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# Physical activity levels and obesity status of Oregon Rural Elementary School children

Katherine B. Gunter [a,*], Patrick Abi Nader [b], Deborah H. John [b]

[a] College of Public Health and Human Sciences, Oregon State University, Corvallis, OR 97331, United States
[b] College of Public Health and Human Sciences, Oregon State University, Corvallis, OR 97331, United States

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ABSTRACT

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

*Methods.* Height (cm), weight (kg), and PA were measured for 1767 children (5–12 years) enrolled in six rural Oregon elementary schools in fall, 2013. PA at school was measured over four days using Walk4Life pedometers. Children with ≥3 valid monitoring days (n = 1482) were included in analyses. Means (min/d) were calculated for wear time, total PA (TPA: combined light, moderate, vigorous PA), and moderate to vigorous PA (MVPA: step count > 120/min). BMI z-scores were calculated and regression models were run to examine the relationship between PA and BMI z-scores, adjusting for wear time, sex, and grade.

*Results.* Overweight (38.1%: BMI ≥ 85$^{th}$ percentile for age and sex) and obesity (19.4%: BMI ≥ 95$^{th}$ percentile) prevalence was similar for boys (n = 782) and girls (n = 700). More MVPA was associated with lower BMI (P < 0.001), independent of sex, wear time 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) during school hours. 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 (Fryar et al., 2012). The most current available data indicate that 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 (Ogden et al., 2014) remain high with obesity rates 10% above the Healthy People 2020 goal of 15.7% (U.S. Department of Health and Human Services and Office of Disease Prevention and Health Promotion, 2014). Longitudinal studies show that obese children are more likely to become obese adolescents (Cunningham et al., 2014), and eventually obese adults (Freedman et al., 2005; Guo and Chumlea, 1999) putting them at greater risk for heart disease, type 2 diabetes, stroke, cancer, osteoarthritis and early mortality (National Heart Lung and Blood Institute (NHLBI), 2012). 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% (Bouchard et al., 1997) 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 at school has been proposed as one of the best options for accelerating progress in obesity prevention (National Physical Activity Plan, 2010; White House Task Force on Childhood Obesity, 2010; IOM (Institute of Medicine)., 2012).

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 (National Association for Sport and Physical Education, American Heart Association, 2012). Even when schools have robust PE programs, it is rare that children spend the recommended 50% of PE class time in MVPA (UCLA Center to Eliminate Health Disparities, Samuels and Associates, 2007). Thus, relying on PE programming to ensure that children are sufficiently active during the school day may be short sighted. Bassett et al. (2013) found

* Corresponding author.
*E-mail addresses:* Kathy.gunter@oregonstate.edu (K.B. Gunter), patrick.abinader@oregonstate.edu (P.A. Nader), deborah.john@oregonstate.edu (D.H. John).

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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 6–7-hour school day may present the best opportunity for many children to meet the recommended 60-min/d minimum of MVPA. As such, statewide surveillance data on PA during school hours has potential as an important health behavior 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 PA at school to health indicators such as BMI. This makes it challenging to advocate school policies and resources to promote PA as critical among rural children. Thus, the purpose of this study was to measure PA levels during the school day among children attending elementary schools in rural Oregon, and to determine the relationship of PA behaviors at school to BMI.

## Methods

### *Participants and settings*

This study was in collaboration with Oregon State University Health Extension (OSUHE) faculty on campus and in the field. OSUHE provides programming in approximately 200 elementary schools throughout Oregon. Participating schools were selected based on the following criteria: 1.) Located in a community designated as a rural place by the US Census (U.S. Department of Agriculture (USDA), 2012), 2.) ≥50% of school families eligible for free and reduced meals, 3.) OSUHE county faculty were available to participate. Three OSUHE faculty members serving three geographically diverse Oregon counties were available and agreed to participate. OSUHE faculty served as liaisons to schools and helped research staff collect data. Researchers trained all staff on assessment protocols. 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.

