Title: Physical Activity Levels and Obesity Status of Oregon Rural Elementary School Children

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Abstract:

Objective: To evaluate the relationship between school-day physical activity (PA, min/school-day) and body mass index (BMI, kg/m^2) among rural elementary-aged children.

Methods: Height (cm), weight (kg), and PA were measured for 1535 children (5-12 years) enrolled in six rural Oregon elementary schools in fall, 2013. School-day PA was measured over four days using Walk4Life pedometers. Children with $\geq$ 3 valid monitoring days (n=1482) were included in analyses. Means were calculated for wear time, total PA (TPA: combined light, moderate, vigorous PA), and moderate to vigorous PA (MVPA: step count > 120/min). BMI percentiles and z-scores were calculated and regression models were run to examine the relationship between PA and BMI z-scores, adjusting for wear time, gender, and grade.

Results: Overweight (38.1%: BMI $\geq$ 85th percentile for age and gender) and obesity (19.4%: BMI $\geq$ 95th percentile) prevalence was similar for boys (n=782) and girls (n=700). More MVPA was associated with lower BMI ($P < 0.001$), independent of gender, TPA or grade. Mean MVPA was 18.9 +/-8 min/d, versus 15.2 +/-6.7 min/d for healthy-weight and obese children, respectively.

Conclusions: Children are not meeting minimum MVPA recommendations (60 min/d) at school. Efforts to promote PA for obesity prevention in rural elementary schools should focus on increasing opportunities for MVPA.

Introduction

The prevalence of overweight and obesity has climbed steadily among children ages 6-11 over the last three decades, rising from 6.5% in 1976-1980 to 18% by 2009-2010[1]. The most current available data indicate the rates for overweight (34.2%; CI 30.1-38.5) and obesity (17.7%; CI 14.5 – 21.4) among children ages 6-11 years[2] remain high with obesity rates 10% above the Healthy People 2020 goal of 15.7%[3]. Longitudinal studies show that obese children are more likely to become obese adolescents[4], and eventually obese adults[5,6] putting them at greater risk for heart disease, type 2 diabetes, stroke, cancer, osteoarthritis and early mortality[7]. The ripple effects of childhood overweight and obesity will be economically crippling in the U.S. if we cannot stem the tide.

Genetic predisposition for a high body mass index (BMI, kg/m^2) is between 25% and 40%[8] suggesting ample potential for environmental influences, including physical activity (PA) exposure , on the development of obesity. For children, who do not generally have volitional control over the environments where they live, learn and play, increasing PA during the school day has been proposed as one of the best options for accelerating progress in obesity prevention[9–11].

Physical education (PE) programming has historically served as the primary mechanism for providing child PA time during the school day. Currently, a majority of schools are challenged with budget cuts or pressure to achieve academic standards that detrimentally impact habitual PE programming. Among schools providing PE, few meet the nationally recommended minimum of 150 min/week of moderate to vigorous physical activity (MVPA) at the elementary level and 225 min/week at the secondary level[12]. Even when schools have robust PE programs, it is rare that children spend the recommended 50% of PE class time in MVPA[13]. Thus, relying on PE programming to ensure children are sufficiently active during the school day may be short sighted. Bassett et al[14] found that optimizing certain policies and practices may significantly influence the habitual dose of PA children experience while at school. Classroom activity breaks, active transportation, and on-site before/after -school programs are among the strategies suggested. However in rural school districts, children often live far from home and have long bus commutes making participation in before/ after school programs or active transportation efforts challenging or inaccessible. In these rural environments, the 6.5-7-hour school day may present

the only opportunity for many children to meet the recommended 60-min/d minimum of MVPA. As such, statewide surveillance data on PA behaviors during the school day has potential as an important health indicator in rural areas.

In Oregon, and nationwide, there is a dearth of data assessing the amount of time spent engaged in PA among children attending rural schools and no data relating school-day PA to health outcomes or health indicators such as BMI. This makes it challenging to advocate policies and resources to promote PA as critical to health outcomes among rural children. Thus, the purpose of this study was to measure school-day PA levels among children attending elementary schools in rural Oregon, and to determine the relationship of school-day PA time to BMI.

