School and individual-level characteristics are associated with children's moderate to vigorous-intensity physical activity during school recess

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Abstract

***Objective*:** The objective of this study was to identify school environmental characteristics associated with moderate to vigorous physical activity during school recess, including morning and lunch breaks.

***Methods*:** Accelerometry data, child-level characteristics and school physical activity, policy and socio-cultural data were collected from 408 sixth grade children (mean age 11 years) attending 27 metropolitan primary schools in Perth, Western Australia. Hierarchical modelling identified key characteristics associated with children's recess moderate to vigorous physical activity (RMVPA).

***Results*:** Nearly 40% of variability in children's RMVPA was explained by school environment and individual characteristics identified in this study. Children's higher daily RMVPA was associated with newer schools, schools with a higher number of grassed surfaces per child and fewer shaded grassed surfaces, and the physical education coordinator meeting Australian physical activity guidelines.

***Conclusions*:** Characteristics of the school physical and social environments are strongly correlated with children's MPVA during recess.

Implications: The school environment is an ideal target for maximising children's physical activity during recess. Future research could examine the impact of modifying these environmental characteristics on children's school physical activity.

Key words: child, motor activity, exercise, sport

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Children who participate in higher amounts of physical activity (PA) benefit from better physical and mental health than less active children.[1] These benefits transcend childhood and adolescence[2,3] and include a reduced risk of being overweight or obese,[4,5] which is a major burden of disease internationally. Research indicates that in Western societies, such as the US[5] and Australia,[6] the majority of children over 9 years of age fail to meet PA guidelines, with just 40% of 9-13 year olds meeting the Australian recommendation of 60 minutes PA each day.[6]

Schools provides a unique setting in which to increase children's PA,[7] and with growing curriculum pressures on class-time, school recess (morning recess, afternoon recess and lunch breaks) can be targeted in efforts to maximise children's PA. This is particularly pertinent given that, while school recess has been traditionally considered children's 'active play time', many children are reported as being sedentary or only participating in low level activity during this time.[8]

Evidence indicates that the time children spend being physically active varies significantly between schools[9,10] and that schools have different levels of environmental support for PA.[11,12] The socio-ecological perspective[13] proposes that there are several spheres of influence on PA including the physical, policy and socio-cultural environments as well as those from the individual. Factors associated with PA at school are also embedded within multiple levels: the school, grade, classroom and child levels. For example, the presence of a grassed sports area is classified within the school-level physical environment sphere.

Correlational studies, mostly undertaken in the US and the UK, have identified positive correlations between the primary school environment and PA during recess including: an increased number of teacher prompts to be active;[14] larger play areas;[15,16] lower child enrolments; higher ball to child ratio;[17] higher levels of supervision;[18] and higher amount of sporting[15] and playground equipment.[19]

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These correlates are valuable for identifying potential targets for interventions; however, most of these studies are from the US and the UK and further information gathered using diverse methodologies will assist with developing a comprehensive understanding of contributors to primary school children's recess moderate to vigorous physical activity (RVMPA).

Identifying environmental correlates is complex, and measuring environments and PA is subject to many challenges.[20] For instance, research has previously used principal, teacher or child perceptions to estimate physical environments,[21-23] rather than the more time-intensive strategy of external observer assessment. Accelerometers are useful for providing time-specific, individual activity measurements,[24] rather than using observer measurement or recall to estimate children's cumulative MVPA.[15,17,18,25,26] Furthermore, use of statistical methodology that incorporates adjustment for clustering of behaviours decreases the chance of invalid inferences,[27] thus adjusting for school level clustering is important. Although peer groups have been shown to be associated with PA,[28] no studies appear to have adjusted for similar behaviour patterns at the classroom level.

Understanding the potential impact of variables from different domains and levels on PA would provide valuable information to stakeholders and practitioners to assist in identifying school characteristics to target.[20] This study integrates objective measurement of school physical environments, accelerometer measurement of PA, adjustment for both school and classroom-level clustering and exploration of multiple levels and domains of influence to identify children's school, classroom and individual correlates, and to quantify their approximate contribution to RMVPA.

Methods

Approval for this study was obtained from the institutional research ethics committee. Parental/guardian and child written consent was obtained for participants.

