Curr Obes Rep (2015) 4:460–476
DOI 10.1007/s13679-015-0178-3

ECONOMY AND ENVIRONMENT (I JANSSEN, SECTION EDITOR)

Playability: Built and Social Environment Features That Promote Physical Activity Within Children

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Published online: 23 September 2015

Abstract The role of neighbourhood built and social environments in shaping children's physical activity has received increasing interest over the past 10 years. We reviewed recent evidence published between 2011 and 2014. Most of the recent evidence continues to be cross-sectional. Few macro-level neighbourhood attributes were consistently associated with physical activity in the expected direction. The strongest evidence for associations between neighbourhood attributes and physical activity with was for the transportation environment, particularly in relation to proximity to school and transport-related physical activity. There was intermediate evidence that neighbourhood walking/cycling infrastructure and pedestrian safety structures are associated with transport-related PA. Recent evidence on associations between the neighbourhood built and social environment and children's PA is modest. Stronger study designs and greater attention to conceptual-matching and specificity of measures are critical to advance the evidence base.

Keywords Physical activity · Children · Built environment · Social environment · Neighbourhood · Transport

This article is part of the Topical Collection on *Economy and Environment*

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Introduction

Childhood obesity is recognised as a serious global public health issue [1]. Rates of overweight and obesity have reached over 30 % in countries such as the USA and England [2, 3] and are rising rapidly in some developing countries [4]. This is of considerable concern given the significant health problems linked to childhood obesity during later years if excess body fat persists, such as hyperlipidaemia, impaired glucose tolerance, hypertension and depression, the increased risk of heart disease, diabetes, certain cancers, osteoarthritis and endocrine disorders [5]. Physical activity is critical for preventing continued increases in overweight and obesity [6] and can also have a range of other benefits for children, such as fitness, bone health, academic and cognitive performance, and reduced symptoms of depression [7–10]. Physical activity recommendations are relatively consistent across the world, with the World Health Organization recommending at least 60 min of moderate-to-vigorous physical activity every day, including 'exercise' that is planned, structured and repetitive, organised and unorganised, and social sport, active play and active transport. However, in most countries, fewer than 40 % of children meet these recommendations [11]. Upstream solutions are needed.

The underlying premise of ecological models is that behaviours are influenced by multiple contexts in which people live their lives [12]. Indeed, past research affirms that children's physical activity is shaped by a range of psychological, social, family, school and environmental factors [13, 14]. The role of the environment in shaping children's physical activity has received increasing attention since 2005 [15••] and has been the subject of several reviews [15••, 16–19]. A supportive neighbourhood environment is considered important for increasing physical activity because it provides children and families with cues, opportunities and supportive infrastructure for free play, structured and unstructured physical activity and active transport-related behaviours such as walking or cycling to school and other places. However, neighbourhood conditions may also pose significant barriers to physical activity for children. Unsupportive environments, for example, have been implicated in helping to create a generation of 'indoor children', with low rates of active transport and independent mobility and increasing levels of supervision [20]. The importance of urban planning for creating environments for active living and preventing obesity is recognised by the World Health Organization [1, 21].

Early research examining links between the neighbourhood environment and children's physical activity focused on provision of facilities for physical activity (e.g. [13]). In the 2000s, research started to emerge examining principles of 'walkability', community design and the transport environment in relation to children's physical activity [22, 23]. Some of this work drew on research being undertaken in adults driven by findings from the transportation literature showing that residential density, street connectivity and land use mix (the three core elements of walkability) are important determinants of transport-related walking [24]. Concurrently, increasing research began to focus on physical activity and safety-related elements of neighbourhood environments [20, 25, 26], which is thought to strongly shape parents restriction of their child's physical activity and independent mobility, and the perceived need to supervise their children (e.g. [27]). Further, over the past 10 years, there have been significant advances in measurement of neighbourhood environment attributes, with objective measures generated through Geographic Information Systems (GIS) and audits being collected alongside traditional perceived environment measures [28, 29].

In 2011, Ding et al. [15••] published a comprehensive review of 65 studies reporting associations between the built environment and physical activity among children aged 3–12 years (adolescents were examined separately). Across measurement modes (perceived vs objectively measured) and outcomes (leisure-time physical activity and active transport), children's physical activity was most consistently related to walkability, land-use mix, residential density, traffic speed or volume, and access or proximity to recreation facilities [15••]. Most of the evidence-base on children included in their review was from North America, half relied on perceptions of neighbourhood attributes, and the review did not distinguish findings between transport-related and leisure-time physical activity. The aim of this paper is to review recent evidence regarding the built and social environment within neighbourhoods and children's physical activity.

Methods

Search Strategy

In March 2015, a literature search was conducted in CINAHL, Medline, Psyc ARTICLES and SPORTDiscus using the following sets of search terms: built and social environment (urban form, urban planning, urban design, physical environment, neighbourhood, walkability, connectivity, community design, access/accessibility, facilities, park, greenspace, public open space, social environment, safety, crime, incivilities, neighbourhood disorder, social disorder, social trust, social cohesion, social capital, social connectedness, sense of community, friends, neighbours) and physical activity (physical activity, active play, active travel, active transport, active transit, active commuting, walking, cycling, sport, recreation, exercise). The search included papers published in the English-language between January 2011 and 31 December 2014. After removing duplicates, titles of 3161 articles and abstracts of 212 of these were screened for relevance. The full-text of 88 articles were assessed against the inclusion/exclusion criteria.

Inclusion and Exclusion Criteria

Empirical papers that included children aged 5–13 years (or reported results separately for a subset of participants that meet this criteria) and reported main effect associations between an aspect of the neighbourhood built or social environment and a physical activity outcome were included. Papers were excluded if the sample included participants outside the age range of interest (e.g. pre-schoolers or children over 13 years), the paper focused on a clinical population, only qualitative or descriptive results were reported, the dependent variable was energy expenditure, fitness or a composite measure that was not reflective solely of physical activity as a behaviour, none of the independent variables related to the neighbourhood context (e.g. school or family environment) or were reported as distinguishable from socio-economic status (SES), the focus was on exploring locations in which physical activity took place, and/or the study was conducted during an active intervention.

Data Extraction

Initially, location, study design, sample size, age and sex characteristics, physical activity outcome and how it was measured, neighbourhood type (residential, school or route) and method(s) of assessment, and the reported direction of associations (negative *(−)*, null *(0)*, positive *(+)*, or mixed *(mix)* results reported between subgroups, such as boys and girls) for each neighbourhood attribute were extracted for each article, consistent with previous reviews [30]. Associations were not extracted separately for sub-groups. In the cases where there were more than two sub-groups, the direction was recorded according to the majority of sub-groups. For each attribute, results were extracted from the most comprehensive (e.g. fully adjusted) model that included that variable. The extracted data were further summarised to quantify statistical comparisons that were null *(0)*, in the expected direction *(+)*, opposite to the expected direction *(−)* or produced mixed results between sub-groups *(mix)*.

