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Consistency of Moderate to Vigorous Physical Activity in Middle School Physical Education

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This study assessed the consistency of moderate to vigorous physical activity (MVPA) in a sample of middle school physical education lessons. Random intercept hierarchical linear regressions were employed to model the relationship between consistency of MVPA and independent variables, including lesson and teacher characteristics. Larger classes spent significantly more time in consistent MVPA in the absence of controlling for teacher characteristics. A significant interaction between class size and teacher experience suggests that experience may play a beneficial role in larger classes, and overall class size does not have to be a barrier to achieving high levels of MVPA.

Key words: adolescent, obesity, overweight, physical education and training, schools

REGULAR participation in physical activity supports healthy growth and development.[1] In particular, habitual moderate to vigorous physical activity (MVPA) has been shown to benefit musculoskeletal and cardiovascular health and the maintenance of normal lipid levels, adiposity, and blood pressure among children and adolescents.[1] Physical activity is also associated with the prevention of chronic health conditions and with improved mental health and academic performance.[1,2] Physical activity-related behaviors during childhood and adolescence are linked to adult lifestyle choices, with inactivity among youth predicting sedentary living in adulthood.[2,3] Given the tendency for activity levels to drop as children grow older, early adolescence seems to be a critical period for establishing habits related to physical activity.[4]

Despite the well-established beneficial effects of physical activity on health, an alarmingly high number of students fail to meet physical activity recommendations.[5-7] According to the United States Department of Health and Human Services' Physical Activity Guidelines for Americans, children and adolescents should engage in at least 60 minutes of MVPA each day.[5] A 2012 national survey found that approximately 20% of 12- to 15-year-olds did not participate in free-time physical activity outside of school.[6] Only 15.4% of 11- to 14-year-olds in California report being physically active for at least an hour a day each week.[7] Among female and Latino and non-Latino African-American students, even fewer students meet guidelines for regular physical activity, trends that persist in adulthood.[7-9]

Environmental factors such as institutional and public policies play a significant role in both promoting and limiting healthy behaviors.[10] Given that children and adolescents spend a large proportion of their waking hours in school, school policies and practices around physical activity have enormous potential to influence student participation in these behaviors. The National Association for Sport and Physical Education (NASPE) recommends 225 minutes of physical education (PE) per week for secondary students, with at least 50% of class time spent in MVPA.[11,12] Although the majority of states mandate teaching PE in middle school, only 35.3% specify a minimum amount required per week, and of those, the majority require amounts well below NASPE recommendations.[13] For students living in low-resourced communities with few opportunities for physical activity outside of school, inadequate physical activity in PE contributes to disparities in physical activity levels by socioeconomic status.[14-16]

In addition to insufficient quantities of physical activity among youth, little attention is paid to the quality of PE instruction. PE often takes a back seat to core academic subjects emphasized for accountability and achievement by the No Child Left Behind Act,[17] resulting in reduced time and resources allocated to PE.[14] Low activity levels, lessons spent

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entirely in free play, and frequent shortening or cancelling of PE classes are all common practices, not only reducing opportunities for MVPA but also sending students the message that schools do not value PE.[18] Other barriers to high-quality physical activity in school include inadequate facilities, insufficient equipment, large class sizes, and competing demands placed on PE teachers.[14] Providing physical activity opportunities is only one of the many goals of PE, along with teaching motor, cognitive, and social skills.[11] This lack of focus has led PE to be described as having a "muddled mission" and has prevented a consensus on how to best meet the health needs of students.[19]

Although barriers to physical activity in schools have been identified, little evidence exists to guide the delivery of more effective PE instruction. Examining policies requiring PE is insufficient for assessing levels of MVPA or quality of instruction, but outside of data regarding PE policies, little research has been done on the national picture of PE. Recent studies in California schools found that class sizes frequently exceed the caps prescribed by state laws and district policies, the percentage of class time in MVPA is often below the recommended 50% of time, and larger classes and less affluent schools report lower levels of physical activity.[20,21] Assessing quality of PE and MVPA levels is best done through direct observation methods that allow for simultaneous measurement of lesson context and physical activity.[22] The System for Observing Fitness Instruction Time (SOFIT) is a direct observation tool that has been used to examine PE in numerous studies across elementary and secondary grade levels.[23-27]

