ARCHIVES of Exercise in Health and Disease

DOI: 10.5628/aehd.v4i2.158

Original Research Manuscript

Environmental determinants of physical activity in children: A systematic review

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The lack of physical activity (PA) in children is an important health risk factor. Previous studies have shown that some environmental features may be associated with PA levels. ***Objectives:*** Find and comprehend which environmental features were mostly positively associated with children's physical activity. ***Methods:*** Twenty-eight studies were systematically reviewed. This research was used to assess the association between environmental features and physical activity among children (ages 3 to 12) who fulfilled the selection criteria. ***Results:*** Results across the various studies showed that facilities and parks/playgrounds are mostly positively associated with children's PA. Sidewalks and bike lanes were positively associated to PA in all studies. Safety, traffic and weather showed inconsistent associations with children's PA. ***Conclusions:*** Beginning to understand which environmental features contribute more to PA in children can lead to increased levels of PA.

Arch Exerc Health Dis 4 (2): 254-261, 2014

Key Words: physical activity; environment; children

INTRODUCTION

The lack of physical activity (PA) during childhood is an important health risk factor (51). Studies have shown that regular PA reduces and prevents obesity among children (5, 20), and provides several benefits including improved physical (3) and mental (4) health. Compared to previous generations, children now spend less time playing outside (29, 45) and more time in sedentary activities at home (29, 42). Therefore, PA promotion is a public health priority (50).

A growing body of evidence indicates that activity-friendly environmental features may influence PA in youth (37). Therefore, understanding and modifying the environmental context where the activity occurs may offer an opportunity for enhancing PA and health (30, 46).

A few reviews have been published on the association between environmental features and PA in children (17, 22, 38). In 2006, Davison et al. (17) reported that the presence of sidewalks in children's neighborhood, fewer uncontrolled intersections, lower traffic density and availability of facilities were positively associated with higher PA levels in children. In the systematic review of Ferreira et al. (22) published in 2007, the authors showed that access to facilities, neighborhood safety and neighborhood dangers (e.g. many roads, no light crossings and heavy traffic) were consistently unrelated to children's PA. On the other hand, also in 2007, Salmon and Timperio (38) reported that safety concerns (fear) of parents, few children in the neighborhood and the lack of parks were negatively associated with children's PA; however in this study, nearby facilities or a good interaction with other children was found to have a positive association. The authors also reported that no conclusions could be drawn about the relation between traffic safety and children's PA. Furthermore, no association was found between stranger danger and PA.

Since these reviews, studies published since 2007 on the relation between environmental features and PA levels in children have been abundant, and, therefore, it is important to update and summarize those findings. In this context, the aim of this study is to review systematically the literature on environmental determinants of PA in children from January 2007 to January 2012.

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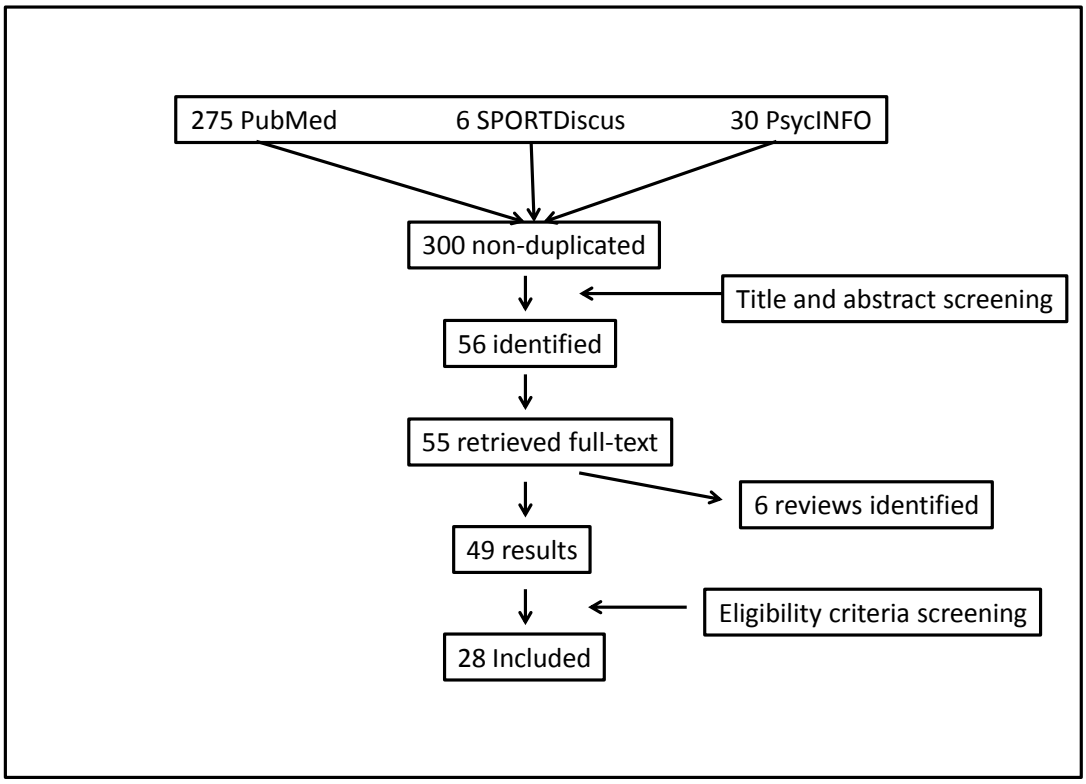