Setting

A list of 308 government-funded primary schools in Perth, Western Australia, was stratified into nine demographic categories based on the school's socioeconomic index (low, middle or high) and the year the school was built (before 1968, 1968 to 1978 or 1979 to 2003). Schools in each stratum were randomly sorted and the first three from each stratum were invited to participate. If a school declined, the next school in the sorted stratum was invited until three from each stratum agreed. To recruit 27 schools, 32 schools were invited (84.4% response rate).

Instruments

Findings from previous research and a qualitative study (incorporating ten child focus groups, ten teacher and three principal interviews at three pilot schools) were used to generate a list of school characteristics potentially correlated with RMVPA. These characteristics were integrated into instruments including questionnaires for the principal, Physical Education (PE) coordinator, classroom teacher and child. An additional instrument to measure the school physical environment audit; the Physical Activity School Scan (PASS) was also created. Inter-rater reliability of items within the questionnaires and intra-rater reliability of the PASS items were assessed in a pilot study, during which questionnaires were administered twice, with at least a ten-day interval. Reliability coefficients were calculated using data gathered from 21 grade six children and 14 teachers from the three pilot schools, and 22 deputy principals and 20 school physical environments from 20 of the main study schools. Questionnaire and survey items with reliability less than 0.5 were modified or removed in the final versions of instruments (final instruments are available from www.uwa.edu.au/people/karen.martin or via email from the first author).

Physical activity data were collected using uniaxial accelerometers (models 7164-2.2 and extended memory 71256; manufactured by The Actigraph), which have been shown to be valid and reliable instruments for estimating children's PA of varying intensities.[29-31]

Procedure

Data were collected between February and December during the 2005 school year, excluding the first and last week of each term and July (the month with highest average rainfall).

At each school, 25 randomly selected grade six children were invited to participate in the study, however if the grade six enrolment at a school was less than 30, all children were invited. Of the total 630 children invited, 74.1% agreed to participate. Date of birth and main language spoken at home were reported by a parent/guardian on the consent form. On accelerometer administration day children were taken out of classes in groups of approximately 15 to a central location, such as the library. Questionnaires were read aloud to children by the first author or a trained research assistant. Children were instructed to wear accelerometers on the provided elastic belt around the waist, to the right side of their body and told to only remove them when bathing, swimming or going to bed. Log books were distributed for children to record days on which they were sick, did not attend school or had not worn their accelerometers. Children's heights and weights were measured by research assistants who had been trained using the International Society for the Advancement of Kinanthropometry (ISAK) protocol.[32]

Staff questionnaires were hand-delivered to school principals, PE coordinators and grade six classroom teachers on or before the accelerometer administration day. Completed questionnaires were collected approximately one week later, with up to two reminder letters and copy questionnaires sent to non-respondents. On, or close to, either accelerometer administration or retrieval day, the first author and a trained research assistant independently assessed each school's physical characteristics using the PASS and a PASS Assessment Guide (available from the first author). The PASS was used to record ratings on a five-point Likert scale of sporting equipment access, variety and quality (four randomly

selected sport items within the main storage area). Each play area available to grade six children during recess was assessed. For each play area, shade at noon was estimated, sporting apparatus (such as goals and cricket pitches on both hard courts and grassed surfaces), playground equipment (such as slides and swings) and playground markings were counted, capacity of any seating available was estimated and ground surface quality was examined and rated (requiring maintenance or good). The Department of Education and Training provided the sizes of the school oval/s (sports field) and other grassed surfaces within the school.

Data treatment

Outcome variable

Children's downloaded accelerometry data were initially screened using Actisoft Analysis Software Version 3.2[33] and data with incorrect baselines and days which included periods of no movement during the school day excluded. Accelerometry data were also excluded for accelerometer administration and retrieval days, when total daily movement counts were outside normal limits (20,000 to 4,000,000)[10] and when children reported they did not attend school. Accelerometers failed to collect data on 33 administrations (7.1% failure rate) and 25 children had insufficient or technically incorrect data. In addition, data were not available for three children who withdrew from the study and one who was withdrawn by the study team.

Using previously validated cut-points[34] and a data reduction program,[35] school day accelerometer counts were condensed into time spent in MVPA during morning and lunch breaks (using start and finish times of morning recess and lunch; no schools had an afternoon break). Total MVPA during these periods were summed to provide RMVPA for each school day. Descriptive and bivariate analyses were undertaken using SPSS (Versions 14.0 and 15.0).[36] As found in other research,[37] there was no significant difference between the total MVPA averages for one, two, or three or more days of monitoring (ANOVA, p=0.584), thus all children with at least one day of data were included in analysis and children's average daily RMVPA was used as the outcome variable.

