Predictors of time spent outdoors among children: 5-year longitudinal findings

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ABSTRACT

Background

Given the importance of physical activity for health and age-related declines in physical activity, understanding influences on related behaviours such as time outdoors is crucial. This study aimed to understand individual, social and physical environmental influences on longitudinal changes in **urban** children's time outdoors.

Methods

Parents (n=421) reported their child's time spent outdoors in 2001, 2004 and 2006 **(age 5-6 and 10-12 years at baseline)**. In 2001, individual, social and physical environmental factors were self-reported by parents. Generalized estimating equations examined longitudinal relationships between baseline predictors and average change in time outdoors over five years.

Results

Children's time outdoors significantly declined over time. 'Indoor tendencies' inversely predicted time outdoors among younger and older boys, and younger girls. **Social opportunities positively** predicted time outdoors among younger boys, **while 'outdoor tendencies' positively** predicted time outdoors among older boys. Parental encouragement for activity **positively** predicted time outdoors among younger and older girls, while lack of adult supervision for active play outdoors after school inversely predicted time outdoors among older girls **and older boys.**

Conclusion

Individual **(indoor and outdoor tendencies)** and social factors **(social opportunities, parental encouragement and parental supervision**) predicted children's time outdoors over five years. Interventions targeting reduced indoor tendencies, increased outdoor play with others, and increased parental encouragement and supervision are warranted.

INTRODUCTION

Physical activity plays an important role in the prevention of a range of adverse health conditions,[1] yet physical activity among children and adolescents in most developed countries appear to be declining.[2, 3] The promotion of children and adolescents' physical activity is therefore an important public health priority. In order to effectively promote physical activity, it is necessary to understand the settings in which it occurs and how these might influence physical activity. For instance, the outdoor setting may be an important 'behaviour setting' in which physical activity takes place. However, currently little is known about the influences on the amount of time children and adolescents spend in outdoor settings.

Although existing evidence examining relationships between time outdoors and children's physical activity has been cross-sectional and primarily on pre-school aged children,[4-7] findings suggest that time spent outdoors is positively associated with physical activity.[8, 9] One longitudinal study found that for every additional hour spent outdoors during cooler months, accelerometer-measured moderate-to-vigorous physical activity (MVPA) increased by 27 minutes/week among 10-12 year-old children.[10] Higher baseline reports of time outdoors on weekends were associated with higher MVPA three years later, and with a 27-41% lower prevalence of overweight. Encouraging children to spend more time outdoors during discretionary periods (e.g. after school and on weekends) may be a low-cost and easily implemented strategy to promote physical activity.

Given this relationship with physical activity, it is important to examine factors that may influence children's time outdoors as they grow older to inform physical activity promotion strategies. Social-ecological models have been suggested as a useful framework for understanding physical activity.[11] They posit that individual (e.g. self-efficacy, motivation), social (e.g. social support, social connectedness) and physical environmental (e.g. availability of and access to equipment or facilities) factors interact to influence behaviour. However, factors that influence changes in children's time outdoors are poorly understood. For example, do children have 'outdoor tendencies' (e.g. go outdoors of their own accord), go outdoors for social purposes (e.g. to play with siblings or friends), and do physical environmental factors (such as a large yard size or access to recreational equipment) promote or hinder time outdoors?

Examining influences on children's time outdoors as they transition into adolescence is crucial given age-related declines in physical activity.[12] This life-stage may represent a critical time in which to intervene to prevent further declines. However, predominantly cross-sectional evidence limits understanding of potentially important factors for explaining changes in time outdoors. Using a social-ecological framework, this study aimed to understand individual, social and physical environmental influences on longitudinal changes in children's time outdoors.

METHODS

The Children Living in Active Neighbourhoods (CLAN) study[13-15] received approval from the Deakin University Human Research Ethics Committee, the Department of Education and Training Victoria and the Victorian Catholic Education Office. Informed written consent was obtained from all parents, and **survey** data were collected between July and December (winter and spring) in 2001, 2004 and 2006.