Results

Following screening, 26 articles were deemed eligible for inclusion in the review (Appendix). Half of the studies were from North America (12 from the USA, one from Canada) [31–43], four were from Australia [44–47], three from the Netherlands [48–50], two from Belgium [51, 52•] and one each from the UK [53•], Portugal [54], Spain [55] and Norway [56]. The majority of the studies (*n*=22) included cross-sectional analyses only; four studies included a prospective design [33, 48, 49, 53•] and two included both cross-sectional and prospective analyses [33, 48]. Sample sizes ranged from 107 to 18,900.

Overall, there was an even representation of transport-related [31, 32, 34, 37–40, 42, 44, 45, 47, 51, 52•, 53•, 55] and overall/leisure-time physical activity or play [31, 33, 35, 36, 41, 43, 46, 48–51, 52•, 54, 56] examined across the studies. Only nine studies included an objective measure of physical activity [31, 36, 39, 41, 43, 46, 51, 52•, 56]. Both perceived and objective methods (audits (7 studies) and GIS (12 studies)) were used to measure attributes of the neighbourhood environment. The spatial range of the audits included street blocks [32, 40], census blocks [36, 43], neighbourhood [50], school attendance boundaries [39] and a quarter-mile (400 m) route from home to nearest non-residential destination [31].

Four studies specifically included attributes of the school neighbourhood [38, 39, 42, 47], and four examined route characteristics (three to school and one towards the nearest non-residential destination) [31, 32, 38, 53•]. All studies included at least one attribute related to the built environment; however, only 16 studies included attributes related to the social environment [32–35, 38, 40, 43–46, 48–50, 52•, 53•, 54].

Macro Built Environment Features

A diverse range of built environment attributes related to the recreation environment, neighbourhood design elements, the transport environment and aesthetic factors at the general neighbourhood (macro) level were examined for overall/leisure-time (Table 1) and transport-related (Table 2) physical activity.

Recreation Environment

Eight studies included a measure of the recreation environment [36, 39, 43, 46, 49, 50, 52•, 54], with 32 tests of associations made for overall/leisure-time physical activity and four for transport-related physical activity. Nine out of 32 tests of associations between the recreation environment (parks and recreation facilities) and physical activity were in the expected direction (mainly for self-reported outcomes). Neither of the two studies [39, 52•] that examined the recreation environment in relation to active transport found associations in the expected direction, although one found a mixed association between convenience of recreation facilities and walking for transport during leisure-time [52•].

Neighbourhood Design

Of the neighbourhood design attributes examined, measures of street connectivity were included in 9 of the 27 studies included in the review [39, 43–45, 47, 50, 52•, 53•, 54], land use mix in eight [36, 39, 42, 43, 50, 52•, 53•, 54], walkability scores in six [35, 37, 41, 44, 47, 51] and residential density in four [39, 42, 50, 52•]. With few exceptions, neighbourhood design attributes were not associated with overall/leisure-time physical activity across a total of 43 statistical comparisons. For transport-related physical activity, residential density was associated in the expected direction in two of eight comparisons [39, 52•] and one mixed result between boys and girls [52•]. Walkability score was associated with transport-related physical activity in the expected direction in two of eight comparisons [37, 51], measures of land-use mix were associated in the expected direction or had mixed results in five of 31 comparisons [42, 52•], and street connectivity was associated in the expected direction in one of ten comparisons [45].

Transport Environment

At least one attribute of the transport environment was examined in 18 of the 26 studies in the review [34, 37–40, 42–50, 52•, 53•, 54, 55]; 56 comparisons were made with a measure of overall/leisure-time physical activity, and 65 with a measure of transport-related physical activity. For overall physical activity, walking and cycling infrastructure (e.g. presence and maintenance of sidewalks, bike paths/lanes) was the most consistent correlate, with two of 17 comparisons associated in the expected direction [43, 52•, 54] and two mixed findings between boys and girls [50, 52•]. Traffic speed/volume was associated in the expected direction in one of five comparisons [54] for overall/leisure-time physical activity. Distance to school was the most commonly studied attribute and the most consistent correlate of transport-related physical activity, with 80 % of comparisons resulting in associations in the expected direction [32, 34, 37, 40, 42, 45, 47, 52•, 53•, 55], as well as

Table 1 Summary of associations between macro neighbourhood attributes and overall or leisure-time physical activity (PA) based on expected directions

		Objective environment measure No. of associations (no. of studies)								Subjective environment measure No. of associations (no. of studies)							
		Objective PA measure				Subjective PA measure				Objective PA measure				Subjective PA measure			
	References	−	0	+	Mix	−	0	+	Mix	−	0	+	Mix	−	0	+	Mix
Recreation environment																	
Parks/playgrounds	[36, 43, 46, 50]		4 (1)			1 (1)	4 (2)	1 (1)			3 (2)	2 (1)			3 (1)	3 (1)	
Recreation facilities	[36, 49, 52•, 54]		4 (1)				2 (1)	1 (1)			1 (1)				1 (1)	2 (2)	
Neighbourhood design																	
Land-use mix/destinations	[36, 43, 50, 52•, 54]		2 (1)				2 (2)				4 (2)				5 (3)		1 (1)
Residential density	[50, 52•]						1 (1)				1 (1)						1 (1)
Street connectivity	[43, 50, 52•, 54]					1 (1)					3 (2)			1 (1)	4 (3)		
Walkability (e.g. *score)*	[35, 41, 51]		4 (2)	2 (1)		1 (1)									1 (1)		
Dog walking infrastructure	[50]								2 (1)								
Easy to walk to transit	[54]														1 (1)		
General activity friendliness	[43, 56]		2 (1)				3 (1)				1 (1)						
Transport environment																	
Walk/cycle infrastructure	[43, 48–50, 52•, 54]						3 (1)		1 (1)		4 (2)				5 (3)	2 (2)	2 (1)
Traffic speed/volume	[48, 50, 54]						1 (1)								3 (1)	1 (1)	
Pedestrian safety infrastructure	[50]						1 (1)		4 (1)								
Car parking	[50]								2 (1)								
Traffic calming measures	[50]							1(1)	3 (1)								
Traffic-related safety	[43, 46, 49, 52•]										4 (3)				4 (2)		1 (1)
Distance to school	[52•]										1 (1)						1 (1)
General barriers to walk/cycle	[43]										4 (1)				6 (1)		
Social environment																	
Crime-related safety	[35, 43, 52•, 54]										5 (2)				7 (3)	2 (2)	
Incivilities/disorder	[50]						2 (1)										
Social trust/cohesion, capital, collective efficacy	[35, 49]														1 (1)	1 (1)	
Children nearby/social network	[46]											1 (1)					
See others walk/exercise	[46] [54]											1 (1)				1 (1)	
General safety	[33, 35, 46, 48]											1 (1)			10 (2)	2 (1)	
Other																	
Aesthetics/attractiveness	[43, 49, 50, 52•, 54]						6 (1)		1 (1)		3 (2)				4 [4]	2 (1)	
Attractiveness for children	[48]														6 (1)		
Water features	[50]						2 (1)										