Previous SOFIT studies conducted in secondary school settings have looked mainly at the total percentage of class time spent in MVPA and have found significant associations with class size and length, type of activity, class gender composition, lesson context, and teacher behavior.[23,28-30] No studies in the literature review have been identified that explore the consistency of physical activity levels within lessons and whether lesson-, teacher-, or school-level factors impact the consistency of MVPA during PE. Examining the consistency of MVPA is important for understanding factors that support the maintenance of high levels of physical activity throughout the lesson, as this type of activity is most beneficial to cardiovascular health.[1,5] Furthermore, understanding the association between potentially modifiable environmental factors and consistent MVPA levels can have important implications for decision making around the delivery of PE in middle schools. Therefore, the purpose of this current investigation was to assess consistency of MVPA in a sample of middle school PE lessons using direct observation methods. We also explored the extent to which lesson characteristics, teacher gender and experience, and school-level variables impact physical activity-related outcomes.

METHODS

Participants

We observed 94 PE lessons taught by 45 teachers in 17 middle schools, with a mean enrollment of 1351 students in a large urban school district in Los Angeles, California. Schools were identified by their willingness to participate in an intervention study and their level of enrollment in the free or reduced price meal program. Across all schools in the study, an average of 76% of students participated in the free and reduced price meal program and the majority of students were Latino (79.8%). Schools were randomly assigned to be either intervention or control, and teacher participation was voluntary. Study approval was obtained through the University Institutional Review Board and the school district. Principals and PE teachers from each school agreed to participate as demonstrated through the establishment of a memorandum of understanding. Depending on the school schedule, students participated in PE class ranging from 38 to 110 minutes in length 2 to 5 days per week taught by credentialed PE specialists employed full-time by the school district.

Data collection procedure

Student activity levels in physical education classes were assessed by trained observers in spring and fall 2014 using a modified version of the SOFIT protocol.[20] As in the original SOFIT protocol,[31] 4 students in each class were observed on a rotating basis every 10 seconds over the duration of the class. Students were chosen at the beginning of each class to be roughly representative of the class in terms of gender and overweight status—2 factors known to influence physical activity intensity and duration. For example, in a class composed of equal proportions of boys and girls with about one quarter with body shapes appearing overweight or obese, students selected for observation would include 2 boys and 2 girls with 3 of the students appearing to be normal weight and 1 appearing to be overweight or obese. All observations were anonymous as neither students nor teachers knew which students were being observed.

At each 10-second mark the observer would note the target student's physical activity level and lesson context. The intensity of students' physical activity was recorded on a 4-point scale: (1) sedentary (eg, sitting or lying down), (2) light physical activity

(eg, standing or casual walking), (3) moderate physical activity (eg, brisk walk or light jog), (4) vigorous (eg, running or other activity sufficiently intense to cause heavy breathing and sweating). The use of this observational approach to assess the intensity of physical activity has been validated using heart rate monitors and accelerometers.[32,33] In a slight divergence from the original SOFIT protocol, sitting and lying down were coded the same, since both correspond to sedentary activity levels.

Similar to the original SOFIT protocol, lesson context was coded as (M) classroom management, (K) knowledge/didactic instruction, (F) fitness/calisthenics/skills development, and (P) playing games. Tasks related to organizing students or equipment were considered management, teacher-led instruction of PE content was identified as knowledge, practicing specific skills and exercises was coded fitness/skills, and organized games were considered play. Each student was observed for 2 minutes (twelve 10-second intervals) before switching to the next student. At the conclusion of each 2-minute segment, the teacher's activity level and engagement was noted. After all 4 students were observed, observations began again with the first student. The primary lesson activity, or the main activity of the class period, was also recorded. Activities were categorized as free play, games (eg, capture the flag), fitness (eg, circuit training), drills and skills (eg, football toss), low movement team sports (eg, softball), or high movement team sports (eg, soccer).

Data collectors included 7 graduate students and the project coordinator, all trained by a coinvestigator and experienced SOFIT observer. After tabletop training with practice observations using videos of PE classes, observers conducted practice observations in the field and compared observations during debriefings. Observers conducted observations in pairs until ratings converged. Formal interrater reliability testing was not assessed, however. Observations were scheduled at various times of the day and on different days of the week, and teachers were asked to conduct a typical class (ie, no testing or unusual activities). Field data from coding sheets were entered into an MS Excel data recording sheet that limited entry to valid values for each field and which was laid out similar to the coding sheet to facilitate easy visual comparison of paper and electronic records to check for discrepancies. School-level and teacher-level data, including percentages of students who participate in the free or reduced price meal program, academic performance indices, and teachers' years of experience were obtained through publicly available databases.