Sample

Twenty-four state elementary schools were selected using stratified random sampling proportionate to school size in high and low socioeconomic areas in metropolitan Melbourne, Australia. Ten schools from low, and nine schools from high, socioeconomic areas agreed to participate in the study (n=19 schools). Families of all children aged 5-6 years (entry year level) and 10-12 years (final two year levels) were invited to participate (n=3,189). Families who provided active consent by returning consent forms (T1 n=1,220; 38.3% response) were asked to be re-contacted for further research. At the first follow-up in 2004 (T2), 590 families provided data and 486 families provided data at the second follow-up in 2006 (T3). **Participants received a thank you letter which contained a small amount of graphical information about the child's physical activity.**

Measures

Parents completed surveys about their child at each time point. Two-week test-retest reliability of the survey at T1 was examined in separate samples (n=119 and n=254) by

administering the same survey to parents two weeks apart. The intraclass correlation (ICC) between responses to the first and second administrations were calculated.

Baseline Demographic Characteristics

At T1, parents reported their sex (86% female), their child's sex and their child's date of birth. Highest education level of the mother/female carer was reported and categorised as low (some high school or less), medium (high school or technical college) or high (university or higher) as a proxy for family-level socioeconomic position (SEP), consistent with previous studies.[16-18] Parental marital status was categorised as married/living as married and not married (separated/divorced/widowed/never married).

Outcome Variable: Time Spent Outdoors

At each time-point, parents were asked 'In total, how many hours/minutes does your child usually spend outside during a typical week after school' separately for warmer and cooler months. The same questions were asked about time spent outdoors on a typical weekend. Responses for weekdays and weekends were summed and averaged over warmer months and cooler months. **Time outdoors data from at least two occasions were available for 69 younger boys, 61 younger girls, 135 older boys, and 156 older girls.** In Melbourne, average maximum temperatures in cooler months (April-September) range from 13.4 to 20.2° C (average 16.1° C), while average maximum temperature in warmer months (October-March) range from 19.6 to 25.8° C (average of 23.5° C). Two-week test-retest reliability was acceptable (ICC: 0.54). Associations with accelerometer measures of children's physical activity suggest reasonable validity.[19]

Predictor Variables

At T1, parents responded to a survey that included items assessing individual, social and environmental factors hypothesized to influence children's time spent outdoors. Item wording and descriptive statistics are presented in **Table 1**. Where internal consistency was acceptable (Cronbach's α>0.60), items conceptually related were summed; otherwise items were treated individually.

Individual factors: Children's 'outdoor and indoor tendencies' were assessed by parents' responses to two statements about their child's outdoor and two statements about their indoor play behaviours (ICC: 0.48-0.64). **These variables were re-coded** as 0 (don't know/doesn't apply, never/rarely, sometimes) **or 1** (often, very often), then summed separately to create 'outdoor tendencies' and 'indoor tendencies' **scores. Possible scores were 0 (low), 1 (medium) and 2 (high).**

Social factors: Social influences were assessed by asking about parental encouragement (ICC: 0.42-0.54), outdoor social opportunities (ICC: 0.61-0.79), rules and restrictions (ICC: 0.21-0.36), parental supervision (ICC: 0.44-0.53), dog ownership (ICC: 0.98) and number of other siblings <18 years (ICC: 1.00). **Responses to** two statements about encouragement of and success in getting their child to play outside ('parental encouragement') and four statements about who their child goes outside with ('social opportunities') were **re-coded** as 0 (don't know/doesn't apply, never/rarely, sometimes) **or 1** (often, very often), **then separately summed. Possible scores for parental**

encouragement were 0 (low), 1 (medium) and 2 (high), while the number of social opportunities were categorised as 0-1 (low), 2 (medium) and 3-4 (high). 'Rules and restrictions' and 'supervision' regarding outdoor play were assessed by parents' reported agreement with four statements on a five-point Likert scale (1=strongly agree, 2=agree, 3=neither/don't know, 4=disagree, 5=strongly disagree). The two statements about outdoor play rules were summed (Cronbach's alpha=0.65). Responses to statements about rules and supervision were reverse-scored, so that a higher score reflected a greater barrier.