### *Assessment of body mass index (BMI)*

Height and weight were measured over 2-days at each school by the same team of 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$^2$). BMI raw data were transformed to BMI z-scores based on the Centers for Disease Control and Prevention (CDC) growth charts (Vidmar et al., 2013). Children were classified as "overweight" or "obese" using the age- and sex-specific 85th and 95th percentiles from the CDC growth charts (Centers for Disease Control and Prevention, 2014).

### *Assessment of physical activity (PA)*

Physical activity was measured on four consecutive school days during the hours children were attending school. Classroom teachers were trained to distribute pedometers, log non-compliance, daily wear time (min/d), and school attendance, and assist children with putting the devices on at the start of each school day and removing them at the end of the school day (approximately 6.5 h). We used Walk4Life MVP pedometers (Walk4Life Inc.; Oswego, IL); a validated device that records all activity and can differentiate activity minutes at or above a pre-specified step rate (Beets et al., 2011). Children wore the pedometers on their right hip, attached by an elastic belt. PA data collection coincided with height and weight assessments.

### *Statistical analyses*

Cumulative averages over the 4-day sampling period were calculated for wear time (min/d at school), total PA (TPA; combined light, moderate, vigorous PA), and MVPA (step count > 120/min). Children with ≥3 valid monitoring days were included in the final analyses. While there were no differences in TPA or MVPA between children with 2, 3, or 4-days of valid PA data, only children with ≥3 days of PA monitoring were included in analyses.

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 z-scores were calculated for use in regression models. Any children with z-scores > 4 SD above or below age and sex matched reference data were identified as outliers and excluded from analyses. Regression models were run to examine the relationships between PA variables (TPA and MVPA) and BMI z-scores, adjusting for wear time, sex, 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, we measured 1767 of 1852 enrolled 1$^{st}$–6$^{th}$ graders (95.4%). The final sample included 1482 children (83.8% of measured children; 782 boys; 700 girls) with valid PA and BMI measurements (BMI z-scores data < 4 SD for sex and age and >3 days of pedometer measured PA data). 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 1**
Characteristics of participating rural elementary schools.

| Grade levels | County 1 | | County 2 | | County 3 | |
|---|---|---|---|---|---|---|
| | School 1 K–6 | School 2 K–5 | School 3 K–6 | School 4 K–6 | School 5 K–6 | School 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.

**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 85$^{th}$ percentile according to the CDC growth chart are considered overweight; children above the 95$^{th}$ percentile are considered obese.

On average, children wore pedometers for 357 (±25 min/d). This equates to approximately 92% of a 6.5-hour school day. The average participation in TPA during the school day 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 4 shows the results of regression analyses examining the relationship of MVPA (min/d) to BMI z-scores, adjusting for wear time (min/d), sex and grade. There was no relationship between TPA time and BMI z-scores, thus, TPA was not included in the final model. More MVPA was associated with lower BMI z-scores ($P < 0.001$), independent of sex, wear time or grade.

Multiple logistic regression models were constructed with BMI percentile categories as the outcome variable (overweight vs. healthy BMI percentile; obese vs. healthy BMI percentile; Table 5). Categories include: underweight (BMI < 5$^{th}$ percentile), healthy weight (BMI >5$^{th}$ percentile and < 85$^{th}$ percentile), overweight (BMI ≥ 85$^{th}$ percentile and < 95$^{th}$ percentile), obese (BMI ≥ 95$^{th}$ percentile). Sixteen participants (1%) were underweight (BMI < 5$^{th}$ percentile) and not included in the logistic analyses. 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 PA (min/d) at school and BMI in rural elementary school children (6–12 y) 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 z-scores 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 were lower, compared to objectively measured, nationally representative data in rural and urban children (Ogden et al., 2014; Long et al., 2013). Nearly 40% of children grades 1–6 were overweight and 20% were obese. The highest rates were among 5$^{th}$ and 6$^{th}$ 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 (Joens-Matre et al., 2008; Liu et al., 2012). Joens-Matre et al. (2008) 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 4$^{th}$–6$^{th}$ graders in our study; excepting 4$^{th}$ grade girls (Table 2). Liu et al. (2012) examined a nationally representative sample of rural (n = 2771) and urban (n = 13,766) children, ages 2–19. They found that rural youth (12–19 y) 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 MVPA (min/d) at school, we found healthy-weight children accrue 19 min/d vs. 15 min/d in obese children. Assuming our 3–4-day average is reflective of a 5-day school week, and that children are not making up the PA time after school, this could translate into a 20-minute deficit during the school week for obese children compared to healthy-weight peers. If we could increase the amount of MVPA at school by 20 min/d for every child, we may see a positive shift in BMI z-scores. Regardless the potential impact on BMI, the evidence is clear that more MVPA ultimately benefits child health.