\+ associations in the expected direction, 0 null associations, − associations in the direction opposite to expected, *Mix* mixed findings between subgroups

three mixed associations between boys and girls [44, 52•]. These associations were generally also strong. For example, Panter et al. [53•] found that the odds of taking up active travel to school were 13 times higher, and of maintaining active travel more than six times higher, among those living within 1 km of school compared to those living more than 2 km from school. Similarly, Giles-Corti et al. [47] found that each kilometre further a child lived from school was associated with 84 % lower odds of walking to school at least six times/week. Pedestrian safety structures/crossing aids (45 % of comparisons, plus one mixed finding) [38, 39, 45] and walking and cycling infrastructure (36 % of comparisons, plus two mixed findings) [38, 52•] were also consistently associated with transport-related physical activity in the expected direction. Traffic speed/volume and general traffic-related safety was associated with transport-related physical activity in the expected direction in one of 12 comparisons [42] and two in ten comparisons, respectively [38].

Neighbourhood aesthetics was examined in six studies but was not consistently associated with either overall/leisure time or transport-related physical activity [38, 43, 49, 50, 52•, 54].

Micro Built Environment Features (Route Characteristics)

Cain et al. [31] examined micro-scale attributes of a 400 m route in the direction of the nearest non-residential destination, Panter et al. [53•] objectively examined density of streetlights along the shortest route to school, whether the route was along a main road, route directness and whether the route went through an urban area, Curriero et al. [32] examined amount of incivility along the shortest route to school, and Oluyumi et al. [38] examined perceptions of the route to school (related to traffic, sidewalks, crossing safety and guards, violence and stray dogs). Both Cain et al. [31] and Oluyumi et al. [38] found that active transport behaviour was associated with route characteristics related to walking infrastructure and aspects of road crossings (Appendix). Cain et al. [31] found a higher number of significant associations between micro-scale features of the route for active transport compared to objective and self-reported moderate-to-vigorous intensity physical activity (MVPA) during leisure-time, particularly when it was objectively measured.

Macro Social Environment

General safety and crime-related safety were the most commonly examined social neighbourhood environment attributes in the studies reviewed, but these were not consistently associated with either overall/leisure-time- or transport-related physical activity in the expected direction (Tables 1 and 2). Five out of 23 comparisons across the outcomes were in the expected direction for general safety [32, 33, 38, 46], while two of 18 comparisons were in the expected direction for crime-related safety [35, 43]. Fewer comparisons were made for incivilities/disorder, social trust/cohesion and seeing others being active in the neighbourhood. One in five comparisons was in the expected direction for social capital [49]. Seeing others being active in the neighbourhood was associated with overall/leisure-time physical activity in both studies in which it was included [46, 54], but not in the studies examining transport-related physical activity [38, 45].

Objective vs Perceived Environment

Of the 134 associations that were examined using objective measures, 25 (19 %) were in the expected direction and a further 16 (12 %) had mixed results. Similarly, of the 213 associations that were examined using perceived measures, 38 (18 %) were in the expected direction, and a further 22 (10 %) had mixed results. There were no differences in the consistency of associations in the expected direction between objective and perceived measures of neighbourhood environment attributes and children's overall/leisure time and transport-related physical activity.

Discussion

This paper sought to review recent evidence regarding the built and social environment within neighbourhoods and children's physical activity. In the four years covered by this review, we identified 26 papers that met the parameters for the review, most of which had a cross-sectional design. These papers examined a diverse range of physical and social neighbourhood attributes, with land-use mix/destinations, walking and cycling infrastructure, and parks/playgrounds being the most commonly examined across studies. In general, few neighbourhood attributes were consistently associated with children's physical activity in the expected direction. The most consistent evidence for associations with either overall/leisure- or transport-related physical activity was for the transportation environment, particularly distance to school where 80 % of comparisons were in the expected direction for transport-related physical activity. This suggests that proximity to school is associated with participation in more frequent active transport. There was intermediate evidence (≥34 % of comparisons [15••]) that neighbourhood walking and cycling infrastructure (e.g. presence and quality of sidewalks) and pedestrian safety/crossing infrastructure is supportive of transport-related physical activity. Findings of studies specifically examining route characteristics support these macro-level findings [31, 32]. In the social environment, seeing others exercise in the neighbourhood was associated with physical activity; however, with the exception of crime and general safety, it should be noted that across all the included studies, there were very few comparisons made between these attributes of the social environment and physical activity.

The findings of the current review differ slightly from the conclusions of Ding et al. [15••] in their review that included 65 studies among children published before January 2010. However, there are important differences in our approach that help explain these differences. Our review did not include multiple comparisons for the same item/variable across different statistical models included in the article (we only included the result for the most comprehensive model in which the variable was examined), we did not include separate results for all sub-groups and we did not exclude comparisons from our review that were conceptually mismatched between the neighbourhood exposure variable and the physical activity outcome. The latter decision may have reduced the proportion of comparisons that were in the expected direction; however, it illustrates the need for future research to carefully consider conceptual matching of exposures and behaviours. Although researchers have been calling for environment-physical activity research to be behaviour- and context-specific for many years (e.g. [57, 58]), in the current review, there were several examples of conceptually mismatched exposures and behaviours (e.g. [42, 43, 50, 54]) which may dilute the evidence of the importance of attributes of the neighbourhood environment for active living and potentially inhibit uptake of evidence into policy.

Including only the results from the most comprehensive adjustments for some variables may also have contributed to dilution of the strength of the evidence in this review. Remmers et al. [48], for example, also examined family environment variables such as parental attitudes, rules and modelling of physical activity in their final statistical models, and these variables had stronger associations with physical activity than parents perceptions of the neighbourhood environment. Consistent with ecological models [12], more proximal individual and inter-personal factors would be expected to have stronger associations with physical activity than neighbourhood level factors. Among children, the family environment is a critical influence on physical activity in the context of neighbourhood environments. For example, children are reliant on parents as decision makers and gatekeepers to provide opportunities for them to engage in physical activity and allow affordances for organised activities, active travel and independent mobility, some of which may be dependent on the degree of risk parents see within their local neighbourhood. As such, the neighbourhood environment may have an indirect or conditional impact on children's physical activity. Some studies have begun to explore this complexity using mediating, moderating and path models in this context. Some early work in this area, for example, suggests that neighbourhood SES [51], parental participation in moderate-to-vigorous physical activity [59], perceived parent responsibility [49], and parental co-participation in physical activity [60] may moderate associations, and that independent mobility [52•] may mediate associations between the built environment and children's physical activity. Further exploration of direct and indirect effects and interactions between these contexts may help progress the field, particularly for further developing theory and to identify potential intervention strategies to increase physical activity.