Environmental factors: Yard size was reported as 1=no yard/no private yard/small, 2=medium or 3=large (ICC: 0.98). 'Home physical activity opportunities' were calculated by summing the presence (0=no, 1=yes) of 'activity-promoting' yard features and physical activity items (ICC: 0.27-0.54). The number of destinations within walking/riding distance ('local destinations') was assessed as how often the child walked/rode a bike to **eight** destinations (ICC: 0.54). Responses to each item were categorised as 0=no (not within walking/riding distance) or 1=yes (never/rarely, <once/week, 1-2 times/week, 3-4 times/week, 5-6 times/week, daily) and summed. The influence of weather on children's outside play was assessed by agreement with two statements on a five-point Likert scale (1=strongly agree, 2=agree, 3=neither/don't know, 4=disagree, 5=strongly disagree). Responses to the two weather statements were reverse-scored, so that a higher score reflected a greater barrier (ICC: 0.52-0.57).

Analysis

Data were available for 588 (48%) families who provided data regarding time spent outdoors on at least two occasions. After excluding children who moved house between T1-T2 (n=141) or T2-T3 (n=26), data for 421 families were available. Descriptive statistics were used to characterise the sample, with average time outdoors at each time-point plotted graphically, stratified by age and sex. Means (standard deviation) or proportions were calculated for the baseline predictor variables **stratified by age and sex, and one-way analysis-of-variance (ANOVA) (continuous data) or chi-squared tests (categorical data) were used to compare sex differences within age strata.** Because of well-documented sex differences in physical activity,[9] ANOVA or Kruskal-Wallis equality-of-populations rank tests were used to test for sex differences at baseline in the outcome variable and continuous predictor variables. Baseline characteristics of those who did and did not participate in follow-up were compared using ANOVA and Kruskal-Wallis tests.

The longitudinal relationship between baseline predictor variables and time outdoors over five years was analysed using a longitudinal linear regression technique, generalized estimating equations (GEE).[20, 21] This method is appropriate for longitudinal analysis as the repeated observations within individuals are taken into account. GEE involves a pooled analysis of cross-sectional (between-subjects) and longitudinal (within-subjects) relationships and results in a single regression coefficient (β) representing the **population** average difference in the outcome variable **over time** that incorporates between-subject and within-subject correlations and uses all data available.[22, 23]

Maternal education, parental marital status, age cohort and number of siblings were examined *a priori* as potential confounders; variables that were associated with the outcomes (p<0.05) were included in all models. A Crude Model assessed the relationship between each predictor and outcome variable separately, adjusted for significant covariates. There was little evidence of confounding by age cohort, although a small number of significant interactions with age cohort were identified; where this occurred, results were presented stratified by age, while all other analyses are adjusted for age cohort. All predictor variables significantly associated with time outdoors in the Crude Model were entered into a Fully Adjusted Model (multivariable model), separately for younger and older children. Prior to entry into multivariable models, correlation between predictor variables was assessed; coefficients greater than *r*=0.5 were excluded from multivariable models as a more conservative approach than suggested (*r*=0.7).[24]

Although the outcome data were non-normally distributed, results were generally unchanged when analyses were conducted using a square root transformation; untransformed variables are therefore presented for ease of interpretation. In a small number of cases, results were different (e.g. became statistically significant) when using the transformed outcome variable; coefficients from the transformed analyses were back-transformed and are presented.

All analyses were conducted using Stata version 10.0 (Statacorp, Texas, USA) and GEE analyses included adjustment for the effects of clustering within school attended at baseline (the sampling unit).

RESULTS

Sample characteristics

Compared to those who participated at T1 only, a higher proportion of parents who provided data at follow-up were high SEP (42 vs. 29%, p<0.01) or were married (86 vs. 78%, p<0.01) at baseline. There were no significant differences in children's time spent outdoors. Those who participated in follow-up more often owned a dog (58 vs. 49%, p<0.01), reported hat it was too dark/cold in winter (boys: p<0.05; girls: p<0.01) and that it was too hot in summer (boys: p<0.05; girls: p<0.01) for their child to play outdoors.