Explanatory variables

Body mass index was calculated and Cole's international standard cut-points[38] were used to classify children as being a healthy weight, overweight or obese. When appropriate, explanatory variables were recoded into binomial response categories (for example, the teacher question '*The school's variety of sport equipment available is good'* the response option '*disagree'* was recoded into '*not good'* and the response options '*somewhat agree, agree, strongly agree and very strongly agree'* were recoded into '*good'*.

To reduce the total number of variables being analysed in bivariate and hierarchical modelling, composite explanatory variables were created. School physical environmental composite variables were created by summing the characteristics of each play area. For example, '*total number of playground items'* was created by adding together the number of playground items (such as slides and swings) in each of the play spaces available to grade six children during recess.

Characteristics from the questionnaires and the PASS were required to exhibit good to excellent intra-reliability in the pilot (intra-class correlation Kappa=0.50),[39] and good to excellent inter-rater reliability for the PASS (intra-class correlation Kappa =0.50)[39] to be included in the analysis.

Bivariate testing

Pearson or Spearman correlations, Student's t-tests, ANOVA, Mann-Whitney U tests and Kruskal-Wallace tests were performed to test explanatory variables (Table 1) for bivariate association with average daily RMVPA minutes. A conservative threshold of p<0.10 was used to determine significance to avoid excluding variables potentially associated with MVPA in hierarchical models.[18]

Modelling

Regression modelling was undertaken using R V2.4.0.[40]

Single regression models

Variables found to be significantly correlated with RMVPA in bivariate testing (p<0.10) were included in the initial respective single category regression model (school physical environment, school policies and socio-cultural environment, classroom and child). All models were adjusted for school and classroom clustering and adjusted for total recess length (morning plus lunch break minutes). If two explanatory variables were significantly correlated, the two variables were inserted into the single category model separately and the variable with the highest association with RMVPA was retained.

Step-wise removal of the variable with the least significant association with RMVPA was performed until all variables within the single category model were significant at the 10% level. Quadratic and interaction terms were tested and non-significant bivariate variables were re-tested in their respective parsimonious single category model and retained if significant.

Hierarchical modelling

Hierarchical modelling incorporated combining single domains while adjusting for school and classroom-level clustering. Combining the school physical environment with the school policy and socio-cultural environment category models created a school-level model (model 1). This school-level model was then combined with the classroom category model to develop model 2. The child-level models were added to this to create model 3. The variable '*school socioeconomic index'* was no longer significantly associated with RMVPA and was removed. All variables not significantly associated with RMVPA in single category modelling were again tested. No other variables had association with p-values less than 0.10. An adjusted R square was calculated for single category and combined models using R.[40]

Results

Sample Characteristics

Of the 467 children who participated in the study, sufficient data were available for 408 (87.4%): 221 boys and 187 girls. Their mean age was 11.0 years (standard deviation [sd] 0.7) and 10% lived in homes in which the main language spoken was not English. Of the sample, 21.3% were overweight and 5.3% obese. A high proportion of children (88.1%) reported that they liked PA.

All 27 principals (100%), 23 PE coordinators (92%) and 51 grade six teachers (89.5%) completed role-specific questionnaires. Two schools did not assign PE coordination to an individual staff member.

Of the 51 grade six teachers who returned questionnaires, 66.7% were female. Less than a third (30.1%) of grade six teachers had participated in 0.5 to 2.5 days of PE professional development (which had focused on PE, sport or fitness) within the previous two years and one teacher (2.0%) had participated in three to

Table 1: School characteristic (composites) potentially associated with recess moderate to vigorous physical activity.