The social environment within neighbourhoods was examined in 16 of the studies included in this review. The most commonly studied attribute within the social environment was 'general safety', which comprised in many cases single-item variables asking about whether parents and children feel safe walking or whether the neighbourhood is safe or safe for their child to walk/cycle during the day or at night. Such items generally lack specificity and, as such, do not contribute to a clear understanding about what conditions (physical or social) are driving the perception of safety on which to base policy responses. For example, it is unclear if a perception that it is unsafe to walk in the neighbourhood during the day is related to sidewalk conditions, traffic, lack of road crossing infrastructure, crime or violence, or any combination of these. Conceptualising feelings of personal safety as distinct from safety-related conditions may help to gain a better understanding of modifiable safety-related barriers to physical activity [61, 62]. Future research should consider the specificity and policy relevance of items used to assess perceptions of the neighbourhood environment.

The studies in this review included both subjective and objective measurement of neighbourhood environments at the macro level, as well as route characteristics. Recent advances in the availability of online tools (many of which are available free) allow virtual neighbourhood auditing from the desktop [63, 64]. Although not without limitations, with increasing quality of imagery and coverage, desktop auditing may significantly advance the cost-effectiveness of auditing neighbourhood attributes at a larger scale, particularly streetscapes. The concept of an 'activity space' is another way of examining exposure to neighbourhood attributes that was not used in the studies included in this review. An activity space is a representation of the actual area in which an individual roams or travels and may have limited overlap with arbitrary boundaries used to define 'neighbourhoods' [65]. Activity spaces can be generated using Global Positioning Systems (GPS) and may provide a more accurate reflection of exposure to environmental features [66]; however, causal inference with behaviour may be impacted by selective daily activity bias whereby access to a specific facility or resource is determined from locations specifically visited to use the resource [67]. To date, most use of GPS devices in physical activity research among children has utilized the devices in conjunction with accelerometry to identify where children engage in physical activity [e.g. 68, 69] or to identify routes to school [70].

The recent evidence base also has a number of additional limitations. Firstly, almost all of the studies included in this review were cross-sectional. There is a need for stronger study designs including prospective and experimental research such as natural experiments which have been identified as a priority for investigating casual associations between the built environment and physical activity [71]. However, due to the substantial costs and logistical challenges of conducting research involving major modification of the built environment, natural experiment studies are not common [72]. A further limitation of the evidence base is that all of the included studies were from developed countries (North America, Europe and Australia). Developing countries with rapidly growing cities and a different urban form and level of infrastructure may provide insights that further advance our understanding of how neighbourhood environments impact children's physical

Table 2 Summary of associations between macro neighbourhood attributes and transport-related physical activity (PA) based on expected directions

		Objective environment measure No. of associations (no. of studies)								Subjective environment measure No. of associations (no. of studies)							
		Objective PA measure				Subjective PA measure				Objective PA measure				Subjective PA measure			
	References	−	0	+	Mix	−	0	+	Mix	−	0	+	Mix	−	0	+	Mix
Recreation environment																	
Recreation facilities	[39, 52•]		1 (1)												2 (1)		1 (1)
Neighbourhood design																	
Land-use mix/destinations	[39, 42, 52•, 53•]		4 (1)				20 (2)	2 (1)							2 (1)	2 (1)	1 (1)
Residential density	[39, 42, 52•]		1 (1)	1 (1)			3 (1)								1 (1)	1 (1)	1 (1)
Street connectivity	[39, 44, 45, 47, 52, 53•]			1 (1)		1 (1)	4 (2)		1 (1)						3 (1)		
Walkability (e.g. score)	[37, 44, 47, 51]						4 (3)	2 (2)							2 (1)		
Transport environment																	
Walk/cycle infrastructure	[34, 38, 45, 52•]														7 (4)	5 (1)	2 (1)
Traffic speed/volume	[34, 42, 44, 45, 47, 53•]						4 (4)	1 (1)	1 (1)						4 (3)		2 (1)
Pedestrian safety infrastructure	[38, 39, 44, 45]		1 (1)	3 (1)			1 (1)								3 (2)	2 (1)	1 (1)
Distance to school	[32, 34, 37, 40, 42, 44, 45, 47, 52•, 53•, 55]							10 (8)	1 (1)							2 (2)	2 (1)
Car parking (double parking)	[39]		1 (1)														
Traffic-related safety	[44, 52•]														5 (2)		3 (2)
Steep hills/slope	[44, 45]														2 (2)		
General walking/cycling barriers	[34, 37]														1 (1)	2 (1)	
Social environment																	
Crime-related safety	[34, 52•]														4 (2)		
Incivilities/disorder	[32, 38, 40]					2 (2)									1 (1)		
Social trust/cohesion	[34, 53•]														3 (2)		
Disapproval from others	[44, 45]														2 (2)		
Children nearby/people to walk with	[44]														1 (1)		
See others walk/exercise	[38, 45]														2 (2)		
General safety	[32, 38, 40, 44, 45]														6 (3)	2 (2)	2 (2)
Stranger danger	[44]														1 (1)		
Other																	
Vegetation/trees/shade	[38]															1 (1)	
Aesthetics/attractiveness	[38, 52•]														5 (2)		1 (1)

+ associations in the expected direction, 0 null associations, − associations in the direction opposite to expected, *Mix* mixed findings between subgroups

activity. Types of safety issues and parent's perceptions of these issues and their neighbourhood environment may also differ from those of parents in developed countries.

This review has a number of limitations. Results were extracted for main effects only and the decision to only extract results for the most advanced model and not to extract results for every subgroup may have diluted the findings of associations in the expected direction. Some attributes of the neighbourhood environment may be more important for some subgroups than for others (e.g. girls compared to boys), but patterns of associations and effect modification were not explored in this review. When mixed findings where an association in the expected direction was observed in at least one subgroup are considered, 29 % of comparisons were in the expected direction. Categorization of the variables examined in the studies included in the review into neighbourhood attributes was in some cases difficult due to a lack of specificity and inconsistencies in measurement, and it is possible that our categorization does not match those made in previous reviews. This review only included studies of children; results are likely to be different for adolescents who are gaining autonomy and freedom to choose how and where they spend their time. There may also be large differences in autonomy within the age range included in this review; however, our review did not distinguish results between younger and older children or between girls and boys.