Time spent outdoors

The average amount of time children spent outdoors significantly (p<0.01) declined over time among **all** boys and **older** girls (**Figure 1**). **Older** boys spent significantly more time outdoors than did **older** girls at each time point, **but no difference was observed between younger boys and girls.** Declines between T1 (2001) and T3 (2006) were larger among **older** girls (**31**%) than **older** boys (19%) **but larger among younger boys (19%) than younger girls (14%). Time outdoors declined between T1 and T2 and between T2 and T3 for 74% and 77% of participants respectively, increased for 26% and 23% of participants respectively, and remained the same for <1% of participants for both time periods.**

Baseline predictor variables

Parental encouragement was significantly greater among older boys compared with older girls (**Table 1**). **While boys tended to have higher outdoor tendencies and lower indoor tendencies, these differences were not statistically significant.**

Table 1: Individual, social and physical environmental factors reported by parents at baseline (2001), by sex of child

Predictor Variable	Range	Mean (SD) or %[1]			
		Younger Children		Older Children	
		Boys	**Girls**	**Boys**	**Girls**
Individual Factors					
Outdoor tendencies, %					
Low	--	27.5	31.2	18.7	30.8
Medium		15.9	11.5	20.2	15.4
High		56.5	57.4	61.2	53.9
Indoor tendencies, %					
Low	--	79.7	72.1	67.9	64.5
Medium		10.1	14.8	21.6	16.1
High		10.1	13.1	10.5	19.4
Social Factors					
Parental encouragement, %					
Low	--	11.6	9.8	26.1	31.7*
Medium		39.1	36.1	26.9	31.4
High		49.3	54.1	47.0	32.1
Social opportunities, %					
None or one	--	21.7	23.0	42.1	40.3
Two		33.3	23.0	39.1	33.8
Three or four		44.9	54.1	18.8	26.0
Rules & restrictions, *M(SD)*	4-10	8.9 (1.3)	9.1 (1.0)	8.5 (1.5)	8.3 (1.7)
I don't allow my child to play outside after dark					
I don't allow my child to walk/ride a bike on the street after dark					
Supervision, *M(SD)*					
My child must be supervised while playing outside	1-5	3.4 (1.0)	3.6 (1.1)	2.6 (1.0)	2.6 (0.9)
There are no adults at home during daylight hours after school to supervise my child in active play outside	1-5	1.6 (0.9)	1.7 (0.9)	1.9 (1.0)	1.9 (1.1)

Dog ownership, *(% yes)*					
Do you own a dog?	--	47.1	52.5	60.5	62.2
Number of siblings, *M(SD)*					
How many other children aged under 18 years currently live in your house?	0-6	1.4 (0.7)	1.4 (0.9)	1.4 (0.9)	1.4 (0.8)
Environmental Factors					
Yard size, *%*	--				
Small		14.5	8.2	6.7	7.1
Medium		71.0	67.2	73.9	69.7
Large		14.5	24.6	19.4	23.2
Home physical activity opportunities, *M(SD)*	3-13	7.9 (2.3)	7.8 (1.8)	8.2 (2.0)	8.2 (2.1)
Which of the following do you have within or outside of your home/yard/garden? (swimming pool/spa, trampoline, basketball ring, sandpits/swings/play equipment) How often does your child use the following at home? (balls, bats/racquets, bikes, home gym equipment, rollerblades, skate-boards, skipping rope, scooter, toys that encourage active play)					
Local destinations, *M(SD)*					
How often does your child walk/ride a bike to the following places? (bike/walking tracks, friends' houses, parks/ovals/playgrounds, **post box,** public transport, school, shops, sport venues)	0-8	6.5 (1.7)	6.2 (2.2)	7.0 (1.4)	6.7 (1.7)
Weather influence, *M(SD)*					
It is too dark/cold in the winter time for my child to play outside	1-5	2.8 (1.1)	3.0 (1.1)	2.7 (1.1)	2.7 (1.2)
It is too hot in the summer time for my child to play outside	1-5	2.1 (0.8)	2.2 (0.9)	2.1 (0.8)	2.1 (0.8)

[1] Values are mean (M) and standard deviation (SD) except where percent (%) indicated

** $p<0.01$, * $p<0.05$ from one-way analysis-of-variance or Kruskal-Wallis equality-of-populations rank test **(continuous variables) or chi-squared test (categorical variables) comparing means/proportions between boys and girls within age groups**

Predictors of time outdoors

For younger boys, high indoor tendencies were associated with nearly less time spent outdoors, while high social opportunities were associated with more time spent outdoors on average over five years (**Table 2**). Among older boys, higher indoor tendencies and a lack of adult supervision were associated with less time spent outdoors, while high outdoor tendencies were associated with more time spent outdoors on average over five years.