Data analyses

The unit of analyses was the lesson, and outcome variables included (1) the percentage of observed class time in consistent MVPA, operationalized as bouts of MVPA of 30 seconds or longer, (2) percentage of class time in MVPA, and (3) percentage of class time in vigorous physical activity (VPA). A logarithm transformation was used to address heavy right skewness in the outcome variables, and these transformed variables were used in all analyses. The primary independent variable of interest was class size, which was dichotomized at 45 students on the basis of district policy for secondary PE class size limits.[34] We also examined lesson context, percentage of scheduled lesson time not engaged in PE content (transition time), observation length, primary activity type, location (indoor or outdoor), time of day, gender composition, and teacher gender and experience level.

We used χ^2 and t tests to identify significant differences in outcome and independent variables between classes with 45 or fewer students and classes with more than 45 students. Because of the nature of the data (lessons nested within teachers), random intercept hierarchical linear regressions were employed to model the relationship between the outcome and independent variables. Hierarchical Poisson and negative-binomial models were also considered, counting the number of 10-second "consistent" intervals and using the total number of 10-second intervals as an offset. However, because of poor goodness-of-fit statistics in the simpler nonhierarchical case, Poisson regression was excluded. Hierarchical negative binomial regression yielded similar conclusions as the hierarchical linear regression, and so is not presented here. As lesson context consists of 4 variables summing to 100%, percentage of time in management, knowledge, fitness/skills, and play, percentage of time in play was excluded from the regressions to avoid inducing multicollinearity among the covariates.

For each of the 3 outcomes, 4 hierarchical linear models were considered. The first model included no explanatory variables to estimate the amount of variation explained when grouping classes by teacher and to determine the appropriateness of hierarchical modeling. The second model included the primary independent variable of interest, which was whether the class had greater than 45 students. The third model controlled for lesson-level variables, including primary lesson activity, observation length, time of day, lesson location, percentage of male students, percentage of time in each lesson context, and percentage of time in transition. The fourth model further controlled for teacher characteristics,

including gender, years of experience, and the interaction between years of experience and class size greater than 45 students. Other interaction terms with class size greater than 45 students were tested, but only years of experience resulted in a significant interaction term in any of the 3 outcomes. Nesting teachers within schools was considered, but no significant amount of variation was explained by this grouping, so this was not presented in the results. In addition, school-level characteristics were not included in these models, as they were not found to be significant explanatory variables in any model. All analyses were conducted using Stata Statistical Software: Release 14 (College Station, Texas).

RESULTS

Table 1 presents descriptive statistics for the 94 PE lessons in the sample. On average, 9.3% of class

TABLE 1. Characteristics of the Sample in Total and by Class Size[a]

Characteristics	Total (N = 94) % or Mean (SD)	Class Size ≤ 45 (N = 47) % or Mean (SD)	Class Size > 45 (N = 47) % or Mean (SD)
Consistent MVPA, %	9.3 (9.3)	7.9 (10.1)	10.7 (7.8)
Consistent MVPA log-transformed[b], %	1.9 (1.0)	1.6 (1.1)	2.2 (0.7)[c]
Time in MVPA, %	14.8 (10.6)	13.3 (11.9)	16.3 (8.9)
Time in MVPA log-transformed[b], %	2.5 (0.8)	2.3 (0.9)	2.7 (0.6)[d]
Time in VPA, %	3.6 (4.5)	3.1 (5.7)	4.0 (2.8)
Time in VPA log-transformed[b], %	1.2 (0.8)	0.9 (0.9)	1.4 (0.7)[c]
Location			
Indoors	28.7	31.9	25.5
Outdoors	71.3	68.1	74.5
Time in context, %			
Management	28.9 (16.1)	29.6 (16.1)	28.2 (16.3)
Knowledge	5.8 (10.2)	5.6 (10.8)	6.0 (9.7)
Fitness/skills	39.3 (28.1)	43.0 (29.5)	35.6 (26.4)
Play	26.0 (28.7)	21.7 (29.0)	30.2 (28.0)
Grade			
5th	2.1	0.0	4.3
6th	31.9	31.9	31.9
7th	28.7	27.7	29.8
8th	13.8	10.6	17.0
Mixed	23.4	29.8	17.0
Male students, %	44.9 (18.6)	42.4 (19.5)	47.3 (17.5)
Activity			
Free play	6.4	4.3	8.5
Games	9.6	10.6	8.5
Fitness	20.2	23.4	17.0
Drills/skills	14.9	17.0	12.8
Team sports (low)	23.4	19.2	27.8
Team sports (high)	25.5	25.5	25.5
Class length	56.6 (14.2)	58.4 (16.6)	54.9 (11.3)
Observation length	38.7 (12.2)	39.5 (12.9)	37.9 (11.5)
Time in transition, %	31.8 (10.2)	32.3 (9.9)	31.4 (10.7)