School-Level		Classroom-Level	Child-Level
Study related	**School policies**	**Teacher**	**age, sex**
data collection month	recess length, class-time length	sex, years teaching	main language at home is English
Physical environment	class size	year teaching at current school	weight status: healthy/ overweight/ obese
enrolment, all children (years 1-7; grade 6)	PE/sport programs; external sport programs	belief in benefit of teaching PE	likes PA
number of staff	weekly PE/sport minimum time policy	attitude to teaching PE	PA is interesting
school socio-economic index	inside areas available at recess	PE professional development	happy with body weight
year school built	inside areas available at lunch	PE/sport/fitness hours/week	sporting equipment in good condition
grass quality	Socio-cultural environment	perception sporting equipment quality	told about sports teams by teacher
grassed surface play areas	principal sex	perception sporting equipment accessibility	scared may get hurt during PE/sport
ovals, oval size	years teaching; years as principal	perception sporting equipment variety	has proper shoes for PE
total size of grassed surfaces	number schools as principal	sporting equipment available from classroom	doesn't like what wear for PE
grassed surface m^2/child	years as principal at current school	number of balls available from classroom	not good at sport
shaded grassed play areas	belief in benefit of teaching PE	two main PE/sport activities during class	there is enough room to run around at recess
sporting facilities on grassed surface	principal meets Adult National PA Guidelines	PE/sport sessions/week	equipment is easy to access at recess
playground equipment, obstacle courses	principal believes PE important in curriculum	class-time hours outside/week	lots of outside rules during recess
hard courts	**Physical Education Coordinator**	meets Adult National PA Guidelines	girls encouraged by boys to participate in games
hard court surface quality	PE coordinator sex		winning is important
shaded hard courts; cover from rain	years teaching; years at current school		sports at school are fun
sporting facilities on hard court	main role of person assigned to coordinate PE		teachers encourage PA during recess
total ground markings on hard court	PE coordinator teaches year sixes		teachers stop activity during recess
sporting equipment accessibility rating	time assigned to PE coordinator		teachers are active with children during recess
sporting equipment organisation rating	PE professional qualifications		easy to obtain sporting equipment during recess
sporting equipment quality rating	belief in benefit of teaching PE		has enough time to be active during recess
	attitude to teaching PE		playgrounds are fun at school
	two main PE/sport activities during class		friends prefer to sit down during recess
	meets National PA Guidelines		has friends to be active with during recess

Abbreviations: PE, physical education; PA, physical activity

five days of PE professional development. Classroom teacher PE professional development attendance in the last two years was significantly correlated with the two main activities taught during PE sessions; that is, teachers who had not attended PE professional development were more likely to hold fitness and management as their two main PE activities, and those who had attended PE professional development were more likely to teach game play and skill drills ($p<.001$).

Two weighted composite variables were created to estimate staff perspectives about PE, one representing attitude towards teaching PE and the other, belief in benefits of PE. These weighted scores (ranging from one to six) were calculated for classroom teachers and PE coordinators. Principal component analysis of these composite variables produced goodness of fit indices of 0.998 for the attitude towards teaching PE composite variable and 0.995 for belief in the benefit of PE composite variable. Both indices were very similar to the factor loadings identified in the initial development and testing of the instruments by Morgan and colleagues.[41]

While 23 schools (85%) had one oval and four schools had two ovals, grade six children were limited to using one oval in all but one school. Twenty schools had an obstacle course and 18 (90%) of these allowed grade sixes to use the course during recesses. Access to sporting equipment was classified as difficult by the external observer in half (n=14) of the schools. Additional child, classroom and school-level physical environment summaries are displayed in Tables 2 and 3.

Children's physical activity during recess and lunch

The average school total recess length was 60 minutes (SD 4.6) per day. Children participated in a daily mean of 27.4 (SD 12.1) minutes in RMVPA; equivalent to 45.7% of recess time on average. There was considerable variation between schools in children's average RMVPA. Notably, in one school, all children recorded an average of less than 10 minutes of RMVPA. In 13 schools, all children recorded more than 10 minutes of RMVPA and in two of these schools every child participated in an average of more than 30 minutes of RMVPA daily.

Multilevel associations between correlates and RMVPA

Single domain modelling identified ten school, classroom and child-level RMVPA variables associated with RMVPA ($p<0.10$) and

Table 2: Children, classroom and school sample characteristics of 408 grade six children in Perth Western Australia.