Table 2: Longitudinal association between individual, social & environmental factors & average weekly time (minutes/week) spent outdoors over 5 years among boys

Baseline Predictor Variables	Crude Model[1]		Fully Adjusted Model			
			Younger Boys[2]		Older Boys[3]	
Individual Factors	β	95% CI	β	95% CI	β	95% CI
Outdoor tendencies						
Low	1.0	(ref)			1.0	(ref)
Medium	132.5	31.2, 233.9*	#		30.5	-96.7, 157.7
High	280.1	230.7, 329.4**			123.2	39.6, 206.8**
Indoor tendencies						
Younger boys						
Low	1.0	(ref)	1.0	(ref)	--	
Medium	-90.7	-236.2, 54.7	-68.0	-200.4, 64.3		
High	-317.7	-435.2, -200.2**	-168.3	-323.5, -13.0*		
Older boys						
Low	1.0	(ref)	--		1.0	(ref)
Medium	-319.3	-386.0, -252.7**			-215.0	-310.6, -119.4**
High	-412.4	-508.8, -316.0**			-324.0	-471.7, -176.3**
Social Factors						
Parental encouragement						
Low	1.0	(ref)	1.0	(ref)	1.0	(ref)
Medium	68.8	-55.3, 192.9	38.1	-58.9, 135.1	7.3	-136.4, 151.1
High	189.9	111.8, 267.9**	52.2	-97.4, 201.9	101.7	-3.8, 207.2
Social opportunities						
Low	1.0	(ref)	1.0	(ref)	1.0	(ref)
Medium	111.3	60.6, 162.0**	14.6	-119.3, 148.5	-49.5	-129.5, 30.5
High	268.7	205.6, 331.7**	169.7	25.9, 313.6*	-16.5	-158.9, 126.0
Rules & restrictions	-21.6	-45.4, 2.17	--		--	
Supervision						

	Crude¹ β	95% CI	Younger boys² β	95% CI	Older boys³ β	95% CI
Child must be supervised while playing outside	-7.8	-49.1, 33.5	--		--	
No adults to supervise active play outside after school	-48.6	-78.2, -18.9**	-0.2	-61.3, 61.0	-46.9	-91.3, -2.6*
Dog ownership	77.9	-4.5, 151.4*	-15.9	-129.7, 97.9	36.9	-70.0, 143.7
Number of siblings	14.4	-14.6, 43.5	--		--	
Environmental Factors						
Yard size						
Younger boys	-60.8	-156.6, 34.9	--		67.8	-37.4, 173.0
Older boys	162.1	68.6, 255.6**				
Home physical activity opportunities	30.4	18.2, 42.5**	16.4	-8.5, 41.3	8.9	-11.0, 28.7
Local destinations	9.7	-12.4, 31.8	--		--	
Weather						
Dark/cold in winter influences outside play	-29.9	-60.2, 0.3	--		--	
Heat in summer influences outside play	-49.3	-89.6, -8.9*	-9.5	-55.9, 36.8	7.7	-40.1, 55.4

Standard errors adjusted for clustering by school; ** p<0.01, * p<0.05; # collinear (*r*>0.5) variables excluded from multivariable model

[1] Crude Model: Adjusted for maternal education, parental marital status, and age cohort (except where stratified by age cohort)

[2] Fully Adjusted Model: Adjusted for maternal education, parental marital status, and all significant variables from the Crude Model within sex strata among younger boys

[3] Fully Adjusted Model: Adjusted for maternal education, parental marital status, and all significant variables from the Crude Model within sex strata among older boys

Among younger girls, higher indoor tendencies were associated with less time spent outdoors, while high parental encouragement was associated with more time spent outdoors on average over five years (**Table 3**). Among older girls, medium outdoor tendencies and high parental encouragement were associated with more time spent outdoors, while a lack of adult supervision was associated with less time spent outdoors on average over five years.