Figure 1. The flow chart of systematic review process.

MATERIAL AND METHODS

Search Strategies and Databases Searched

This systematic review consisted of a search of published literature in the English and French languages. Databases that were searched included PubMed, SPORTDiscus and PsycINFO. A search using the same keywords as MESH terms in all sources was performed. The main strategy used was the combination of the keywords: environment, physical activity and children between January 2007 and January 2012. Previous reviews with children and adolescents were also examined for further research.

Inclusion/Exclusion Criteria

The present review was concerned with the amount and type of environmental features or attributes that could influence PA levels in children. Therefore, the studies were selected if: (i) they had been published between January 2007 and January 2012; (ii) they included a sample of children between the ages of 3 to 12; (iii) they had either one method to measure environmental perceptions and PA or both; (iv) they had at least one association between PA and the environment. Studies were excluded when (i) the results were not reported separately for children, in the studies including both children and adolescents; (ii) the sample of the study consisted of children with disabilities; (iii) environmental features consisted only of school facilities or playgrounds.

Systematic Review Process

Figure 1 shows the search and retrieval process. The number of references searched in each database were 275 (PubMed), 6 (SPORTDiscus), and 30 (PsycINFO). After removing all duplicates, 300 references were found of which 56 were identified as possible results for this review by title and abstract screening. Full texts of 55 papers were retrieved. Of those, six were reviews (three systematic and three comprehensive) and in consequence they were excluded; their reference lists were reviewed and potential results were found. Twenty-one possible results were then excluded due to the age specifications. As a result of the combination of results between children and adolescents, the age of children varied. In some of the papers the participants' age was not specified, and they did not show

Table 1. Child studies categorized by author, sample size, country, measurement of environmental perceptions and PA, facilities, parks/playgrounds, safety, traffic, sidewalks, bike lanes and weather.