Methods

Participants and Settings

Participating schools were selected based on the following criteria: 1.) Located in a community designated as a rural place by the US Census[15], 2.) $\geq$ 50% of school families eligible for free and reduced meals, 3.) County Extension faculty were available to participate in the project. Once eligible schools were identified, the appropriate Oregon State University (OSU) county Extension faculty were contacted and invited to participate; three faculty serving three geographically diverse Oregon Counties, agreed to participate. Table 1 presents the characteristics of participating schools. School families were informed of the school-based assessments through school initiated communications and provided the chance to opt-out. Data were collected in fall 2013 over a 5-week period. The study was approved by the OSU Institutional Review Board.

Table 1. Characteristics of Participating Rural Elementary Schools

	COUNTY 1		COUNTY 2		COUNTY 3	
	School 1	**School 2**	**School 3**	**School 4**	**School 5**	**School 6**
Grade Levels	K-6	K-5	K-6	K-6	K-6	K-6
Student enrollment (n)	571	442	495	347	166	191
Participation in National School Lunch and Breakfast Program (Yes/No)	Yes	Yes	Yes	Yes	Yes	Yes
Students eligible for free/reduced school meals - n (%)	321 (56.2)	289 (65.4)	297 (60.0)	215 (62.0)	156 (94.0)	151 (79.1)
Race/Ethnicity - n (%)						
White	461 (80.7)	260 (58.8)	438 (88.5)	287 (82.7)	64 (38.6)	132 (69.1)
Hispanic	66 (11.6)	160 (36.2)	22 (4.4)	20 (5.8)	11 (6.6)	39 (20.4)
Other	44 (7.7)	22 (5.0)	35 (7.1)	40 (11.5)	91 (54.8)	20 (10.5)

Data source: Oregon Department of Education http://www.ode.state.or.us/data/reports/toc.aspx#students. Data reflect 2013-2014 enrollment information.

Assessment of Body Mass Index (BMI)

Height and weight were measured over 2-days at each school by trained research assistants. Height was measured to the nearest 1 mm using a portable stadiometer; weight was measured to the nearest 0.1 kg using a portable digital scale and data were used to calculate BMI ($kg.m^{-2}$). Children were classified as "overweight" or "obese" using the age- and sex-specific 85th and 95th percentiles from the Centers for Disease Control and Prevention (CDC) growth charts[16].

Assessment of Physical Activity (PA)

Classroom teachers were trained to distribute Walk4Life MVP pedometers (Walk4Life, Inc; Oswego, IL), log non-compliance, daily wear time (min/d), and school attendance, and assist children with putting the devices on at the start of the school day and removing them at the end of the school day. Children wore the pedometers on their right hip, attached via an elastic belt. Data were collected over four consecutive days coinciding with height and weight assessments.

Statistical Analyses

Cumulative averages over the 4-day sampling period were calculated for wear time (min/d), total PA (TPA; combined light, moderate, vigorous PA), and MVPA (step count > 120/min). Children with $\geq$ three valid monitoring days were included in the final analysis. A valid monitoring day consisted of a full school day of PA data on a given child.

T-tests were used to compare means of PA variables (TPA, and MVPA), by sex (boys vs girls) and by grade (grade 1 vs grade 2-6). Proportional tests were used to compare proportions of overweight/ obese and obese children by sex and by grade.

BMI percentiles and z-scores were calculated and regression models were run to examine the relationships between PA variables (TPA and MVPA) and BMI z-scores, adjusting for wear time, gender, and grade. A p-value<0.05 was used to identify a statistically significant relationship. All analyses were conducted in Stata/IC 13.1.

Results

Within the six rural schools, complete height and weight data permitting calculation of BMI were collected on 1535 children (5-12 years old); 1611 children provided $\geq$ 3 valid days of PA monitoring. The final sample included 1482 children (782 boys; 700 girls) with valid PA and BMI measurements. The combined overweight/obesity prevalence was 36.8% for girls and 39.3% for boys; obesity prevalence was 17.8% and 20.8% for girls and boys, respectively (Table 2). Overall, there were no differences between boys and girls for prevalence of overweight/ obesity ; however, a greater proportion of 4^{th} grade boys compared to girls were classified as obese (P = 0.004; Table 2).