Abbreviations: MVPA, moderate to vigorous physical activity; SD, standard deviation; VPA, vigorous physical activity.
[a]For categorical variables χ^2 tests were performed. For continuous variables, 2-sided 2-sample independent t tests were performed. Some reported percentages may not sum to 100 because of rounding.
[b]Each value was increased by 1 before taking the logarithm to avoid undefined values.
[c]$P < .01$; [d]$P < .05$.

time was spent in consistent bouts of MVPA of 30 seconds or longer. Across all lessons, a mean of 14.8% of class time was spent in MVPA and 3.6% of time was spent in VPA. The majority of lessons were held outdoors (71.3%). Classes had an average of 47.5 students, of whom 44.9% were male, and most observations were conducted in the sixth- and seventh-grade classes (31.9% and 28.7%, respectively). Teachers had an average of 13.6 years of experience and over half (55.3%) were male. The average scheduled class length was 56.6 minutes, but average observation length (ie, instructional time) was only 38.7 minutes. Thus, 31.8% of the scheduled class period was spent not engaged in content related to PE, such as transitioning to and from physical activity spaces or changing in locker rooms.

With regard to lesson context, on average 28.9% of lesson time was spent in management, 5.8% in knowledge, 39.3% in fitness/skills, and 26.0% in play. The primary lesson activity was team sports for 48.9% of lessons, drills and skills for 14.9% of lessons, fitness for 20.2% of lessons, games for 9.6% of lessons, and free play for the remaining 6.4% of lessons. Differences in outcomes and independent variables by class size are also presented in Table 1. There were no significant differences in outcomes between classes with 45 or fewer students and classes with more than 45 students. However, the log-transformed outcome variables showed a significantly higher percentage of class time spent in consistent MVPA, MVPA, and VPA in classes with more than 45 students.

Consistent moderate to vigorous physical activity

Table 2 presents the results of the hierarchical linear models predicting percentage of lesson time engaged in consistent MVPA. Significant teacher-level variation in percentage of lesson time in consistent MVPA was found across all models. Results of the null model (Table 2, Model 1) indicate that approximately 20% of the variation in percentage of lesson time in consistent MVPA can be attributed to teacher-level characteristics (ICC = 0.20), whereas the remaining 80% can be attributed to lesson-level characteristics. The positive coefficient for classes

TABLE 2. Summary of Hierarchical Linear Regressions Predicting Log-Transformed Percentages Consistent MVPA (N = 94)

	Model 1 B (SE(B))	Model 2 B (SE(B))	Model 3 B (SE(B))	Model 4[a] B (SE(B))
Fixed effects				
Intercept	1.90 (0.11)[b]	1.57 (0.14)[b]	1.15 (0.69)	1.68 (0.76)[c]
Greater than 45 students		0.65 (0.19)[d]	0.66 (0.18)[b]	0.07 (0.30)
Fitness class			0.63 (0.25)[c]	0.59 (0.25)[c]
Observation length			0.01 (0.01)	0.00 (0.01)
Time of day—afternoon (reference: morning)			0.29 (0.22)	0.15 (0.25)
Outdoor activity (reference: indoor)			0.43 (0.20)[c]	0.51 (0.20)[c]
Male, %			0.00 (0.00)	0.00 (0.00)
In M, %			0.01 (0.01)	0.01 (0.01)
In K, %			0.00 (0.01)	0.00 (0.01)
In FS, %			0.00 (0.00)	0.01 (0.00)
In transition, %			−0.02 (0.01)	−0.02 (0.01)[c]
Teacher gender—male (reference: female)				0.12 (0.22)
Teacher years of experience				−0.03 (0.01)[c]
Greater than 45 students × teacher years of experienc				0.04 (0.02)[c]
Random effects				
Teacher-level error variance[e]	0.19 (0.13)[c]	0.19 (0.11)[c]	0.17 (0.09)[c]	0.19 (0.09)[d]
Class-level error variance[f]	0.73 (0.14)	0.63 (0.12)	0.48 (0.09)	0.42 (0.08)
ICC	0.20	0.23	0.26	0.31