Authors	Study Design	Sample Size (N, age)	N Boys	N Girls	Country	Method to measure environmental perceptions	Method to measure physical activity	Facilities	Parks/ Playgrounds	Safety	Traffic	Sidewalks	Bike Lanes	Weather
Alton et al. (2)	Cross-sectional	473 (9-11y)	250	223	United Kingdom	Questionnaire	Self-report	+		-	+/- (high walkers/ low walkers)			
Borrestad et al. (7)	Cross-sectional	1339 (10-12y)	630	684	Norway		Self-report for children							+/ø (winter/spring, fall)
Bringolf-Isler et al. (8)	Cross-sectional	636 (6-10y)	323	313	Switzerland	GIS	Reported by parents			-	-			-
Carson et al. (10)	Cross-sectional	3421 (9-11y)	1642	1779	Canada	Survey for parents	Self-report; PAQ-C; Parent proxy report		+	ø		+		
Carver et al. (12)	Cross-sectional	170 (10-11y)	87	83	Australia	Survey for parents	Accelerometry			-				
Carver et al. (14)	Cross-sectional	188 (8-9y)	83	105	Australia	Reported by parents; GIS	Accelerometry	-		-	-			
Carver et al. (13)	Longitudinal	170 (8-9y)	87	83	Australia	Reported by parents; GIS	Accelerometry	+			+	+		
Carver et al. (11)	Cross-sectional	188 (8-9y)	100	88	Australia	Questionnaire for parents	Accelerometry			ø	-			
Crawford et al. (15)	Longitudinal	301 (10-12y)	128	173	Australia	Reported by parents; GIS	Accelerometry	ø		ø	-/ ø (boys/girls)			
D'Haese et al. (16)	Cross-sectional	696 (11-12y)	362	334	Belgium	NEWS-Y by parents; Routenet online router planner	Reported by parents				+			
de Vries et al. (18)	Cross-sectional	422 (6-11y)	207	215	Netherlands	Observations	Diary	ø	-		-		+	
de Vries et al. (19)	Cross-sectional	448 (6-10y)	216	232	Netherlands	NEWS-Y	Diary	+	+	+	+	+		
Giles-Corti et al. (24)	Cross-sectional	1480 (11-12y)	702	778	Australia	GIS; Pedshed					+			
Harrison et al. (25)	Cross-sectional	1794 (9-10y)	808	986	United Kingdom		Accelerometry							-
Holt et al. (26)	Cross-sectional	168 (6-12y)			Canada	Drawing			+			+		
Hume et al. (27)	Cross-sectional	280 (10y)			Australia	Self-report; Survey for children	Accelerometry	+		+/- (boys/girls)				
Jones et al. (28)	Longitudinal	3935 (11y)	1861	2074	United Kingdom		Questionnaire; Accelerometry							+
Panter et al. (32)	Cross-sectional	2012 (9-11y)	899	1113	United Kingdom	Questionnaire; GIS		ø		-	+		+	
Rodriguez et al. (34)	Cross-sectional	1897 (8-11y)	996	901	USA	Survey for children		-		+				
Roemmich et al. (35)	Cross-sectional	88 (8-12y)	44	44	USA	GIS	Accelerometry	+	+		+			
Rosenberg et al. (36)	Longitudinal	116 (5-11y)	55	61	USA	NEWS-Y	Survey; Self-report	+	+	+	+	+	+	
Scott et al. (39)	Cross-sectional	1367 (11-12y)	-	1367	USA	Self-report; GIS	Accelerometry	+						
Smith et al. (40)	Cross-sectional	764 (7-9y)	384	380	Australia	Screen time reported by parents	Reported by parents	+						
Spengler et al. (41)	Cross-sectional	2358 (≤10y)	1309	1049	USA		Direct Observation (SOPLAY)	+	+					
Timperio et al. (43)	Cross-sectional	163 (8-9y)	90	73	Australia	GIS	Accelerometry		+ (boys)					
Veitch et al. (48)	Cross-sectional	212 (8-12y)	105	107	Australia	Mapping; Survey		+	+					
Veitch et al. (49)	Cross-sectional	187 (8-9y)	99	88	Australia	Survey for parents	Accelerometry		+	+				
Zhu et al. (52)	Cross-sectional	1185 (4-11y)			USA	Survey for parents				-				

GIS – Geographical Information System; PAQ-C – Physical Activity Questionnaire for Older Children; NEWS-Y – Neighborhood Environment Walkability Scale for Youth; Routenet online router planner – objectively determine the distance of the shortest route from each child's home to school; Pedshed – i.e., a ratio of the pedestrian network area to the maximum possible area within a defined distance based on Euclidian distance; SOPLAY – System for Observing Play and Leisure Among Youth. For safety and traffic the signals of minus (-) and plus (+) should be interpreted as the following: (i) minus means that lower safety was associated with lower PA levels; and plus means that higher safety was associated with higher PA levels; (ii) minus indicates a lower traffic or traffic considered not to be safe,that was associated with lower PA levels; and plus indicates a positive association between lower traffic or traffic considered to be safe that was associated with higher PA levels.

associations between PA and the environment. Ultimately, 28 published studies were included in this review.