Table 2. Overweight and obesity prevalence among rural Oregon school children grades 1-6. Data collected fall 2013.

GRADE	GIRLS (n=700)		BOYS (n=782)		P-values	P-values
Grade (n)	OW/OB[a] %	Obese %	OW/OB%	Obese %	Boys vs. Girls OW/OB	Boys vs. Girls Obese
All (1482)	36.8	17.8	39.3	20.8	0.342	0.147
1 (229)	38.2	15.7	26.7	11.8	0.064	0.394
2 (237)	36.4	18.2	38.5	19.7	0.725	0.769
3 (278)	37.9	15.3	42.2	19.5	0.467	0.366
4 (249)	29.8	11.4	40.0	25.9	0.094	0.004
5 (275)	41.4	25.2	42.1	22.6	0.907	0.626
6 (214)	35.9	19.4	45.9	26.1	0.136	0.243

[a] OW/OB = Combined prevalence of overweight and obese. Children above the 85th percentile according to the CDC growth chart are considered overweight; children above the 95th percentile are considered Obese.

On average, children wore pedometers for 357 (±25 min/d). The average daily participation in TPA was 46 (±19) and 55 (+/-21 min/d), for girls and boys respectively. Girls averaged 16.5 (+/-6.8 min/d) of MVPA, while boys spent 19.4 (+/-8.5 min/d) in MVPA. Boys accrued more TPA and MVPA than girls at every grade ($P < 0.05$; Table 3).

Table 3. Average school-day physical activity (PA) among rural Oregon school children grades 1-6. Data collected fall 2013.

GRADE	**GIRLS (n=700)**		**BOYS (n=782)**		**P-values**	**P-values**
Grade (n)	Total PA[a] Mean (SD)	MVPA[b] Mean (SD)	Total PA Mean (SD)	MVPA Mean (SD)	Boys vs. Girls Total PA	Boys vs. Girls MVPA
All (1482)	45.8 (18.8)	16.5 (6.8)	54.6 (20.9)	19.4 (8.5)	0.000	0.000
1 (229)	50.9 (16.1)	19.9 (5.7)	58.9 (19.4)	21.3 (8.4)	0.0009	0.1521
2 (237)	47.4 (15.2)	19.4 (6.2)	54.6 (17.6)	21.3 (8.1)	0.0009	0.0450
3 (278)	46.8 (20.5)	17.8 (7.2)	58.1 (22.7)	22.1 (9.7)	0.0000	0.0001
4 (249)	44.9 (15.6)	15.8 (6.1)	50.5 (20.5)	18.1 (7.2)	0.0170	0.0121
5 (275)	43.1 (22.2)	13.8 (5.8)	52.2 (25.4)	17.8 (8.3)	0.0017	0.0000
6 (214)	42.7 (19.2)	13.1 (6.6)	52.4 (16.5)	15.1 (6.7)	0.0001	0.0330

[a] Total PA Mean =4-day average total minutes of physical activity (includes light, moderate, and vigorous); [b] MVPA = 4-day average minutes of moderate and vigorous physical activity above a step count of 120 steps/minute.

Table 4 shows the results of regression analyses examining the relationship of MVPA (min/d) to BMI z-scores, adjusting for wear time (min/d), gender and grade. There was no relationship between TPA time and BMI percentile, thus, TPA was not included in the final model. More MVPA was associated with lower BMI percentile ($P < 0.001$), independent of gender, wear time or grade.