Conclusion

A supportive neighbourhood environment has the potential to increase children's free play, structured and unstructured physical activity, and active transport-related behaviours such as walking or cycling to school and other places. However, this review indicates that recent evidence on relationships between the neighbourhood built and social environment and children's physical activity is modest. The evidence-base could be strengthened by greater emphasis on conceptual specificity and the policy relevance of neighbourhood attributes examined, incorporation of experimental and prospective study designs and exploration of mediation and/or moderation with other more proximal influences.

Acknowledgments Anna Timperio is supported by a Future Leader Fellowship from the National Heart Foundation of Australia (Award 100046). Jenny Veitch is supported by an Early Career Fellowship from the National Health and Medical Research Council (ID1053426).

Compliance with Ethics Guidelines

Conflict of Interest Anna Timperio, Jacqueline Reid and Jenny Veitch declare that they have no conflict of interest.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

Appendix

Table 3 Characteristics of studies included in the review and overview of findings

Author, country	Design	Sample	Outcome(s)	Neighbourhood type (measure)	Findings (actual direction of associations)
Aarts et al. 2012 [50] The Netherlands	Cross-sectional	*n*=3651 Age: 4–12 years Sex: 51 % boys	Outdoor play (min/week) (parent-report)	Residential neighbourhood (audit)	Residential density (0) Land use mix (0) Presence of unoccupied houses (0) Maintenance of houses (mix) Number of formal outdoor play facilities (−) Quality of formal outdoor play facilities (0) Presence of green space (0) Quality of green space (0) Amount of water (ditches, pools, lakes) (0) Quality of water (0) Presence of sidewalks (mix) Quality of sidewalks (0) Presence of bike lanes (0) Quality of bike lanes (0) Traffic volume and speed (0) Presence of: pedestrian crossings without traffic lights (mix) pedestrian crossings with traffic lights (mix) traffic lights (mix) safety islands (mix) parallel parking places (mix) parking lots (mix) speed bumps (mix) home zones (mix) 30 km/h zones (mix) roundabouts (+) intersections (−) dog walking area (0) dog waste disposal (0) graffiti (0) vandalism (0) street lighting (mix) dark spaces (0) General impressions (0)
Bergh et al. 2011 [56] Norway	Cross-sectional	*n*=1129 Age: Grade 6; Mean 11.2 years (SD=0.3)	% daily MVPA (accelerometer)	Residential neighbourhood environment (child report)	Environmental opportunities for PA (access to play space, play rules, supervised

Table 3 (continued)

Author, country	Design	Sample	Outcome(s)	Neighbourhood type (measure)	Findings (actual direction of associations)
		Sex: 50 % boys			programs, environmental barriers) (0)
Cain et al. 2014 [31] United States	Cross-sectional	n=758 Age: 6–11 years Sex: 50 % boys	Frequency of active travel^{AT}; frequency of PA near home^{NPA} (parent report). MVPA min/day in the neighbourhood^{NMVPA}; non-school MVPA min/day^{NSMVPA} (accelerometer)	One route in residential neighbourhood (audit)	***Destinations & land use*** Residential mix (0^{AT}, $-^{NPA}$, 0^{NMVPA}, 0^{NSMVPA}) Shops (0^{AT}, $-^{NPA}$, 0^{NMVPA}, 0^{NSMVPA}) Restaurant – entertainment ($+^{AT}$, 0^{NPA}, 0^{NMVPA}, 0^{NSMVPA}) Institutional – service ($+^{AT}$, $-^{NPA}$, 0^{NMVPA}, 0^{NSMVPA}) Government – service (0^{AT}, 0^{NPA}, 0^{NMVPA}, 0^{NSMVPA}) Public recreation (0^{AT}, $-^{NPA}$, 0^{NMVPA}, 0^{NSMVPA}) Private recreation (0^{AT}, 0^{NPA}, $+^{NMVPA}$, $+^{NSMVPA}$) Parking (0^{AT}, $+^{NPA}$, 0^{NMVPA}, 0^{NSMVPA}) Transit stops ($+^{AT}$, $-^{NPA}$, 0^{NMVPA}, 0^{NSMVPA}) Overall score ($+^{AT}$, 0^{NPA}, $+^{NMVPA}$, 0^{NSMVPA}) ***Streetscape characteristics*** Overall score ($+^{AT}$, 0^{NPA}, 0^{NMVPA}, 0^{NSMVPA}) ***Aesthetics & social characteristics*** Overall score (0^{AT}, $+^{NPA}$, 0^{NMVPA}, 0^{NSMVPA}) ***Crossings/intersections*** Crosswalk amenities ($+^{AT}$, 0^{NPA}, 0^{NMVPA}, 0^{NSMVPA}) Curb quality ($+^{AT}$, $+^{NPA}$, $+^{NMVPA}$, 0^{NSMVPA}) Intersection control (0^{AT}, 0^{NPA}, 0^{NMVPA}, $-^{NSMVPA}$) Road width ($+^{AT}$, 0^{NPA}, 0^{NMVPA}, 0^{NSMVPA}) Impediments ($-^{AT}$, $-^{NPA}$, $-^{NMVPA}$, 0^{NSMVPA}) Overall score ($+^{AT}$, 0^{NPA}, 0^{NMVPA}, 0^{NSMVPA}) ***Street segments*** Building height set-back ($+^{AT}$, 0^{NPA}, 0^{NMVPA}, 0^{NSMVPA}) Building height – road width ratio (0^{AT}, 0^{NPA}, 0^{NMVPA}, $+^{NSMVPA}$) Buffer ($+^{AT}$, 0^{NPA}, 0^{NMVPA}, 0^{NSMVPA}) Bike infrastructure (0^{AT}, 0^{NPA}, 0^{NMVPA}, 0^{NSMVPA}) Trees (0^{AT}, 0^{NPA}, 0^{NMVPA}, 0^{NSMVPA}) Building aesthetics/design (0^{AT}, 0^{NPA}, 0^{NMVPA}, 0^{NSMVPA}) Sidewalk ($+^{AT}$, 0^{NPA}, $+^{NMVPA}$, 0^{NSMVPA}) Sidewalk obstruction/hazards ($-^{AT}$, $-^{NPA}$, 0^{NMVPA}, 0^{NSMVPA})

Table 3 (continued)