Coding of Results

In the present review, studies were selected by their association between PA and the environmental features. The associations reported in Table 1 were coded with the following signs: +, - and ø. A plus (+) indicated a positive association between PA and the environment; a minus (-) indicated a negative

association between PA and the environment; a null symbol (ø) was used when there was no association found. For safety and traffic the signs of minus and plus should be interpreted as follows: (i) minus means that lower safety was associated with lower PA levels; and plus means that higher safety was associated with higher PA levels; (ii) minus means that lower traffic or traffic considered not to be safe was associated with lower PA levels; and plus indicates a positive association between lower traffic or traffic considered to be safe was associated with higher PA levels.

RESULTS

As previously indicated, a total of 28 publications that presented at least one association between PA and environmental determinants were identified. All of the studies in Table 1 were published in the last five years. There were more publications in 2008 (8, 11, 14, 26, 43, 48, 52) and 2010 (10, 12, 15, 19, 28, 32, 40, 49). A similar amount of publications were found in the remaining years of study.

The vast majority of the studies (24 of 28 studies) used a cross-sectional design.

The sample size of the different studies varied between 83 and 3935 participants. Regarding study location, most studies were conducted in Australia (11-15, 24, 27, 40, 43, 48, 49); USA (34-36, 39, 41, 52) and United Kingdom (2, 25, 28, 32). Overall, the methods to measure environmental perceptions were mostly measured by GIS (8, 13-15, 24, 32, 35, 39, 43) and reported by parents (13-15, 40) .

After reviewing these perceptions, we sought to find which methods to measure PA were most used. Among those reviewed, accelerometry was mentioned the most (12 studies) followed by self-report (4 studies).

Only three studies (15, 27, 43) reported differences between genders in the associations between PA and environmental features. In relation to the environmental features or attributes associated with PA levels, both sidewalks and bike lanes were always positively associated with PA.

As shown in Table 1, the existence of facilities and parks/playgrounds in the neighborhood was compelling, and its association with PA was positively associated in most studies. Even though safety and traffic are the two most studied environmental features, their associations with PA levels are inconclusive. Bike lanes and weather are the environmental features least studied among the features.

Availability of Recreation Areas and Spending on Recreational Infrastructure

In ten out of fifteen studies, a significant positive association was identified between the availability and presence of recreational facilities near the neighborhood and the children's PA. Of those ten, five studies did not specify the type of recreational facilities under investigation. In a study measuring environmental perceptions and PA, Hume et al. (27) found that friends' houses within easy distance were positively associated with PA. Similarly, Alton et al. (2) and Veitch et al. (48) using samples from the United Kingdom and Australia respectively, found that nearby shops or friends' houses in the neighborhood were positively correlated to children's PA. Among US samples, Scott et al. (39) reported that a greater amount of facilities for basketball, as determined by objective assessment, were positively associated with PA levels in children and Spengler et al. (41) found out that both basketball and tennis courts were positively associated with PA. In addition, Carver et al. (14) and Rodriguez et al. (34) found a negative association between facilities outside the neighborhood environment and children's PA. Finally, no association was identified between facilities and children's PA in three studies (15, 18, 32).

Proximity of Parks and Playgrounds

A significant positive association between the proximity of parks and playgrounds and children's PA was identified in nine out of ten studies. Among these nine studies, two of them, measuring subjective environmental perceptions, found that nearby playgrounds were positively associated with children's PA (19, 26). Furthermore, Timperio et al. (43) reported that nearby playgrounds were only positively associated with boys' PA. Several studies (10, 35, 36, 41, 48, 49) showed that environmental perceptions were positively correlated with nearby parks and children's walking or cycling trips. Of those assessing children's PA, only two studies (35, 49) objectively measured PA with accelerometers.

One negative association was found between nearby playgrounds and children's PA. This association was due to the fact that it was a paved playground that affected the PA negatively PA (18).

Safety and Neighborhoods

A significant positive association between safety perceptions and PA was found in five of fifteen studies. Of these five, two (34, 49) reported that the perception of the neighborhood being safe was positively associated with PA in children. Rosenberg et al. (36) and de Vries et al. (19) reported that the lack of criminal activities and the presence of pedestrian

crossings, respectively, were positively associated with PA.

A study by Hume et al. (27) determined a positive association between safety perceptions and PA in boys; however, it also found a negative association for girls. Negative associations were found in seven of fifteen studies. Six (2, 8, 12, 14, 27, 52) of them were related to parental concerns about neighborhood safety. Panter et al. (32) found that the lack of streetlights was negatively associated with children's PA. Finally, no associations were found in three of fifteen studies. Of those, two (10, 15) referenced safety concerns. Carver et al. (11) did not find any association regarding pedestrian crossings and PA levels in children.