Table 4. Regression model with BMI Z-score as outcome

Variable	Coef.	SE	T	P>|t|	[95% Conf. Interval]	
Mean MVPA[a] (n=1482)	-0.0205366	0.0035234	-5.83	0.000	-0.0274479	-0.0136252
Sex (f=0; m=1)	.1639585	0.0527306	3.11	0.002	.0605234	.2673936
Grade[b] (n)						
1[c](229)	--	--	--	--	--	--
2 (237)	0.1685549	0.0922358	1.83	0.068	-0.0123725	0.3494824
3 (278)	0.1327545	0.0889906	1.49	0.136	-0.0418074	0.3073163
4 (249)	0.0293762	0.091849	0.32	0.749	-0.1507926	0.2095449
5 (275)	0.1376162	0.0905722	0.129	0.129	-0.0400481	0.3152805
6 (214)	0.0277179	0.0975812	0.776	0.776	-0.1636951	0.2191309
Mean wear time[d]	-0.0013107	0.0010354	-1.27	0.206	-0.0033416	0.0007203
Constant	1.455601	0.3818981	3.81	0.000	0.7064784	2.204723

Number of observations included in the model = 1482; F (8, 1473) = 6.19; P=0.0000; R-Squared = 0.0325; Adjusted R-Squared = 0.0272; Root MSE = 0.99355

Note: [a] Mean MVPA = 4-day average minutes with step count >120 steps/minute; [b] Grade = Child grade in school; [c] Grade 1 is computed as the reference group for the grade comparison; [d] Mean Wear Time = average school-day min/d pedometer was worn during assessment period

Multiple logistic regression models were constructed with BMI percentile categories as the outcome variable (overweight vs. healthy BMI percentile; obese vs. healthy BMI percentile).

Categories include: underweight (BMI < 5th percentile), healthy weight (BMI >5th percentile and < 85th percentile), overweight (BMI $\geq$ 85th percentile and < 95th percentile), obese (BMI $\geq$ 95th percentile). Sixteen participants (1%) were underweight (BMI <5th percentile). More children in the healthy weight category participated in MVPA (19±8 min/d) compared to those children classified as obese (15±7 min/d; P < 0.001). Obese children had 7.3% lower odds of participating in MVPA compared to children in the healthy weight group. Overall, children classified as overweight participated in less MVPA (18±8 min/d) than children classified as healthy weight, but this difference was not statistically significant (P = 0.18).

Discussion

This is the first study to objectively assess the relationship between school-day PA (min/d) and BMI percentile in rural elementary school children (5-12y) in Oregon. Regardless of grade level, on average children accrued < 60 min/d of TPA and < 20 min/d of MVPA, during a 6-h school day; with higher MVPA associated with lower BMI percentiles for boys and girls.

Our data contribute new information on BMI and PA in rural schools. Overweight and obesity prevalence among our rural sample is higher, and school-day MVPA levels lower, compared to objectively measured, nationally representative data in rural and urban children[2,17]. Nearly 40% of children grades 1-6 were overweight and 20% were obese. The highest rates were among 5th and 6th graders; 41.8% and 41.1% of whom were overweight; 24% and 22.9% were obese, respectively. The high prevalence of obesity in this study is consistent with what others have reported in rural versus non-rural children[18,19]. Joens-Matre et al[18] observed 25% of rural Iowan 4th-6th graders were obese, compared to 17% of children from small cities and 19% of those living in urban areas. These data are similar to the values observed among the 4th-6th graders in our study; excepting the 4th grade girls (Table 2). Liu et al[19] examined a nationally representative sample of rural (n=2771) and urban (n=13,766) children, ages 2-19. They found rural youth (12-19y) had 30% higher odds of overweight and obesity compared to urban youth after adjusting for socio-demographic factors, health, diet, and exercise behaviors.

When we examined obesity status relative to school-day MVPA (min/d), we found healthy-weight children accrue 19 vs.15 mind/d in obese children. Over a 5-day period, this would translate into a 20-minute deficit for obese children compared to healthy-weight peers. If

we could increase the amount of MVPA all children get by 20 minutes per school day, we may expect an approximate 0.4-0.5 standard deviation change toward a healthier BMI Z-score. This is a meaningful shift, particularly for children bordering on overweight or obesity.

To our knowledge there are no published studies examining the relationship between school-day MVPA (min/d) and BMI percentile in elementary age children. However, others have reported school-day MVPA without measuring BMI, or considering the relationship of PA to weight status. Long and colleagues[17] examined daily PA in a nationally representative sample. They observed 6-11 year-old girls and boys accrued 28 and 37 min/d of school day MVPA, respectively. These values are higher than we observed for both boys and girls, perhaps explained by sample differences. Although Long et al objectively measured PA, urban or rural residency was not indicated, a limitation the authors cited. Further, nearly 70% of their participants were classified as "higher income" reflecting total household incomes > 130% of the federal poverty level. Our sample was entirely rural, and school populations ranged from 56% to 94% eligible for free and reduced meals based on federal poverty levels.