Abbreviations: FS, fitness/skills; ICC, intraclass correlation coefficient; K, knowledge; M, management.
[a]Four observations were removed from this model (N = 90) because of missing values of years of teaching experience.
[b]$P < .001$; [c]$P < .05$, [d]$P < .01$.
[e]Significance of teacher-level error variance was tested using likelihood ratio tests.
[f]Significance of class-level (residual) error variance was not tested.

with greater than 45 students in Models 2 and 3 suggests that students in larger classes spent a significantly greater percentage of class time engaged in consistent bouts of MVPA. However, in Model 4, the introduction of teacher-level characteristics results in the coefficient for class size being reduced to nonsignificance. Lessons that were held outdoors and those with fitness as the primary lesson activity resulted in a significantly greater percentage of class time in consistent bouts of MVPA, as shown in Models 3 and 4. Teacher experience is significantly associated with a lower percentage of class time spent engaged in consistent MVPA, and the interaction term between class size and teacher experience was significant. In addition, percentage of class time spent in transition has a significant negative association with the percentage of class time engaged in consistent MVPA.

Moderate to vigorous physical activity

Results of multilevel models predicting the percentage of lesson time spent in MVPA are presented in Table 3. Significant teacher-level variation in percentage of lesson time spent in MVPA was found only in Models 3 and 4. Results of the full model (Table 3, Model 4) indicate that 23% of the variation in percentage of lesson time spent in MVPA can be explained by teacher-level characteristics (ICC = 0.23), whereas the remaining 77% is attributed to lesson-level characteristics. Similar to results of consistent MVPA, students in larger classes spent a significantly greater percentage of class time in MVPA (Table 3, Model 2). With the addition of lesson-level covariates in Model 3, class size remains a predictor of greater percentage of lesson time in MVPA along with classes held later in the day. Introducing teacher-level characteristics and an interaction term in Model 4 results in the coefficient for class size being reduced to nonsignificance.

Vigorous physical activity

Table 4 presents the results of the hierarchical linear models predicting percentage of lesson time engaged in VPA. No teacher-level variation was found when predicting percentage of lesson time spent in VPA in any of the models. Again, positive

TABLE 3. Summary of Hierarchical Linear Regressions Predicting Log-Transformed Percent MVPA (N = 94)

	Model 1 B (SE(B))	Model 2 B (SE(B))	Model 3 B (SE(B))	Model 4[a] B (SE(B))
Fixed effects				
Intercept	2.49 (0.09)[b]	2.30 (0.11)[b]	2.10 (0.58)[b]	2.16 (0.65)[c]
Greater than 45 students		0.39 (0.15)[c]	0.40 (0.15)[c]	0.11 (0.26)
Fitness class			0.25 (0.21)	0.21 (0.22)
Observation length			0.00 (0.01)	0.00 (0.01)
Time of day—afternoon (reference: morning)			0.38 (0.19)[d]	0.31 (0.21)
Outdoor activity (reference: indoor)			0.27 (0.17)	0.29 (0.17)
Male, %			0.00 (0.00)	0.00 (0.00)
In M, %			0.00 (0.01)	0.00 (0.00)
In K, %			0.00 (0.01)	0.00 (0.01)
In FS, %			0.00 (0.00)	0.00 (0.00)
In transition, %			−0.01 (0.01)	−0.01 (0.01)
Teacher gender—male (reference: female)				0.18 (0.18)
Teacher years of experience				−0.01 (0.01)
Greater than 45 students × teacher years of experienc				0.02 (0.01)
Random effects				
Teacher-level error variance[e]	0.11 (0.08)	0.10 (0.07)	0.10 (0.06)[d]	0.10 (0.06)[d]
Class-level error variance[f]	0.47 (0.09)	0.44 (0.08)	0.35 (0.07)	0.34 (0.07)
ICC	0.18	0.19	0.23	0.23