Traffic

Eight of fourteen studies found positive associations between traffic perceptions and PA in children. A good street connectivity was positively associated in three studies (16, 24, 35) in which two of them were measured by the NEWS-Y system. De Vries et al. (19) and Panter et al. (32) reported that traffic lights and density of roads, respectively, were positively associated with children's PA.

Two (24, 36) out of eight studies identified that the lack of traffic concerns in general, was positively associated with PA. Alton et al. (2) found that positive and negative traffic perceptions were associated with PA in high walkers and low walkers, respectively. Thus, six negative associations were found out of fourteen studies, three of which were related to general concerns about traffic (2, 8, 14). De Vries et al. (18) reported that a negative perception of intersections was negatively associated with children's PA.

Two studies (11, 15) showed that the lack of traffic lights was negatively associated with PA. In the same study by Carver et al. (11) it is interesting to note that a negative association was found between traffic lights and boys' PA, but no association was found regarding traffic lights and girls' PA.

Presence of sidewalks and bike lanes

In this review, results supported that the presence of sidewalks and bike lanes in the neighborhood were strongly associated with children's PA. Only one study assessed both sidewalks and bike lanes (36). In general, all studies subjectively measured environmental perceptions with the exception of the studies by Carver et al. (13) and Panter et al. (32) in which they used the Geographical Information System (GIS). Finally, only one study objectively assessed PA levels in children (13).

Weather

A significant positive association between weather and children's PA was identified in two of four studies. Although Jones et al. (28) reported that PA was positively associated in the summer, Borrestad et al. (7) found that even in winter, weather could positively influence PA levels in children. In the same study of Borrestad et al. (7), they did not find any association regarding PA in the spring or fall.

Harrison et al. (25) reported that rainfall negatively influenced 9-10 year-old children's PA. Related to the same subject, Bringolf-Isler et al. (8) showed that poor weather conditions negatively influenced the mode of travel of children.

DISCUSSION

In this paper, we systematically reviewed research on associations between environmental features and children's PA. The most consistent pattern of findings was evident to sidewalks and bike lanes, which were always positively associated with PA, followed by facilities and parks which were mostly positively associated with children's PA. However, some environmental features, such as safety, traffic and weather, were inconclusive in regard to their association with children's PA.

Results from previous studies examining facilities and children's PA showed that the proper equipment functioning and athletic facilities were associated with higher levels of PA (21). However, in the study of Adkins et al. (1), it was reported that the perceptions of facilities were not associated with PA in girls. Comparing these results with the current review, we can see that there is not much difference from what was already known. Environmental features are studied more often nowadays. To support this point of view, the review by Davison et al. (17) found five studies that assessed the proximity of parks and playgrounds and children's PA; in the present study, we found double this number. Of those studies, only three were positively associated with children's PA. In the current review nine were found since 2007.

Findings are more consistent when it comes to safety, with more studies than before finding positive associations with safety and children's PA. Indeed, in the review of Davison et al. (17), most studies reported a null association between safety and children's PA. Parents and children have a tremendous concern regarding road safety (31) and stranger danger (14, 31, 47). Effectively, this will always be under discussion, because it is expected that there will always be negative and positive perceptions regarding safety and children's PA. Different parents and children have

different perceptions; additionally, neighborhoods and the neighborhood environment are not all the same.

In contrast to safety, traffic concerns seem to have diminished. Prior to 2007 we found some studies regarding traffic and children's PA. The majority of them (23, 44, 47) were negatively associated with PA in children. According to our results, traffic is currently studied more, and the results reflect the opposite of what was previously indicated. Most of the studies in our review showed that there are more positive perceptions of parents and their children regarding traffic and children's PA.

The perception of traffic being safe enhances PA levels in children, and this is shown in areas with sidewalks and bike lanes. The association between traffic and sidewalks or bike lanes is worthy of discussion. In a previous review (33) it was reported that the presence of sidewalks as walking trails were protectors to safety of pedestrians in urban and residential places. In an intervention plan designed by Boarnet et al. (6) called Safe Routes to School (SR2S), they determined that children who passed through those constructs were more physically active. Bike lanes have been studied equally over time; however, for our age range we did not find any references that influenced children's PA before 2007.