Table 3: Longitudinal association between individual, social & environmental factors & average weekly time (minutes/week) spent outdoors over 5 years among girls

Baseline Predictor Variables	Crude Model [1]		Fully Adjusted Model			
			Younger Girls[2]		Older Girls[3]	
Individual Factors	β	95% CI	β	95% CI	β	95% CI
Outdoor tendencies						
Low	1.0	(ref)	#		1.0	(ref)
Medium	199.6	94.3, 304.9**			200.4	26.5, 374.3*
High	185.9	137.6, 234.3**			103.4	-5.6, 212.8
Indoor tendencies						
Low	1.0	(ref)	1.0	(ref)	1.0	(ref)
Medium	-74.3	-158.4, 9.9	-188.3	-355.5, -21.2*	37.9	-40.1, 116.0
High	-171.7	-268.5, -74.8**	-246.9	-374.0, -119.7**	0.7	-139.2, 140.5
Social Factors						
Parental encouragement						
Low	1.0	(ref)	1.0	(ref)	1.0	(ref)
Medium	128.7	43.8, 213.5**	144.0	-58.9, 347.0	83.3	-8.2, 174.8
High	211.9	125.4, 298.4**	234.0	30.1, 437.8*	151.4	66.6, 236.2**
Social opportunities						
Low	1.0	(ref)	1.0	(ref)	1.0	(ref)
Medium	48.3	-36.7, 133.4	-44.1	-199.0, 110.9	-21.3	-94.5, 51.8
High	104.8	27.6, 181.9**	-89.1	-232.8, 54.6	46.5	-28.6, 121.5
Rules & restrictions	-7.8	-29.8, 14.2	--		--	
Supervision						
Child must be supervised while playing outside	5.8	-12.8, 24.4	--		--	
No adults to supervise active play outside after school	-43.3	-77.6, -9.0*	11.4	-78.1, 100.9	-34	-59.6, -9.1**
Dog ownership	3.5	-49.7, 56.7	--		--	

Number of siblings	9.1	-25.3, 43.4	--		--	
Environmental Factors						
Yard size	17.8	-52.0, 87.6	--		--	
Home physical activity opportunities						
Local destinations	6.5	-5.7, 18.7	--		--	
Weather	-8.0	-20.2, 4.2	--		--	
Dark/cold in winter influences outside play	-27.0	-53.0, -0.8*	39.9	-24.4, 104.3	-4.6	-33.9, 24.8
Heat in summer influences outside play						
Younger girls	-91.0	-169.8, -12.2*	-42.3	-105.1, 20.4	--	
Older girls	-13.6	-41.1, 13.9	--		--	

Standard errors adjusted for clustering by school; ** p<0.01, * p<0.05; # collinear (*r*>0.5) variables excluded from multivariable model

[1] Crude Model: Adjusted for maternal education, parental marital status, and age cohort (except where stratified by age cohort)

[2] Fully Adjusted Model: Adjusted for maternal education, parental marital status, and all significant variables from the Crude Model within sex strata among younger girls

[3] Fully Adjusted Model: Adjusted for maternal education, parental marital status, and all significant variables from the Crude Model within sex strata among older girls

DISCUSSION

This study aimed to understand influences on longitudinal changes in children's time outdoors. There were significant declines in time spent outdoors among boys and girls over the five-year period, consistent with previous studies of physical activity among children and adolescents.[12] Among participants in the current study, individual and social factors were more important predictors of change in time outdoors than were physical environmental factors. **Because findings differed by age and sex, further research must ensure that the needs of boys and girls at different ages are examined separately.**

Children who had greater 'indoor tendencies' spent significantly less time outdoors on average over five years. Having greater indoor tendencies may be a function of children's preferences for play activities. A review of correlates of children's physical activity found that children's preferences were positively associated with physical activity in 60% of the studies reviewed.[9] For instance, baseline data from an earlier analysis of the present study (n=881 children) found girls who preferred to watch TV had twice the odds of being classified as 'low-active'.[25] Alternatively, higher reports of indoor tendencies may be related to limited access to outdoor play space, although this seems doubtful given only 11% of children in this study had no or a small yard.