Domain / Variable	n	%
School Physical Environment		
Shaded grassed surfaces[a]		
0	22	81.5
1	4	14.8
2	1	3.7
Year school built		
Pre 1968	9	33.3
1968-1978	9	33.3
1979- 2003	9	33.3
SES category		
Low	9	33.3
Middle	9	33.3
High	9	33.3
School Socio-Cultural Environment		
PE coordinator meets National PA Guidelines[b]		
no	2	8.7
yes	21	91.3
Classroom Teacher		
PE professional development[c]		
none	33	67.3
0.5 – 2.5 days	15	30.6
3.0 – 5.0 days	1	2.0
Child		
Sex		
boy	221	54.2
girl	187	45.8
Ethnicity		
main language at home English	367	90.0
main language at home not English	41	10.0
Weight status		
healthy weight	293	71.8
overweight	85	21.3
obese	21	5.3
Not good at sport		
disagree	293	74.0
agree	103	26.0

a greater than 40% shade at noon; PE, physical education; SES, socio-economic status;

b participates in 30 minutes or more of moderate- to vigorous PA on all of the last 7 days;

c within the last two years;

Table 3. School sample characteristics of 27 schools, in Perth, Western Australia.

Variable	Median	IQR	Min	Max
Year school built	1975	29	1899	1999
School socio-economic Index	99.1	17.9	83.1	114.1
Total child enrolment (grades 1-7)	285	136.5	98	548
Grassed surface[a] / child (m^2)	112.1	96.3	20.1	253.9
Grassed play areas sporting facilities[b]	3	3	1	6

Abbreviations: IQR, inter-quartile range; Min, minimum value; Max, Maximum value.

a total school grassed surface including oval and interspersed grassed surfaces;

b sum of cricket nets and pitches, soccer and Australian Rules football goals, long jump pits and wall markings.

these are listed in single models (Table 4). Hierarchical modelling involved the combination of single category models. The school-level model (model 1, Table 4), produced by combining the policy and socio-cultural variable with the physical environment model, resulted in minimal change to the physical environment coefficients but reduced the coefficient of the variable '*PE coordinator meeting Australian PA Guidelines for Adults'*.[42] The school-level model explained 38% of the variance in RMVPA. The addition of the classroom variable '*classroom teacher participated in PE professional development'* had little impact on the adjusted R square (0.39) or on the variable coefficients (model 2, Table 4). The final parsimonious model (final model, Table 4), developed after the addition of the child category variables and subsequent removal of '*socioeconomic index'* (as it no longer reached significance, p=0.11), accounted for 40% of the variation in children's RMVPA.

The final model indicated that children participated in an average of 4.5 (95% CI 0.6, 8.4) minutes of RMVPA daily for each 100 square metres of grassed surface at the school. An average extra 7.9 (95% CI 2.5, 13.4) minutes of RMVPA daily was recorded if all grassed play areas at the school were unshaded. For each year that the school was newer, children recorded an average extra 0.1 (90% CI 0.01, 0.14) minutes of RMVPA daily. In schools employing a PE coordinator who met the National Physical Activity Guidelines for Australians, children achieved an average extra 6.4 (90% CI 0.3, 12.4) minutes of RMVPA daily. Children whose classroom teacher had not attended PE professional development in the last two years participated in an average extra 4.9 (95% CI 1.1, 8.6) minutes of RMVPA daily than children whose classroom teacher had attended PE professional development. Boys participated in 7.6 (95% CI 5.7, 9.4) more minutes of RMVPA daily than girls. Children who perceived they were good at sport participated in an average extra 3.4 minutes (95% CI 1.2, 5.5) of RMVPA than children who perceived they were not good at sport. Children who were a healthy weight participated in an average extra 3.2 (95% CI 0.9, 5.5) and 3.9 (90% 0.4, 7.4) minutes of RMVPA daily than children who were overweight and obese, respectively.

Table 4: Hierarchical modelling, coefficients and confidence intervals of children's recess moderate to vigorous physical activity (minutes per day).