It seems that there is sufficient evidence that all of these factors are important influences of PA in children, but one factor that cannot be ignored is the weather. As the weather is the only feature studied that we cannot control, it is interesting to see how it is associated with children's PA. Although there were fewer studies compared to the present, they are consistent with our current data. Brodersen et al. (9) found that the weather was positively associated in children's PA, though precipitation negatively affected girls' PA.

Limitations and Strengths

We acknowledge some limitations in our current review. First, the keywords used to retrieve studies from existing literature may have not been exact enough. The main outcome was overall PA, not enabling to determine the specific environmental correlates of specific physical activities. Some studies did not use objective measures for environmental perceptions and physical activity. However, the few databases searched did reveal a considerable amount of studies fulfilling the selection criteria.

CONCLUSIONS

In spite of the fact that obesity levels are growing all over the world, these perceptions have been studied more, and currently there is a lot more positive evidence regarding PA and the environment. Facilities and parks/playgrounds have been studied the most over time and have been positively associated with PA in the majority of studies. The presence of sidewalks and bike lanes should be targets of special attention, because most of the studies indicated that these were always positively associated with PA. Despite the fact that the environmental features previously mentioned have been easily associated with PA, there are still inconclusive features, such as safety, traffic and weather regarding association with PA. In these, only traffic concerns have diminished, which reflects the idea that the environment has been more studied more than in the past. Understanding which environmental features contribute to PA in children can lead to increased levels of PA.

Perspectives

Future studies on the associations between environmental perceptions on objective measures and PA levels in children should consider the use of objective measures of PA.

REFERENCES

1. Adkins S, Sherwood NE, Story M, and Davis M. Physical activity among African-American girls: The role of parents and the home environment. *Obes Res 12 Suppl*: 38S-45S, 2004.
2. Alton D, Adab P, Roberts L, and Barrett T. Relationship between walking levels and perceptions of the local neighbourhood environment. *Arch Dis Child* 92: 29-33, 2007.
3. Andersen LB, Harro M, Sardinha LB, Froberg K, Ekelund U, Brage S, and Anderssen SA. Physical activity and clustered cardiovascular risk in children: A cross-sectional study (The European Youth Heart Study). *Lancet* 368: 299-304, 2006.
4. Biddle SJ, Gorely T, and Stensel DJ. Health-enhancing physical activity and sedentary behaviour in children and adolescents. *J Sports Sci* 22: 679-701, 2004.
5. Blair SN and Brodney S. Effects of physical inactivity and obesity on morbidity and mortality: Current evidence and research issues. *Med Sci Sports Exerc* 31: S646-662, 1999.
6. Boarnet MG, Anderson CL, Day K, McMillan T, and Alfonzo M. Evaluation of the California safe routes to school legislation: Urban form changes and children's active transportation to school. *Am J Prev Med* 28: 134-140, 2005.
7. Borrestad LA, Andersen LB, and Bere E. Seasonal and socio-demographic determinants of school commuting. *Prev Med* 52: 133-135, 2011.
8. Bringolf-Isler B, Grize L, Mader U, Ruch N, Sennhauser FH, and Braun-Fahrlander C. Personal and environmental factors associated with active commuting to school in Switzerland. *Prev Med* 46: 67-73, 2008.
9. Brodersen NH, Steptoe A, Williamson S, and Wardle J. Sociodemographic, deveopmental, environmental, and psychological correlates of physical activity and sedentary behavior at age 11 to 12. *Amals of Behavioral Medicine* 29: 2-11, 2005.
10. Carson V, Kuhle S, Spence JC, and Veugelers PJ. Parents' perception of neighbourhood environment as a determinant of screen time, physical activity and active transport. *Can J Public Health* 101: 124-127, 2010.