To our knowledge there are no published studies examining the relationship between MVPA (min/d) at school and BMI percentile in elementary age children. However, others have reported MVPA at school without measuring BMI, or considering the relationship of MVPA to weight status. Long et al. (2013) examined daily PA in a nationally representative sample. They observed 6–11 year-old girls and boys accrued 28 and 37 min/d of MVPA at school, 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 PA at school and full-day PA is important. Long et al. (2013) examined PA measured across the entire day—something we were unable to do. They found that PA at school

**Table 3**
Average physical activity (PA) at school 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 |

Data collected in Oregon, fall 2013.
[a] Total PA Mean = average total minutes of physical activity at school (includes light, moderate, and vigorous).
[b] MVPA = average minutes of moderate and vigorous physical activity at school above a step count of 120 steps/min.

**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. Data collected in Oregon, fall 2013.
[a] Mean MVPA = average minutes with step count >120 steps/min.
[b] Grade = child grade in school.
[c] Grade 1 is computed as the reference group for the grade comparison.
[d] Mean wear time = average min/d pedometer was worn at school during assessment period.

accounted for the largest proportion of total weekday MVPA (~45%) and that every minute of MVPA accrued during school was associated with 1 min of additional MVPA throughout the day. Assuming that 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 and 125 min, PA at school may provide a greater fraction of daily MVPA. Our data indicate children are in motion 13%–15% of the school day and are active at an intensity shown to positively benefit health only 5% of the school day.

Others have found that rural youth (2–11 y) are *more* active than non-rural youth across the entire day (Liu et al., 2012). Thus, rural youth may make up the deficit in TPA and MVPA through before/after school opportunities. However given the reliance on bussing, this seems unlikely for our sample. It's also important to recognize the PA data reported by Liu et al. (2012) 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 MVPA during school to BMI z-scores among Oregon rural children; however, there are limitations that may influence interpretation of these data. While accelerometers would have provided more robust data, they are not