Category Variables [reference category]		Single Models β[a] (CI)	Model 1 PEnv+PSc β (CI)	Model 2 PEnv+ PSc+CI β (CI)	Final Model PEnv+PSc+CI + Ch β (CI)
School physical environment	Adj R^2	0.24			
Year school built		0.15 (-0.57,0.86)[d]	0.11 (0.04,0.19)[c]	0.09 (0.01,0.17)[c]	0.08 (0.01,0.14)[b]
School socio-economic Index		0.27 (0.03, 0.50)[c]	0.26 (0.02,0.49)[c]	0.18 (-0.06,0.41)	
Grassed surface[e]/child (100m^2)		5.48 (1.21,9.75)[d]	4.91 (0.88,8.94)[c]	5.46 (1.50,9.42)[c]	4.46 (0.61,8.31)[c]
Shaded grassed play areas		-10.94 (-16.28,-5.59)[d]	-9.29 (-14.54,-4.04)[d]	-10.00 (-15.22,-4.79)[d]	-7.94 (-13.42,-2.46)[c]
Policies and socio-cultural environment	Adj R^2	0.22			
PE[e] coordinator meets National PA[a] Guidelines[f] [no]		13.54 (5.18, 21.89)[c]	7.42 (0.19,14.65)[c]	6.51 (1.02,11.09)[b]	6.37 (0.30,12.45)[b]
Classroom	Adj R^2	0.22			
PE professional development[g] [no]		-5.50 (-9.77,-1.23)[c]		-4.74 (-8.66,-0.82)[c]	-4.87 (-8.64,-1.10)[c]
Child	Adj R^2	0.37			
Sex [boy]		-7.89 (-9.76,-6.03)[d]			-7.56 (-9.43,-5.69)[d]
English first language spoken at home [yes]		3.19 (0.03,6.36)[c]			3.00 (0.34,5.66)[b]
Weight status [healthy weight]					
overweight		-3.25 (-5.52,-0.98)[c]			-3.21 (-5.49,-0.94)[c]
obese		-3.93 (-7.41,-0.45)[b]			-3.88 (-7.40,-0.37)[b]
Child feels they are good at sport [agree]		-3.23 (-1.10,-5.36)[c]			-3.39 (-1.25,-5.53)[d]
Combined model	**Adj R^2**		**0.38**	**0.39**	**0.40**

Note: all models were adjusted for total recess time.

Abbreviations: Adj, adjusted; PA, Physical activity; PE, physical education; PEnv, physical environment; PSc, school policy and socio-cultural environment; Cl, classroom; Ch, child;

a β, Beta coefficient (represents additional minutes spent in CMVPA per child per day)CI, 95% confidence interval for p-value<0.05, 90% confidence interval for p-value<0.10.

b p-value < 0.10,

c p-value < 0.05,

d p-value < 0.005;

e total school grassed surface including oval and interspersed grassed surfaces;

f participates in 30 minutes or more of moderate to vigorous PA on all of the past 7 days;

g within the past two years.

Discussion

This study identified multidimensional characteristics related to objectively measured recess moderate to vigorous physical activity (RMVPA) in the primary school environment and is unique as it quantifies the approximate contribution of correlates to total RMVPA, as well as adjusting for both school and classroom behaviour clustering. Children attending schools which were newer, had higher grassed surface per child, had more unshaded grassed surfaces and a physically active PE coordinator, participated in significantly higher amounts of RMVPA.

Physical environment correlates

An important finding from this study was the association between grassed surface and RMVPA. The average additional 4.5 minutes of RMVPA accumulated daily per 100 m^2 of grass surface per child suggests that expansive grassed surfaces are important for optimising RMVPA. The current findings are supported by previous research that indicated that the size of school play areas was associated with PA[16] and that availability of open fields correlated to higher PA in secondary school children.[43] In contrast, in an American study, Sallis and colleagues[18] found that boys were most active on hard courts and girls most active in indoor areas with equipment, these discrepant results may be due to methodological differences as well as cultural differences. Our results indicate that the amount of grassed play area available per child is an important variable to consider during school planning and that the common practice in Australian schools of locating transportable classrooms on grassed surfaces to accommodate increasing student numbers[44] may have a negative impact on children's RMVPA.

Children attending schools with only unshaded grassed surfaces available to them during recess recorded nearly eight minutes more daily RMVPA than those with one or more moderate to highly shaded grassed surfaces. While a study of preschool children's PA indicated shade was positively associated with PA,[45] expansive and unobstructed grassed surface is ideal for older children's sports and games. Another potential explanation of this finding is that undesired effects from shade-trees include obstructions, poor grass cover[46] and plant debris (including leaves, berries and twigs) and could lead to sections of grassed surface being less suitable for children's MVPA. Appropriate choices of grass and tree species and use of shade sails could assist in maximising both grass quality and shade availability, and provision and application of sunscreen and hats could be incorporated to counter the dangers of excessive sun exposure. Further exploration of the association between shaded grass and children's PA is encouraged.