11. Carver A, Timperio A, and Crawford D. Perceptions of neighborhood safety and physical activity among youth: the CLAN study. *J Phys Act Health* 5: 430-444, 2008.
12. Carver A, Timperio A, Hesketh K, and Crawford D. Are children and adolescents less active if parents restrict their physical activity and active transport due to perceived risk? *Soc Sci Med* 70: 1799-1805, 2010.
13. Carver A, Timperio A, Hesketh K, and Crawford D. Are safety-related features of the road environment associated with smaller declines in physical activity among youth? *Journal of Urban Health* 87: 29-43, 2009.
14. Carver A, Timperio AF, and Crawford DA. Neighborhood road environments and physical activity among youth: the CLAN study. *Journal of Urban Health: Bulletin of the New York Academy of Medicine* 85: 532-544, 2008.
15. Crawford D, Cleland V, Timperio A, Salmon J, Andrianopoulos N, Roberts R, Giles-Corti B, Baur L, and Ball K. The longitudinal influence of home and neighbourhood environments on children's body mass index and physical activity over 5 years: The CLAN study. *Int J Obes (Lond)* 34: 1177-1187, 2010.
16. D'Haese S, De Meester F, De Bourdeaudhuij I, Deforche B, and Cardon G. Criterion distances and environmental correlates of active commuting to school in children. *The International Journal of Behavioral Nutrition and Physical Activity* 8: 88, 2011.
17. Davison KK and Lawson CT. Do attributes in the physical environment influence children's physical activity? A review of the literature. *The International Journal of Behavioral Nutrition and Physical Activity* 3: 19, 2006.
18. de Vries SI, Bakker I, van Mechelen W, and Hopman-Rock M. Determinants of activity-friendly neighborhoods for children: Results from the SPACE study. *Am J Health Promot* 21: 312-316, 2007.
19. de Vries SI, Hopman-Rock M, Bakker I, Hirasing RA, and van Mechelen W. Built environmental correlates of walking and cycling in Dutch urban children: Results from the SPACE study. *Int J Environ Res Public Health* 7: 2309-2324, 2010.
20. DeLany JP, Bray GA, Harsha DW, and Volaufova J. Energy expenditure in preadolescent African Americans and white boys and girls: The Baton Rouge Children's Study. *Am J Clin Nutr* 75: 705-713, 2002.
21. Fein AJ, Plotnikoff RC, Wild C, and Spence JC. Perceived environment and physical activity in youth. *International Journal of Behavioral Medicine* 11: 135-142, 2004.
22. Ferreira I, van der Horst K, Wendel-Vos W, Kremers S, van Lenthe FJ, and Brug J. Environmental correlates of physical activity in youth - a review and update. *Obes Rev* 8: 129-154, 2007.
23. Gielen AC, Defrancesco S, Bishai D, Mahoney P, Ho S, and Guyer B. Child pedestrians: the role of parental beliefs and practices in promoting safe walking in urban neighborhoods. *Journal of Urban Health: Bulletin of the New York Academy of Medicine* 81: 545-555, 2004.
24. Giles-Corti B, Wood G, Pikora T, Learnihan V, Bulsara M, Van Niel K, Timperio A, McCormack G, and Villanueva K. School site and the potential to walk to school: The impact of street connectivity and traffic exposure in school neighborhoods. *Health Place* 17: 545-550, 2011.
25. Harrison F, Jones AP, Bentham G, van Sluijs EM, Cassidy A, and Griffin SJ. The impact of rainfall and school break time policies on physical activity in 9-10 year old British children: A repeated measures study. *The International Journal of Behavioral Nutrition and Physical Activity* 8: 47, 2011.
26. Holt NL, Spence JC, Sehn ZL, and Cutumisu N. Neighborhood and developmental differences in children's perceptions of opportunities for play and physical activity. *Health Place* 14: 2-14, 2008.
27. Hume C, Salmon J, and Ball K. Associations of children's perceived neighborhood environments with walking and physical activity. *Am J Health Promot* 21: 201-207, 2007.
28. Jones AP, van Sluijs EM, Ness AR, Haynes R, and Riddoch CJ. Physical activity in children: Does how we define neighbourhood matter? *Health Place* 16: 236-241, 2010.
29. Karsten L. It all used to be better? Different generations on continuity and change in urban children's daily use as space. *Children's Geographies* 3: 275-290, 2005.