The relationship between school-day PA and full-day PA is important. Long et al[17] examined PA measured across the entire day – something we were unable to do.. They found that school-day PA accounted for the largest proportion of total weekday MVPA (~45%) and that every minute of MVPA accrued during school was associated with 1 minute of additional MVPA throughout the day. This means that the majority of MVPA was obtained during the school day. Assuming this relationship holds true for our sample, this would translate to approximately 40 min/d of MVPA – still well below the minimum recommended daily dose. This finding is alarming considering that, among our sample of rural children, a majority of whom travel to school by bus with one-way commute times between 14-125 minutes, school-day PA may provide a greater fraction of daily MVPA.

Others have found that rural youth (2-11 y) are *more* active than non-rural youth across the entire day[19]. Thus, rural youth may make-up the deficit in school-day TPA and MVPA through before/after school opportunities. The PA data reported by Liu et al[19] were not objectively measured and findings are based on analyses of parent proxy self-report of children's PA. Regardless, results suggest that among our rural population, the burden of providing

sufficient PA opportunities for children is placed on families who may have insufficient time, opportunity or resources to carry that burden.

This study is novel in that it relates objectively measured school-day MVPA to BMI percentile among Oregon rural children; however, there are limitations that may influence interpretation of these data. The pedometers we used allowed us to set a step/minute threshold that characterized MVPA, but we were unable to individualize those cut-points. We set our threshold at >120 steps/minute for all children based on limited available data[20–22] recommending cut-points for children and youth from 112-140 steps/minute based on data from children 10-15 years of age. Since collecting these data, Morgan et al[23] estimating step rate thresholds for moderate intensity walking among children 9-12y using indirect calorimetry. They found that for healthy weight children, step counts ranging from 120-140 and 110-130 steps/min were reflective of moderate PA for 9-10 and 11-12 year olds, respectively. The ranges were slightly lower (110-130 and 110-120 steps/min) for overweight/obese children. Thus, our steps/minute data are similar to these. We did not control for day-to-day variations in school and class schedules, such as PE, recess, or local climate. However, the intent of this study was not to examine the relationship of PA to any particular program, but rather to characterize the daily school-day dose. –A review of school and classroom schedules indicated daily recess and weekly PE were offered at all schools during the periods of data collection. Unfortunately, those opportunities for PA do not appear sufficient to provide children with the daily MVPA dose recommended to minimally protect them from chronic hypokinetic conditions. The study would have been strengthened by examining full-day PA and collecting child level demographic data and information on commute time or active transportation. Future studies would benefit by including these factors to improve our understanding of the specific rural school settings (recess, PE, classroom etc.) policies (mandatory minimums in weekly PE/PA) and programs (bussing, active transportation) that can be optimized to increase children's daily MVPA.

Conclusions

This is the first study to objectively assess the relationship between school-day PA (min/d) and BMI in rural elementary school children. Regardless of grade level, children accrued < 60 min/d of TPA and < 20 min/d of MVPA during a 6-hour school day. Obesity levels were high, particularly among 5th and 6th graders and there was an inverse relationship between BMI

percentile and minutes of MVPA for both boys and girls. Efforts to promote PA as a strategy for obesity prevention in rural schools should focus on increasing opportunities for MVPA during the school-day, since this is the component of TPA shown to have the greatest potential to reduce the risk of disease associated with low PA levels.

Highlights:

- Rural children (6-11y) in Oregon exhibit high rates of overweight (38.1 %) and obesity (19.4 %).
- Rural children in Oregon exhibit low levels of PA during the school day (<60 min/d of Total PA and < 20 min/d of MVPA).
- The level of MVPA children accrue at school is related to weight status among rural children in Oregon.

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Conflict of Interest

The authors declare there is no conflict of interest.

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