Author, country	Design	Sample	Outcome(s)	Neighbourhood type (measure)	Findings (actual direction of associations)
					Wide one-way street design (0^{AT}, 0^{NPA}, 0^{NMVPA}, $-^{NSMVPA}$) Slope ($-^{AT}$, $-^{NPA}$, $-^{NMVPA}$, 0^{NSMVPA}) Overall score ($+^{AT}$, $+^{NPA}$, 0^{NMVPA}, 0^{NSMVPA}) ***Cul-de-sacs*** Overall (0^{AT}, $+^{NPA}$, 0^{NMVPA}, 0^{NSMVPA}) ***Grand valence and overall*** Overall grand score ($+^{AT}$, 0^{NPA}, $+^{NMVPA}$, 0^{NSMVPA})
Curriero et al. 2013 [32] USA	Cross-sectional	*n*=362 Age: 8–12 years Sex: 46 % boys	Active travel to school (parent report, child report)	Residential neighbourhood & shortest route to school (GIS, audit, child & parent report)	Residential neighbourhood Is neighbourhood safe (parent) $(+)^{S}$ Is neighbourhood safe (child) $(0)^{S}$ How safe are neighbourhoods on way to school (child) $(0)^{S}$ Incivilities of home street block $(+)^{O}$ Shortest route to school characteristics Length $(-)^{O}$ Incivilities en route $(0)^{O}$
D'Haese et al. 2014 [51] Belgium	Cross-sectional	*n*=494 Age: 9–12 years Sex: 45 % boys	Duration of transport walking during leisure^{WT}; transport cycling during leisure^{CT}; active travel to school^{ATS}; leisure-time sports^{Sp} (child report assisted by parent). min/day MVPA on weekdays^{MVPAwd} and weekend days^{MVPAwe} (accelerometer)	Residential neighbourhood (GIS)	Walkability ($+^{WT}$, 0^{CT}, 0^{ATS}, $-^{Sp}$, 0^{MVPAwd}, 0^{MVPAwe})
Datar et al. 2013 [33] USA	Cross-sectional & longitudinal (8 years)	*n*=18,900 Age: Kindergarten at baseline Sex: not specified	Vigorous PA (days per week≥20 min) (parent report, child report)	Residential neighbourhood (parent report)	Safety for children to play outside during the day ($+^{C}$,$+^{L}$)
De Meester et al. 2014 [52•] Belgium	Cross-sectional	*n*=736 Age: 10–12 years Sex: 52 % boys	Duration of active transport to/from school^{ATS}; walking for transport during leisure^{WT}; cycling for transport during leisure^{CT}; overall PA^{PA} (child report). Steps/day^{STEP1} (accelerometer or pedometer)	Residential neighbourhood (parent report)	Residential density (mix^{ATS}, $+^{WT}$, 0^{CT}, mix^{PA}, 0^{STEP1}) Land use mix: diversity ($+^{ATS}$, $+^{WT}$, 0^{CT}, 0^{PA}, 0^{STEP1}) access ($+^{ATS}$, mix^{WT}, 0^{CT}, mix^{PA}, 0^{STEP1}) Closer distance to school ($+^{ATS}$, mix^{WT}, ,mix^{CT}, mix^{PA}, 0^{STEP1}) Connectivity (0^{ATS}, 0^{WT}, 0^{CT}, 0^{PA}, 0^{STEP1}) Walking/cycling infrastructure (mix^{ATS}, mix^{WT}, 0^{CT}, $+^{PA}$, 0^{STEP1}) Maintenance/quality of walk/cycle infrastructure (0^{ATS}, 0^{WT}, 0^{CT}, mix^{PA}, 0^{STEP1}) Aesthetics (0^{ATS}, mix^{WT}, 0^{CT}, 0^{PA}, 0^{STEP1}) Safety for traffic (0^{ATS}, 0^{WT}, 0^{CT}, mix^{PA}, 0^{STEP1}) Safety for crime (0^{ATS}, 0^{WT}, 0^{CT}, 0^{PA}, 0^{STEP1}) Convenience of recreation facilities (0^{ATS}, mix^{WT}, 0^{CT}, 0^{PA}, 0^{STEP1})

Table 3 (continued)

Author, country	Design	Sample	Outcome(s)	Neighbourhood type (measure)	Findings (actual direction of associations)
DeWeese et al. 2013 [34] United States	Cross-sectional	n=327 Age: 6–11 years Sex: not specified	Active travel to school ≥1 day/week (parent report)	Residential neighbourhood (GIS, parent report)	Very unsafe to walk, run, bike play due to traffic (0)^{S} Very unsafe to walk, run, bike play due to crime (0)^{S} Very unpleasant to walk, run, bike play (0)^{S} Poor sidewalk condition (0)^{S} Neighbourhood cohesion scale (0)^{S} Distance to school (−)^{O}
Echeverria et al. 2014 [35] United States	Cross-sectional	n=107 Age: 3–12 years Sex: not specified	MET-min/week score (parent report)	Residential neighbourhood (parent report)	Violence scale (seen acts of violence) (−) Safety scale (feel safe to walk; overall violence; crime) (0) Walking environment scale (mix of attributes) (0) Collective efficacy scale (0)
Galvez et al. 2013 [36] USA	Cross-sectional	n=324 Age: 6–8 years Sex: 26 % boys	≥2 h unscheduled outdoors PA^{UOPA}; ≥1 h MET-h/week scheduled PA^{MET} (parent report, child report). ≥11,000 steps/day ^{STEP2} (pedometer)	Residential neighbourhood (audit)	Playgrounds (+^{UOPA}, 0^{MET}, 0^{STEP2}) Community gardens (0 ^{UOPA,} 0^{MET}, 0^{STEP2}) Sports fields (0 ^{UOPA,} 0^{MET}, 0^{STEP2}) Recreation centres (0 ^{UOPA,} 0^{MET}, 0^{STEP2}) Parks (0 ^{UOPA,} 0^{MET}, 0^{STEP2}) Total number of PA resources on block (+^{UOPA})
Giles-Corti et al. 2011 [47] Australia	Cross-sectional	n=1132 Age: Grades 5–7 Sex: 47 % boys	Walking to school ≥6 trips/week (parent report)	School neighbourhoods (GIS)	Pedshed (−) Road traffic volume (0) Walkability (0) Distance to school (−)
Gutiérrez-Zornoza et al. 2015 [55] Spain	Cross-sectional	n=956 Age: 10–12 years Sex: 49 % boys	Frequency of walking/cycling to school (child report)	Residential environment (GIS)	Distance to school (−)^{O}
Machado-Rodrigues et al. 2014 [54] Portugal	Cross-sectional	n=1886 Age: 7–9 years Sex: 100 % girls	Duration of habitual PA (sum of duration of PA at school, walking/cycling to school & sport outside school) (parent report)	Residential neighbourhood (parent report)	Many stores within easy walking distance (0) Easy to walk to a transit stop (0) Many four-way intersections (0) Sidewalks on most of the streets (+) Traffic makes it difficult/unpleasant to walk (−) Crime rate makes it unsafe/unpleasant to walk (0) See many people being physically active (+) Many interesting things to look at while walking (0) Public recreation facilities (+)
Napier et al. 2011 [37] USA	Cross-sectional	n=193 Age: Grade 5 Sex: not specified	Usual frequency of walking to/from school (child report)	Residential neighbourhood (community type, GIS, child & parent report)	Walkable and mixed community vs less walkable community (+)^{O} Distance by road to school (−)^{S} Barriers (unsafe to cross, traffic, difficult to walk, too far, crime) Parent (−)^{S} Child (−)^{S}
Oluyomi et al. 2014 [38] United States	Cross-sectional	n=830 Age: Grade 4 Sex: 50 % boys	Walks to school most days (parent report)	Residential & school neighbourhood environments, route to school (child & parent report)	Residential neighbourhood Sidewalks on many streets (+) Many sidewalks well maintained (+) Safe road crossings (+)