30. King AC, Stokols D, Talen E, Brassington GS, and Killingsworth R. Theoretical approaches to the promotion of physical activity: Forging a transdisciplinary paradigm. *Am J Prev Med* 23: 15-25, 2002.
31. Mullan E. Do you think that your local area is a good place for young people to grow up? The effects of traffic and car parking on young people's views. *Health Place* 9: 351-360, 2003.
32. Panter JR, Jones AP, Van Sluijs EM, and Griffin SJ. Neighborhood, route, and school environments and children's active commuting. *Am J Prev Med* 38: 268-278, 2010.
33. Retting RA, Ferguson SA, and McCartt AT. A review of evidence-based traffic engineering measures designed to reduce pedestrian-motor vehicle crashes. *Am J Public Health* 93: 1456-1463, 2003.
34. Rodriguez A and Vogt CA. Demographic, environmental, access, and attitude factors that influence walking to school by elementary school-aged children. *J Sch Health* 79: 255-261, 2009.
35. Roemmich JN, Epstein LH, Raja S, and Yin L. The neighborhood and home environments: Disparate relationships with physical activity and sedentary behaviors in youth. *Ann Behav Med* 33: 29-38, 2007.
36. Rosenberg D, Ding D, Sallis JF, Kerr J, Norman GJ, Durant N, Harris SK, and Saelens BE. Neighborhood Environment Walkability Scale for Youth (NEWS-Y): Reliability and relationship with physical activity. *Prev Med* 49: 213-218, 2009.
37. Sallis JF and Glanz K. The role of built environments in physical activity, eating, and obesity in childhood. *Future Child* 16: 89-108, 2006.
38. Salmon J and Timperio A. Prevalence, trends and environmental influences on child and youth physical activity. *Med Sport Sci* 50: 183-199, 2007.
39. Scott MM, Evenson KR, Cohen DA, and Cox CE. Comparing perceived and objectively measured access to recreational facilities as predictors of physical activity in adolescent girls. *Journal of Urban Health: Bulletin of the New York Academy of Medicine* 84: 346-359, 2007.
40. Smith BJ, Grunseit A, Hardy LL, King L, Wolfenden L, and Milat A. Parental influences on child physical activity and screen viewing time: A population based study. *BMC Public Health* 10: 593, 2010.
41. Spengler JO, Floyd MF, Maddock JE, Gobster PH, Suau LJ, and Norman GJ. Correlates of park-based physical activity among children in diverse communities: Results from an observational study in two cities. *Am J Health Promot* 25: e1-9, 2011.
42. Tandy C. Children's diminishing play space: A study of inter-generational change in children's use of their neighborhood. *Aust Geogr Stud* 37: 154-164, 1999.
43. Timperio A, Giles-Corti B, Crawford D, Andrianopoulos N, Ball K, Salmon J, and Hume C. Features of public open spaces and physical activity among children: Findings from the CLAN study. *Prev Med* 47: 514-518, 2008.
44. Timperio A, Salmon J, Telford A, and Crawford D. Perceptions of local neighbourhood environments and their relationship to childhood overweight and obesity. *Int J Obes (Lond)* 29: 170-175, 2005.
45. Tranter P and Doyle J. Reclaiming the residential street as play space. *Int Play J* 4: 91-97, 1996.

46. TRB and IMNA. *Does the built environment influence physical activity? Examining the evidence*. Washington, DC.: Transportation Research Board and Institute of Medicine of the National Academies, 2005.
48. Veitch J, Salmon J, and Ball K. Children's active free play in local neighborhoods: A behavioral mapping study. *Health Educ Res* 23: 870-879, 2008.
49. Veitch J, Salmon J, and Ball K. Individual, social and physical environmental correlates of children's active free-play: A cross-sectional study. *International Journal of Behavioral Nutrition and Physical Activity* 7: 11, 2010.
47. Veitch J, Bagley S, Ball K, and Salmon J. Where do children usually play? A qualitative study of parents' perceptions of influences on children's active free-play. *Health Place* 12: 383-393, 2006.
50. WHO. Global Strategy on Diet, Physical Activity and Health, 2004, p. 38-55.
51. WHO. World Health Organization. Global recommendations on physical activity for health. Switzerland, 2010.
52. Zhu X, Arch B, and Lee C. Personal, social, and environmental correlates of walking to school behaviors: Case study in Austin, Texas. *TheScientificWorldJournal* 8: 859-872, 2008.