by a combination of the child's sex, history of preterm birth, childcare center, and father's BMI (Table II). Boys had higher counts than girls, children born at term had higher counts than children born preterm, and fathers' BMIs were inversely associated with the activity counts. Similar findings were observed in the analysis for sensor counts between 9 AM and 5 PM; 37% of the variation in these counts were explained by the same variables. Mean sensor counts between 9 AM and 5 PM among the centers represented a range of 45% to 64% of the total daily counts, and 23% of the variance in percent of time in vigorous activity was also explained by sex, history of preterm birth, childcare center, and father's BMI.

## DISCUSSION

Our findings of greater activity levels in boys compared with girls is consistent with other studies in this age group.<sup>8-11</sup> Because no sex differences existed between participation in organized activities and there were no differences in daily activity counts between children who participated in or

**Table II.** Factors associated with average daily activity counts, activity counts between 9 AM and 5 PM, and the percentage of time spent in vigorous activity

Daily activity counts ( $\times 10,000$ ) model $r^2 = .224$			
Variable	Finding*	P value	Partial $r^2$
Sex	Boys (28.9 + 1.1) > girls (25.3 + .9)	<.001	.062
History of preterm birth	Term (29.2 + .7) > preterm (24.9 + 1.5)	.006	.043
Childcare center	Range (20.8 + 1.3-29.9 + 2.9)	<.001	.172
Father's BMI	Inverse relationship	.01	.033

(Mean  $\pm$  SEM).  
\*Least square means adjusting for other variables in the model.

ganized activities and children who did not, we speculate that sex differences are based on activity levels during free play situations. This is supported by the findings of Baranowski et al<sup>9</sup>, who reported a higher level of physical activity in boys compared with girls in both inside and outside locations and in both home and play school environments. In addition, McKenzie<sup>11</sup> reported that preschool boys spent more time than girls in moderate to vigorous activity during recess sessions.

We did not find a relationship between the children's activity levels and their BMI, or their mothers' BMIs, at this age. We did, however, find a consistent relationship between the child's activity level and the father's BMI. Sallis et al<sup>13</sup> identified both the father's and mother's BMI as significant predictors of activity in the home or playground setting in 63 preschool-aged children. In our study, more active children were more likely to have a father with a lower BMI than less active children. We speculate that the father's BMI is a reflection of the father's activity level. Although we did not report the activity of the parents, Sallis did report a significant relationship between parental activity (self-report) and father's BMI. Moore et al<sup>14</sup> reported that children whose parents were active were more likely to be active themselves. The authors suggest that the association between parental and child activity may be partly because of the tendency of

families with young children to carry out activities as a family unit. This might explain the inclusion of the father's BMI in the variation of total activity counts. In addition, the father's BMI was associated with activity counts between the hours of 9 AM and 5 PM. Other authors<sup>12,13</sup> have suggested that parental physical activity through role modeling could influence a child's physical activity, even when the child is away from home. Parental influence is thought to be the most modifiable factor in increasing children's physical activity in this age group.<sup>15</sup>

The childcare center was identified as a strong determinant of physical activity in the children studied; it explained 46% of the variation in activity counts between 9 AM and 5 PM and counts during this period accounted on average for more than 50% of the average daily activity counts. Restricted or decreased space in a childcare setting may restrict movement. We previously reported an association between percentage of body fat among 12-month-old infants and square footage of childcare centers.<sup>16</sup> The daily programming for these centers may influence physical activity in these children. Programming for these centers included some physical activity time, but the quantity and quality of this time can vary depending upon indoor space, supervision, gross motor play equipment, and outdoor play area. We did not obtain objective measures that describe differences in these centers.

Further investigation is warranted to determine the differences in centers' facilities, programming, and the implications on physical activity of young children. The childcare centers have an opportunity to offer intervention that could promote physical activity in young children.

Children who were born preterm had lower activity counts and less time in vigorous activity than children born at term. The mechanism to explain such an association is unknown. A child with a history of preterm birth may have growth and maturation delays compared with a child born at term that might influence their physical activity levels, or their parents may be more protective of these children and discourage physical activity. In the current study, the children with a history of preterm birth were born an average of 4 weeks early. We are not aware of any reports of long-term growth or maturation delays with this degree of prematurity. Infants born preterm demonstrate less spontaneous volitional movements,<sup>17</sup> although it is not known whether this pattern continues into childhood. Preterm infants have been reported to have long-term deficits in bone mineral content and bone mineral density.<sup>18</sup> Bone mineral density is associated with physical activity in adults and older children,<sup>19</sup> and it is possible that decreased activity in children with history of prematurity may be partially responsible for these bone deficits.