Abbreviations: FS, fitness/skills; ICC, intraclass correlation coefficient; K, knowledge; M, management.
[a]Four observations were removed from this model (N = 90) due to missing values of years of teaching experience.
[b]$P < .001$; [c]$P < .01$; [d]$P < .05$.
[e]Significance of teacher level error variance was tested using likelihood ratio tests.
[f]Significance of class level (residual) error variance was not tested.

TABLE 4. Summary of Hierarchical Linear Regressions Predicting Log-Transformed Percent VPA (N = 94)

	Model 1 B (SE(B))	Model 2 B (SE(B))	Model 3 B (SE(B))	Model 4[a] B (SE(B))
Fixed effects				
Intercept	1.14 (0.09)[b]	0.91 (0.12)[b]	−0.02 (0.62)	0.56 (0.69)
Greater than 45 students		0.48 (0.17)[c]	0.49 (0.16)[c]	0.14 (0.29)
Fitness class			0.66 (0.23)[c]	0.66 (0.24)[c]
Observation length			0.02 (0.01)	0.01 (0.01)
Time of day—afternoon (reference: morning)			−0.01 (0.20)	−0.11 (0.24)
Outdoor activity (reference: indoor)			0.42 (0.17)[d]	0.47 (0.18)[d]
Male, %			0.00 (0.00)	0.00 (0.00)
In M, %			0.00 (0.01)	0.00 (0.01)
In K, %			0.00 (0.01)	−0.01 (0.01)
In FS, %			0.00 (0.00)	0.00 (0.00)
In transition, %			0.00 (0.01)	0.00 (0.01)
Teacher gender—male (reference: female)				−0.22 (0.18)
Teacher years of experience				−0.02 (0.01)
Greater than 45 students × teacher years of experienc				0.02 (0.02)
Random effects				
Teacher-level error variance[e]	0.03 (0.09)	0.00 (0.00)	0.01 (0.06)	0.01 (0.06)
Class-level error variance[f]	0.68 (0.13)	0.64 (0.09)	0.53 (0.10)	0.52 (0.10)
ICC	0.04	0.00	0.01	0.02

Abbreviations: FS, fitness/skills; ICC, intraclass correlation coefficient; K, knowledge; M, management.
[a]Four observations were removed from this model (N = 90) because of missing values of years of teaching experience.
[b]$P < .001$; [c]$P < .01$; [d]$P < .05$.
[e]Significance of teacher-level error variance was tested using likelihood ratio tests.
[f]Significance of class-level (residual) error variance was not tested.

coefficients for classes with greater than 45 students were found in Models 2 and 3, but the introduction of teacher-level characteristics (Table 4, Model 4) resulted in a reduction in this coefficient to nonsignificance. In addition, lessons that were held outdoors and those with fitness as the primary lesson activity resulted in a significantly greater percentage of class time engaged in VPA.

DISCUSSION

This study aimed to use direct observation techniques to examine the consistency of physical activity levels during middle school physical education. This is the first study to examine consistent MVPA as an outcome and employ modified SOFIT as the data collection instrument. Overall, the average percentage of lesson time spent in MVPA in this sample (14.8%) fell well below the recommendation of at least 50% of class time in higher levels of physical activity.[12] This finding is consistent with other direct observation studies using the original SOFIT tool, although these studies have found proportions of MVPA ranging from 38% to 46%.[20,21,24] The proportion of lesson time lost to transition in this study (31.8%) was similar to other studies conducted in middle school PE classes, which found 19% to 36% of lost instructional time.[23,24,29,30] Thus, only an average of 68% of class time was spent engaged in content related to PE in this sample. Much of the lost instructional time is due to time spent changing in locker rooms at the beginning and end of class, as well as time taken up by transitioning to and from physical activity spaces, particularly when located a long way from locker rooms. Other factors that may contribute to lost lesson time may be interruptions due to addressing individual student needs or school-wide schedule changes. Reducing transition time through more efficient procedures could be an effective strategy for increasing the amount of class time spent in activity. In addition, a supportive school environment that prioritizes PE could contribute to higher quality instruction, allowing teachers more control of the time spent with students.