Table 3 (continued)

Author, country	Design	Sample	Outcome(s)	Neighbourhood type (measure)	Findings (actual direction of associations)
					People walk/bike (0) Feel safe walking (0) Feel safe riding (0) Safe for child to walk/bike (+) Afraid when out alone after dark (0) School neighbourhood Sidewalks on many streets (+) Many sidewalks well maintained (+) Trees along many streets (+) Availability of bike lanes/ paths/trails (+) Bike lanes/paths/trails well maintained (0) Safe road crossings (+) Attractive buildings/natural things to see (0) Abandoned houses/vacant lots (0) Condoms, drug-related paraphernalia (0) Well-maintained homes, apartments, gardens (0) School route characteristics Traffic safety not a problem (+) Amount of traffic not a problem (+) Sidewalks/pathways a problem (+) Safety at intersections/ crossings not a problem (+) Availability of crossing guards (+) Availability of adults/ other children to walk/bike with problematic (−) Violence/crime a problem (−) Stray/dangerous animals a problem (−)
Panter et al. 2013 [53•] United Kingdom	Longitudinal (1 year)	*n*=912 Age: primary schools; mean 10.2 years (SD=0.3) at baseline Sex: 41 % boys	Uptake of active travel to school^{U}; maintenance of active travel to school^{M} (child report)	Residential neighbourhood and school route (GIS, child & parent report)	Neighbourhood characteristics Social cohesion/trust (parent) $(0^{U}, 0^{M})^{S}$ Neighbourhood walkability score (parent) $(0^{U}, 0^{M})^{S}$ Safe to walk/play during the day $(0^{U}, 0^{M})^{S}$ Road density $(0^{M})^{O}$ Street light density $(0^{M})^{O}$ Junction density $(0^{M})^{O}$ Effective walkable area $(0^{U})^{O}$ Land use mix $(0^{M})^{O}$ School route characteristics Route length between home/school $(-^{U}, -^{M})^{O}$ Streetlights/km $(0^{U}, 0^{M})^{O}$ Main road on route $(0^{U}, 0^{M})^{O}$ Route length ratio $(-^{U}, 0^{M})^{O}$ School route safety score (parent) $(+^{U}, 0^{M})^{S}$
Remmers et al. 2014 [49] The Netherlands	Longitudinal (2 yr)	*n*=1875 Age: mean 5.0 years (SD=0.5) at baseline Sex: not specified	Duration of unstructured outside play (parent report)	Residential neighbourhood (parent report)	Accessibility of PA facilities (+) Social capital (+) Functionality of sidewalks/ cycle paths (0) Traffic Safety (0) Attractiveness (0)
Remmers et al. 2014 [48] The Netherlands	Cross-sectional & longitudinal (2 yr;	*n*=2007 Age: mean 5.8 years	Duration of unstructured outside play (parent report)	Residential neighbourhood (parent report)	Lots of traffic $(0^{C5y},0^{C7y},0^{L})$ Presence of sidewalks $(0^{C5y},0^{C7y},0^{L})$

Table 3 (continued)

Author, country	Design	Sample	Outcome(s)	Neighbourhood type (measure)	Findings (actual direction of associations)
	control group within RCT)	(SD=0.4) at baseline Sex: 51 % boys			Perceived safety – daytime (0^{C5y},0^{C7y},0^{L}) Perceived safety – evening (0^{C5y},0^{C7y},0^{L}) Friendliness for children (0^{C5y},0^{C7y},0^{L}) Attractiveness for children (0^{C5y},0^{C7y},0^{L}) Safety without supervision (0^{C5y},0^{C7y},0^{L})
Rossen et al. 2011 [40] USA	Cross-sectional	n=365 Age: 8–13 years Sex: 46 % boys	Walking to school (parent report, child report)	Residential neighbourhood (audit, child & parent report)	Perceived neighborhood safety (child) (0) ^{S} Incivilities on street block above the median $(+)^{O}$ Distance to school $(-)^{O}$
Rothman et al. 2014 [39] Canada	Cross-sectional	n=118 schools Age: Elementary school Sex: not specified	Proportion of walking to school (observation)	School neighbourhood environment (GIS+census; audits)	Child population/1000 m^2 (+) Total population/1000 m^2 (0) Recreation facilities/1000 m^2 (0) Commercial land use (0) Industrial land use (0) Institutional land use (0) Double parking (0) Other schools in boundary (0) Intersection/km road (+) Pedestrian crossovers/km road (+) Traffic lights/km road (+) Presence of school crossing guard (+) Crossing guard/km or road (0)
Salmon et al. 2013 [46] Australia	Cross-sectional	n=613 Age: mean 9.4 years (SD=2.2) Sex: 47 % boys	MVPA min/day (accelerometer)	Residential neighbourhood (parent report)	Descriptive norms for PA (+) Good places to play (0) Social network (+) Personal safety (+) Road safety concerns (0)
Stevens et al. 2011 [41] USA	Cross-sectional	n=187 Age: Grade 5 Sex: 42 % boys	MVPA min/day in: half hour before school^{HBS}; half hour after school^{HAS}; from ½hour after school until 9 pm ^{AS}; on weekends^{MVPAwe} (accelerometer)	Residential neighbourhood (objective measure of community type)	Degree of walkability ($+^{HBS}$, $+^{HAS}$, 0^{AS}, 0^{MVPAwe})
Su et al. 2013 [42] United States	Cross-sectional	n=4338 Age: 5–7 years Sex: 52 % boys	Walk to school (parent report)	Residential & school neighbourhood (GIS)	<u>Residential neighbourhood</u> Distance to school (−) Population within 200 m (0) Population within 500 m (0) Population within 1 km (0) Traffic density within 150 m (0) Traffic density within 300 m (−) Land use: Contagion Index – 500 m (0) Contiguity index – 500 m (0) Fractal dimension index – 500 m (0) Land shape index – 500 m (0) Percent residential – 500 m (0) Percent agricultural & open – 500 m (0) Percent government/ institutional – 500 m (0) Percent other land use – 500 m (0) Simpson's diversity index – 500 m (0)