Activity counts ( $\times 10,000$ ) from 9 AM to 5 PM model $r^2 = .368$			% time spent in vigorous activity model $r^2 = .228$		
Finding*	P value	Partial $r^2$	Finding*	P value	Partial $r^2$
Boys (16.1 + .6) > girls (14.0 + .6)	.002	.051	Boys (5.5 + .2) > girls (4.3 + .3)	<.001	.081
Term (16.7 + .5) > preterm (13.4 + .9)	.001	.060	Term (5.4 + .2) > preterm (4.4 + .4)	.03	.027
Range (8.5 + .8-19.5 + 1.8)	<.001	.471	Range (3.1 + .4-5.9 + .8)	<.001	.184
Inverse relationship	.02	.029	Inverse relationship	.01	.034

In summary, we identified several factors that predicted activity levels in preschool children. The childcare center was the strongest predictor of activity levels, with more than 50% of the daily activity counts occurring between 9 AM and 5 PM. These findings support a role of childcare centers in promoting quality activity programs and providing space and time for young children to be active. Our finding of increased activity in children of fathers with a low BMI is consistent with previous reports and may indicate that a possible means of increasing activity levels in preschool children is to increase the activity levels of the family. Our finding of decreased activity levels in preschool children with a history of preterm birth needs to be confirmed in additional studies. These children would not have been considered high-risk infants given the level of their prematurity (2-9 weeks) and would not normally be evaluated for developmental delays.

## REFERENCES

- Sallis JF, Prochaska JJ, Taylor WC. A review of correlates of physical activity of children and adolescents. *Med Sci Sports Exerc* 2000;32:963-75.
- Capizzano J, Adams G. The hours that children under 5 spend in child care: variations across states. *Assessing the New Federalism Series B, No. 8.* Washington (DC): The Urban Institute; 2000.
- Casper LM. Who's minding our preschoolers? *Current Population Reports, No. 3.* Washington (DC): United States Bureau of the Census; 1996. p. 70.
- Mini Mitter Company, Inc. Actiwatch 16/Actiwatch 64/ Actiwatch-L activity monitors: instruction manual. Bend (OR): Mitter Company; 1999.
- Finn KJ, Specker BL. Comparison of Actiwatch motion sensor and children's activity rating scale in children. *Med Sci Sports Exerc* 2000;32:1794-7.
- Baxter B, Nichols JF, Sallis JF, Calfas KJ. Validity and reliability of the CSA accelerometer worn on the ankle, hip, and wrist [abstract]. *Med Sci Sports Exerc* 1998;30:S53.
- Janz, KF, Witt J, Mahoney LT. The stability of children's physical activity as measured by accelerometry and self report. *Med Sci Sport Exerc* 1995; 27:1326-32.
- Puhl J, Greaves K, Hoyt M, Baranowski T. Children's Activity Rating Scale (CARS): description and calibration. *Res Q Exerc Sport* 1990;61:26-36.
- 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;64:127-33.
- DuRant RH, Baranowski T, Puhl J, Rhodes T, Davis H, Greaves KA, et al. Evaluation of the Children's Activity Rating Scale (CARS) in young children. *Med Sci Sports Exerc* 1993; 25:1415-21.
- 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;13:173-80.
- Moore LL, Nguyen UDT, Rothman KJ, Cupples LA, Ellison RC. Preschool physical activity level and changes in body fatness in young children: the Framingham Children's Study. *Am J Epidemiol* 1995;42:982-8.
- Sallis JF, Patterson TL, McKenzie TL, Nader PR. Family variables and physical activity in preschool children. *J Dev Behav Pediatr* 1988;9:57-61.
- Moore LL, Lombardi DA, White MJ, Campbell IL, Oliveria SA, Ellison RC. Influence of parents' physical activity levels of young children. *J Pediatr* 1991;118:215-9.
- Kohl H, Hobb KE. Development of physical activity behaviors among children and adolescents. *Pediatrics* 1998; 101:549-55.
- Mulligan L, Specker B, Buckley DD, O'Connor LS, Ho M. Physical and environmental factors affecting motor development, activity level, and body composition of infants in child care centers. *Pediatric physical therapy.* Philadelphia (PA): Lippincott, Williams and Wilkins; 1998. p. 156-61.
- Kolobe THA, Campbell SK, Arrevalo A. The effects of gestational age at birth on motor performance [abstract]. *Phys Ther* 1999;79:S37.
- Schanler RJ, Burns PA, Abrams SA, Garza C. Bone mineralization outcomes in human milk-fed preterm infants. *Pediatr Res* 1992;31:583-6.
- Slemenda CW, Miller JZ, Hui SL, Resiter TK, Johnston CC Jr. Role of physical activity in the development of skeletal mass in children. *J Bone Miner Res* 1991;6:1227-33.