Classes with more than 45 students spent significantly greater amounts of time in consistent MVPA, MVPA, and VPA in the absence of controlling

for teacher characteristics. Although this finding may seem counterintuitive, previous research has demonstrated mixed results regarding class size. McKenzie et al[23] found a significant relationship between larger class sizes and lower levels of physical activity, though effect sizes were small. Alternatively, other studies have reported that class size is not significantly associated with activity levels, and students have been found to be significantly more engaged during PE class with increasing class size.[24,35] Although hypothesized that larger classes may spend more time in fitness activities (eg, circuit training or running), which may be easier to manage with a large number of students, the significant relationships between class size and consistent MVPA, MVPA, and VPA were not influenced by lesson characteristics in this study. However, future studies could consider measuring other lesson characteristics, such as student engagement or motivation, which may account for differences in levels of activity by class size. Furthermore, the significant positive interaction coefficient between class size and teacher experience suggests that experience may play a beneficial role in teaching larger classes. In addition, school-level factors, such as school climate and culture may be important characteristics to consider. Overall, the results of this study demonstrate that large class size does not have to be a barrier to achieving high levels of consistent MVPA, MVPA, and VPA.

Conducting lessons outdoors was associated with a 67% increase in percentage of class time in consistent MVPA and a 60% increase in percentage of class time in VPA when controlling for all covariates. This finding is consistent with previous studies, which have demonstrated higher intensity in lessons conducted outdoors rather than indoors.[24,30] It is likely that outdoor classes provide more space to move, particularly when classes are larger in size. Interestingly, the percentage of class time spent in MVPA was 46% higher in classes held later in the day, though this effect was no longer significant after the addition of teacher-level variables. Because teacher-level covariates were all found to be nonsignificant in this particular model, time of day may remain an important factor.

Lesson context, which refers to whether the class is engaged in management, knowledge, fitness/skills, or play, was not found to be a significant predictor of activity levels in any of the models tested in this study. Previous studies have consistently found a mediating effect of lesson context on percentage of time in various levels of physical activity.[24,30] Additional analysis is needed to identify whether the timing or duration of different lesson contexts may explain this unexpected finding. Despite a lack of significance in the current study, allocation of time to different lesson contexts may still be an important strategy for increasing MVPA during lessons. Best practices for improving the quality of instruction in physical education include incorporating strategies to minimize time spent on classroom management, in transition, and on administrative tasks.[25,36] For example, integrating the delivery of knowledge with simultaneous physical movement may increase class time spent in MVPA. Furthermore, lessons where the primary activity was fitness were associated with an 80% increase in percentage of time in consistent MVPA and a 93% increase in percentage of time in VPA. Although this finding is not unexpected, further efforts could be made to increase activity levels during all standards-based activities.

Limitations

As with many community and school-based observational studies, there are some limitations that should be addressed. This study was cross-sectional and limited to a single geographical area. As such, results do not demonstrate causal relationships or generalizability. The small sample size, as well as varying numbers of observations per school and teacher, could contribute to the results presented earlier. However, some of these limitations were addressed by using hierarchical regression models during analyses. Although we did not detect school-level variation, a study with a larger sample size may reveal differences in school characteristics. Finally, teacher experience level was not evenly distributed among schools, and given that more experienced teachers are generally found at higher income schools, this should be considered when interpreting results.

CONCLUSION

Physical education provides a critical opportunity to promote physical activity in the school setting. Given the association between physical activity and positive physical health, mental health, and academic outcomes,[1,2] research examining the quality of PE delivery in schools is of great value for understanding best practices and strategies to increase activity levels during PE. This study identifies several factors that contribute to higher levels of consistent MVPA, MVPA, and VPA. Specifically, lessons where the primary activity is fitness, lessons held outdoors, and classes held later in the day were all associated with higher levels of activity. Most notably, higher activity levels in larger classes suggest large class size is not necessarily a barrier to implementing high-quality physical education. Future directions for this research include gaining a deeper

understanding of the school environment and physical education through qualitative methods. More research is needed to further explore lesson, teacher, and school-level characteristics and their effects on physical activity.

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