Social environment correlates

Children attending schools with a physically active PE coordinator participated in significantly more RMVPA daily. This finding may be attributable to the impact of the beliefs held by the PE coordinator and/or the physical activity role modelling to children at the school. A more positive physical activity culture within a school is likely to be created when the PE coordinator is physically active, as higher physical activity participation in adults is associated with positive attitude towards physical activity.[47] This may result in extra encouragement and support PA for children (for example, ensuring easy supply of sporting equipment for children). Furthermore, a physically active PE coordinator provides a positive role-model for children, which has been noted previously as being associated with higher MVPA.[47] Further research could explore the physical activity behaviours, attitudes, training and role of PE coordinators in primary schools.

This study found that children participated in less RMVPA when their classroom teacher had participated in PE professional development. While previous research[48] has found that intensive classroom teacher PE training (32 hours in the first year of the intervention) was associated with higher PA during PE sessions, in our study 15 (of the 16 teachers reporting professional development) participated in between 0.5 and 2.5 days of PE, sport or fitness training. In our study, attending PE professional development was associated with teachers mainly teaching game-play and skill-drills during class-time. This may have resulted in children spending more time playing games and practising skills during recess and thus less time in MVPA; while children whose teacher had not participated in PE professional development may have participated in more traditional recess type activities such as tag or 'running around' leading to a higher accumulation of RMVPA. An alternative explanation for this finding is that teachers whose students are less active may be more likely to attend PE professional development to assist them with gathering knowledge to maximise their pupils' PA levels. Further research exploring generalist teacher PE professional development and children's MVPA to establish if this finding is replicable is warranted.

Child-level correlates

The finding that children whose family spoke a language other than English participated in more MVPA is supported by another Australian study, which found that grade eight children from European backgrounds participated in higher total daily MVPA than children from English speaking backgrounds.[49] Due to high cultural diversity in Australia, it is difficult to establish a pattern in relation to cultural background and children's physical activity behaviour. Consistent with prior research, this study indicates that children who are overweight or obese[50] participated in less RMVPA. Further sensitive strategies are needed to increase RMVPA for these vulnerable populations; and these strategies require appropriate consultation with children to ascertain preferred activities during recess. Being a boy and having a more positive perceived sport competence were identified as positive RMVPA correlates in this study. These have also been identified as physical activity correlates in previous research.[51,52] Physical activity promotion programs supporting girls' physical activity and children who feel they are not good at sport are warranted.

Study strengths and limitations

A methodological strength of this study is the objective assessment of multiple levels and domains within school environments by an

external observer to minimise reporting bias. Other study strengths included the use of stratification of schools by socioeconomic index and school age, random selection of schools and children, high response rates, measurement of environments specific to the outcome measure, as well as hierarchical modelling to incorporate multiple domains and adjust for school and classroom clustering. Accelerometer data enabled calculation of objectively measured cumulative RMVPA.

A limitation of this study was the use of staff self-report for measuring perceptions and behaviour. The study was also limited to grade six children enrolled in government-funded metropolitan primary schools in a temperate climate, potentially constraining generalisability of findings. The days on which data were collected may not represent a full, usual week of children's habitual RMVPA,[53] however, with school average RMVPA of interest, this is unlikely to have affected identification of school environment correlates.

Sporting events and school 'trends' (temporarily popular recess activities) at the time of data collection were not examined. Grassed surface area sizes were not measured objectively and may have varied slightly at the time of the study from the sizes provided by the Department of Education. School and child-level variables associated with PA may not have been identified and measured. While this data was collected in 2005, physical characteristics of schools are relatively stable, thus the results are still relevant.

Despite these limitations, the study is unique in that it incorporates multiple levels and domains of influence concurrently and provides insights that can be applied and pursued in future interventions and research. The results of this study suggest that ensuring schools have adequate areas of grassed surface relative to child enrolment may assist in optimising children's RMVPA. While shade limits sun exposure in the school grounds, it may also decrease the amounts of suitable surfaces available for children's play. Strategies that ensure the PE coordinator is sufficiently active are needed to provide positive role modelling for children and to promote a culture that is supportive of physical activity within the school. Girls, children who are overweight and obese, and those who do not feel they are good at sport require extra assistance to maximise their RMVPA.

Conclusions

Modifying school environments to maximise PA opportunities during recess has the potential to impact on large numbers of children over many years. While further exploration of school environmental characteristics that optimise children's RMVPA are warranted, this study indicates that socio-ecological interventions are timely and likely to assist in increasing children's PA in the school setting.

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