Table 3 (continued)

Author, country	Design	Sample	Outcome(s)	Neighbourhood type (measure)	Findings (actual direction of associations)
					<u>School neighbourhood</u> # grocery stores (0) # fast food stores (0) No food stores (0) Land use: Contagion Index – 500 m (+) Contiguity index – 500 m (0) Fractal dimension index - 500 m (0) Land shape index – 500 m (0) Percent residential – 500 m (0) Percent agricultural & open – 500 m (0) Percent government/ institutional – 500 m (+) Percent other land use – 500 m (0) Simpson's diversity index – 500 m (0)
Tappe et al. 2013 [43] United States	Cross-sectional	n=724 Age: 6–11 years Sex: 51 % boys	Neighbourhood PA on ≥4 days/week^{NPA}; park-based PA on ≥2 days/ week^{PPA}; ≥60 min MVPA on ≥5 days/week ^{GL} (parent report). MVPA min/day age based 3+ METs^{MVPA1}& Evenson cutpoints ^{MVPA2} (accelerometer)	Residential neighbourhood (GIS, audit, parent report)	High walkable & ≥1 high quality park (0^{NPA}, 0^{PPA}, 0^{GL}, 0^{MVPA1}, 0^{MVPA2})^{O} Safety against crime (0^{NPA}, $+^{PPA}$, 0^{GL}, 0^{MVPA1}, 0^{MVPA2})^{S} Street connectivity ($-^{NPA}$, 0^{PPA}, 0^{GL}, 0^{MVPA1}, 0^{MVPA2})^{S} Aesthetics ($+^{NPA}$, $+^{PPA}$, 0^{GL}, 0^{MVPA1}, 0^{MVPA2})^{S} Traffic safety (0^{NPA}, 0^{PPA}, 0^{GL}, 0^{MVPA1}, 0^{MVPA2})^{S} Walk/cycle facilities (0^{NPA}, $+^{PPA}$, 0^{GL}, 0^{MVPA1}, 0^{MVPA2})^{S} Proximity to stores (0^{NPA}, 0^{PPA}, 0^{GL}, 0^{MVPA1}, 0^{MVPA2})^{S} Proximity to play areas (0^{NPA}, 0^{PPA}, $+^{GL}$, $+^{MVPA1}$, $+^{MVPA2}$)^{S} Logistical barriers to walking/ cycling (0^{NPA}, 0^{PPA}, 0^{GL}, 0^{MVPA1}, 0^{MVPA2})^{S} Route barriers to walking/cycling (0^{NPA}, 0^{PPA}, 0^{GL}, 0^{MVPA1}, 0^{MVPA2})^{S} Lack of appropriate play areas ($-^{NPA}$, $-^{PPA}$, 0^{GL}, 0^{MVPA1}, 0^{MVPA2})^{S} Crime (0^{NPA}, 0^{PPA}, 0^{GL}, 0^{MVPA1}, 0^{MVPA2})^{S}
Trapp et al. 2011 [44] Australia	Cross-sectional	n=1197 Age: Grades 5–7 Sex: 48 % boys	Cycling to/from school >1 cycle trip/week (child report)	Residential neighbourhood (GIS, child & parent report)	Distance (mix)^{O} Road traffic volume (0)^{O} Pedshed (0)^{O} School walkability index (0)^{O} Stranger danger (parent) (0)^{S} Many friends in my neighbourhood (child) (0)^{S} Safe for child to cycle to school with friends (parent) (mix)^{S} Child would have to cross a busy road (parent) (mix)^{S} I (child) would have to cross a busy road (0)^{S} No safe crossings for my child to use (parent) (0)^{S} I (child) feel safe crossing the road near school (0)^{S} A lot of traffic near school (parent) (0)^{S} Steep hills (parent) (0)^{S}

Table 3 (continued)

Author, country	Design	Sample	Outcome(s)	Neighbourhood type (measure)	Findings (actual direction of associations)
					Disapproval from others (parent) (0)[S]
Trapp et al. 2012 [45] Australia	Cross-sectional	n=1298 Age: 9–13 years Sex: 47 % boys	Walking to/from school ≥6 trips per week (child report)	Residential neighbourhood (GIS, child & parent report)	Distance (km) (−)[O] Low road traffic volume (mix)[O] High connectivity (mix)[O] Low traffic x high connectivity (mix)[O] Safe to allow child to walk to school with friends (parent) (mix)[S] Child would have to cross a busy road (parent) (mix)[S] I (child) would have to cross a busy road (mix)[S] No safe crossings for my child to use (parent) (mix)[S] I (child) feel safe crossing road near school (0)[S] A lot of traffic in neighbourhood (parent) (0)[S] A lot of traffic in neighbourhood (child) (0)[S] Steep hills (parent) (0)[S] Not enough footpaths (parent) (0)[S] Often see adults/children walking, nice/friendly place to walk (parent) (0)[S] Disapproval from others (parent) (0)[S]

+ reported associations in the positive direction, 0 null associations, − reported associations in the negative direction, *mix* mixed findings between subgroups

[AS] Moderate-to-vigorous physical activity min/day from ½hour after school until 9 p.m.; [AT] Active travel; [ATS] Active travel to school; [C] Cross-sectional; [CT] Transport cycling during leisure; [C5y] child age 5 years; [C7y] child aged 7 years; [GL] ≥60 min MVPA on ≥5 days/week; [HAS] MVPA min/day in half hour after school; [HBS] MVPA min/day in half hour before school; [L] Longitudinal; [M] Maintenance of active to travel to school; [MET] ≥1 h MET-h/week scheduled PA; [MVPA] Moderate-to-vigorous PA (MVPA); [MVPA1] MVPA min/day age based 3+ METs; [MVPA2] MVPA min/day (Evenson cutpoints); [MVPAwd] min/day MVPA on weekdays; [MVPAwe] min/day MVPA weekend days; [NMVPA] MVPA in the neighbourhood; [NPA] Physical activity (PA) in the neighbourhood; [NSMVPA] Non-school MVPA min/day; [O] Objective; [PA] Overall PA; [PPA] PA in the park; [S] Subjective; [Sp] leisure-time sports; [Step1] Steps/day; [Step2] ≥11,000 Steps/day; [U] Uptake of active travel to school; [UOPA] ≥2 h unscheduled outdoors PA; [WT] Duration of transport walking during leisure.

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- •• Of major importance

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