**Table 5**
Multiple logistic regression models—BMI percentile category as outcome.

| | Odds ratios | Std. err. | z | P > z | [95% conf. interval] | |
|---|---|---|---|---|---|---|
| Normal weight (reference category)[a] | – | – | – | – | – | – |
| Overweight | | | | | | |
| MVPA[b] | 0.9876124 | 0.0092715 | −1.33 | 0.184 | 0.9696068 | 1.005952 |
| Sex (boys vs girls) | 1.047798 | 0.1478826 | 0.33 | 0.741 | 0.7945875 | 1.381698 |
| *Grade*[c] | | | | | | |
| 1[d] | – | – | – | – | – | – |
| 2 | 1.071009 | 0.2629888 | 0.28 | 0.780 | 0.6618792 | 1.733037 |
| 3 | 1.360198 | 0.3131841 | 1.34 | 0.182 | 0.8661912 | 2.135946 |
| 4 | 0.8664541 | 0.2173784 | −0.57 | 0.568 | 0.5298998 | 1.416764 |
| 5 | 1.058103 | 0.2574975 | 0.23 | 0.816 | 0.6567216 | 1.704804 |
| 6 | 1.010237 | 0.2646768 | 0.04 | 0.969 | 0.6045232 | 1.688238 |
| Mean wear time[e] | 0.9966874 | 0.002678 | −1.23 | 0.217 | 0.9914523 | 1.00195 |
| Constant | 1.158667 | 1.149968 | 0.15 | 0.882 | 0.1656332 | 8.105316 |
| *Obese* | | | | | | |
| MVPA[b] | 0.9266799 | 0.010319 | −6.84 | 0.000 | 0.9066742 | 0.9471271 |
| Sex (boys vs girls) | 1.518401 | 0.2156269 | 2.94 | 0.003 | 1.149498 | 2.005695 |
| *Grade*[c] | | | | | | |
| 1[d] | – | – | – | – | – | – |
| 2 | 1.547433 | 0.4111454 | 1.64 | 0.100 | 0.9192881 | 2.604785 |
| 3 | 1.447277 | 0.3788074 | 1.141 | 0.158 | 0.8664822 | 2.417372 |
| 4 | 1.175091 | 0.3091869 | 0.61 | 0.540 | 0.7016261 | 1.968056 |
| 5 | 1.541974 | 0.3926028 | 1.70 | 0.089 | 0.9361644 | 2.539814 |
| 6 | 1.282047 | 0.3488311 | 0.91 | 0.361 | 0.7521445 | 2.185278 |
| Mean wear time[e] | 1.002751 | 0.0028559 | 0.96 | 0.335 | 0.997169 | 1.008364 |
| Constant | 0.2601313 | 0.2731909 | −1.28 | 0.200 | 0.0332091 | 2.037641 |

Number of observations included in the model = 1466; LR Chi-square (16) = 73.78; P = 0.0000; pseudo R-squared = 0.0270. Data collected in Oregon, fall 2013.
[a] Normal weight = children of normal weight category served as reference category for all comparisons.
[b] Mean MVPA = average minutes with step count >120 steps/min.
[c] Grade = child grade in school.
[d] Grade 1 is computed as the reference group for the grade comparison.
[e] Mean wear time = average school-day min/d pedometer was worn during assessment period.

feasible for such a large sample. Instead we used the Walk4Life MVP pedometer (approximately $15/ea.) that records activity time at or above a pre-specified step/min frequency and provides a comparable estimate of MVPA among youth in relation to accelerometry (Beets et al., 2011). We set our threshold at >120 steps/min for all children based on available data (Jago et al., 2006; Graser et al., 2009; Beets and Pitetti, 2011; Morgan et al., 2014) recommending cut-points for children and youth ages 9–15 from 112 to 140 steps/min (Jago et al., 2006; Graser et al., 2009; Beets and Pitetti, 2011; Morgan et al., 2014). Though we did not control for day-to-day variations in school and class schedules (e.g. PE, recess) or local climate, we did gather these data. A review of school and classroom schedules indicated daily recess and weekly PE were offered at all schools during the periods of data collection. PE programming ranged from 30 to 150 min/wk; delivered by classroom teachers, PE specialists, or a combination of the two. Cumulative rainfall varied, but observations by our research assistants indicated all schools allowed kids out to play at recess regardless of weather. 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. There are numerous factors that influence child BMI and may mediate the relationship of school day MVPA and BMI that were not measured in this study. Examining PA before, during, and after school, measuring eating behaviors, and gathering demographic, commute time, active transportation, recess time and PE data for each child would have strengthened the study and allowed us to tease out the relative impact of PA at school on child weight status. 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 PA (min/d) at school 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 5$^{th}$ and 6$^{th}$ graders and there was an inverse relationship between BMI and minutes of MVPA for both boys and girls. While there are numerous other factors that likely contribute to this relationship including PA outside of school and child eating behaviors, this study provides some insights into the dearth of PA provided in rural schools and the potential effects this may have on child weight status. 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.

## Conflict of interest

The authors declare that there is no conflict of interest.

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