Younger boys who **had more social opportunities (e.g. played outside with friends, siblings or pets)** spent significantly greater time outdoors. These findings suggest that for boys, having someone to go outdoors with (e.g. social opportunities) may be beneficial in

terms of time spent outdoors and, by inference, active outdoor play. Although they assessed different social dimensions, DiLorenzo and colleagues[26] found that social factors were important for longitudinally predicting girls' physical activity, while Trost and colleagues[27] found social influences were significantly correlated with MVPA among boys. Combined, these findings suggest that changes in physical-activity related behaviours differ between boys and girls, and that social influences may be sex- and context-specific; these differences should be considered when developing interventions promoting time outdoors.

Greater parental encouragement to spend time outdoors was positively associated with girls' time outdoors. Given that parental encouragement for children to go outdoors was lower among girls, there is much scope to target parental encouragement in interventions. For instance, there is potentially a need to change perceptions among parents and girls of the value of time outdoors. While it is plausible that parental encouragement to go outdoors is lower among girls because of parental awareness of girls' preferences for indoor play, in the current study this appears unlikely as parental encouragement was associated with time outdoors independently of indoor tendencies, which was also a significant predictor of time outdoors in the multivariable model.

Older **boys and** girls who had less adult supervision at home for outdoor play after school spent less time outdoors. This may be related to the findings observed for parental encouragement (i.e. no adults to supervise active outdoor play after school may mean less parental encouragement of outdoor play). **This may be true for boys, because parental**

encouragement was not independently predictive of time outdoors in the multivariable model. However, among girls both adult supervision and parental encouragement remained significant predictors in the multivariable model among suggests that these two factors were independently associated with time outdoors.

There was no evidence of an association between the physical environmental factors and time outdoors **in the current study.** This is consistent with a review of correlates of physical activity among youth, which found no evidence of a relationship between access to facilities/home equipment and physical activity among 85% of studies reviewed.[28] Possibly the measures used in the current study lacked sensitivity, or the limited heterogeneity in reduced the likelihood of associations. Alternately, it may be that proximal factors (e.g. individual and social) are more important influences on time outdoors than distal factors (e.g. physical environment). Further, parents may restrict their children's outdoor play due to anxiety in relation to road safety and stranger danger,[29] which may directly influence time spent outdoors. Future studies should examine a broader range of environmental variables, including neighbourhood safety and relationships between indoor and outdoor tendencies, time outdoors and parental safety concerns.

Limitations of this study include the self-report measures, the baseline response rate **(likely due to the large amount of information requested, although similar to other Australian studies [30])** and the attrition rate **(largely attributed to the older children, who during the follow-up period moved from elementary to secondary school and**

were therefore more widely dispersed and more difficult to contact). Although there were no baseline differences in time outdoors between children who did and did not participate in follow-up, those who participated in follow-up tended to be of higher SEP and to have married parents. These limitations should be acknowledged when considering the generalisability of findings. Strengths include the collection of data at three time points over five-years, and the range of predictor variables selected using a theoretically-driven approach.

In conclusion, this study provides longitudinal evidence of the importance of individual and social factors in predicting children's time outdoors over five years. Given the relationship between time outdoors and MVPA, strategies that aim to promote and prevent declines in children and adolescents' physical activity should consider the role of these individual and social factors in encouraging time outdoors. Intervention studies that target reducing indoor tendencies, increasing outdoor activities with siblings and friends (among boys), increasing parental encouragement, and promoting adult supervision of active outdoor play after school (among girls) are warranted.

COMPETING INTEREST

The authors have no competing interests to declare

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FIGURE LEGEND

Figure 1: Children's average time spent outdoors (minutes/week) over five years, by sex & age cohort

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Paragraph 1: What is already known on this subject?

We currently have a poor understanding on the longitudinal influences on children's

physical activity-related behaviours, such as time spent outdoors. Given the importance

of physical activity for health and the age-related declines observed physical activity, it is

important to understand these influences in order to inform strategies that aim to promote

physical activity among youth. This study aimed to longitudinally examine the

individual, social and physical environmental influences on children's time spent

outdoors over five years.

Paragraph 2: What does this study add?

This study has provided important insights into the longitudinal influences on time spent

outdoors among youth. Children with 'indoor tendencies' spent on average less time

outdoors over five years, **outdoor social opportunities were** important for **younger**

boys' time outdoors, while parental encouragement and supervision were important

influences on girls' **and older boys'** time outdoors. Interventions aiming to promote

physical activity among youth should consider sex-specific strategies that target these

individual and social influences.