

Possible Actions in the Built Environment to Enhance Physical Activity: Systematic Review

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Abstract

As a crucial factor of health, physical activity is widely explored in many empirical studies. The problem of how the built environment may affect physical activity attributes was discussed in previous studies, and the classification of interventions was presented in a limited scope. Therefore, the present study aims to review built environment interventions while classifying them into motivators and barriers of physical activity in residential neighbourhoods worldwide. Firstly, the main dimensions explaining how the built environment affects physical activity are presented. Fifteen papers published between 2009 and 2019 were identified by an extensive search in ScienceDirect, Web of Science, Scopus and PubMed. These works were systematically reviewed based on their main characteristics and then classified based on their relevant operationalisation of variables. Improving motivators and conquering barriers of physical activity on neighbourhoods lead to a healthy and sustainable society. The results of the current work can help policymakers and urban planners use exclusive methods for each part of neighbourhood planning and create an environment that overcomes barriers and promotes public physical activity levels.

Keywords: built environment, motivators and barriers, neighbourhood design, physical activity

1. Introduction

A growing body of evidence, including socio-ecological models, shows that an individual's health status is influenced by not only the person's behaviour but also by the interventions of surrounding built environment (Stokols, 1992). The built environment concept may have various dimensions and aspects, and it is defined as 'elements of the physical environment that are man-made, in contrast to the natural environment. The built environment includes everything from metropolitan land-use patterns to urban transportation systems to individual buildings and the spaces around them' (Anderson, 2009, p. 28). The effect of city environment features (including form, facilities and utilities) on public health began in the 19th century when the prevalence of contagious disease was described (Koohsari, Badland, & Giles-Corti, 2013; Snow, 1855). Furthermore, 'urban planning can, and should, play a role in making the impact of urbanisation on health beneficial for people' (World Health Organization, 2011, p. 2). People's health status is not only affected by individual treatment but also by attributes of the surrounding area (Barton & Grant, 2006; Stokols, 1992). Physical inactivity is a crucial contributor to global health, and it is related to the built environment. Determining the causes of physical activities is important to enhance and improve public health interventions (Sallis, Owen, & Fotheringham, 2000). Approximately 31% of adults worldwide are physically inactive; 17% of adults in Southeast Asia are inactive and the figure rises to 43% in the eastern Mediterranean and in North and South America. Furthermore, inactivity increases with age, especially in women (Hallal et al., 2012). Public physical activity alteration by using current surveillance data is a crucial challenge in the 21st century due to new trends in society that led to the reduction, not the enhancement, of physical activities (Hallal et al., 2012).

Physical activity may be affected by many environmental factors. Correlates of human physical activity and environmental factors were investigated in the last few years and categorised into social environment, built environment and natural environment factors (Bauman et al., 2012). Physical activity is defined as 'any bodily movement produced by skeletal muscle that results in energy expenditure' (Caspersen, Powell, & Christenson, 1985, p. 126). Physical activity encompasses a broad range of activities, including walking, jogging, cycling,

swimming, exercise and dancing. By contrast, it can be categorised by aims of recreation and utility (Frank, Engelke, Engelke, & Schmid, 2003). Other categorisations include transport, recreational, professional and indoor activities, like household activities (Koohsari et al., 2013). Recreation from physical activity comprises activities undertaken for discretionary reasons in someone's leisure time', whereas utilitarian physical activities are 'those that are worked with daily habits' (Frank et al., 2003, p. 58). Features of the built environment can substantially affect physical activity, particularly that of urban populations, leading to issues in health and well-being (Bauman et al., 2012; Zapata-Diomed, Herrera, & Veerman, 2016). The major part of noncommunicable disease can directly and indirectly be attributed to the insufficiency of physical activity (Allender, Cavill, Parker, & Foster, 2009). Evidence shows the links between the built environment and physical activity attributes from various perspectives (Abildso, Zizzi, Abildso, Steele, & Gordon, 2007; Clarke, Ailshire, Bader, Morenoff, & House, 2008; Kahn et al., 2002; Li, Fisher, Brownson, & Bosworth, 2005; Saelens & Handy, 2008; Schulz, Romppel, & Grande, 2016; Wang, Chau, Ng, & Leung, 2016), including the infrastructure, aesthetic, street network design, safety, exercise facilities and density and intensity dimensions. In recent years, an increasing number of quantitative studies were conducted to fill the gap between the built environment interventions and public physical activities. Few reviews on the relationship between built environment and physical activity focused on a limited geographic scope area (Day, 2016; O. Ferdinand, Sen, Rahurkar, Engler, & Menachemi, 2012), barriers (Wang et al., 2016) and older adults (Gharaveis, 2020; Moran et al., 2014); they also generally discussed the built environment and physical activity (Smith et al., 2017). However, the detailed distinction and classification of interventions into categories of motivators and barriers have not been presented yet. Thus, in the present study, we attempt to review a wide range of interventions focusing worldwide on neighbourhood areas with large sample sizes. The present study takes the following objectives:

- 1) to identify the association among built environment, physical activity and public health;
- 2) to describe the characteristics and methodologies of studies published in this field;
- 3) to classify the barriers and motivators of physical activity within the built environment;
- 4) to recognise how urban planners and decision-makers help create a built environment that is supportive of physical activity.

In the last few decades, continuous studies represented the different dimensions of the built environment influencing physical activity. As a result, several theories with numerous bodies of knowledge emerged to investigate the effects of the built environment on physical activity. Table 1 shows a categorised summary of major dimensions, based on respected indicators, explaining how the built environment may affect physical activity attributes.

Table 1. Classification of diverse dimensions and indicators on the linkage of built environment and physical activity attributes

Dimension	Indicators	Representatives
Infrastructure	- Access and close proximity to routine destinations - Design of public spaces - Diversity of land use - Ability to provide recreational - Neighbourhood upkeep condition	(Wang, Chau, Ng, & Leung, 2016) (Schulz, Romppel, & Grande, 2016) (Piyapong, Riruengrong, Wipawee, Siriphan, & Passanan, 2019)
Aesthetic qualities	- Enjoyable scenery - Arrangement of the physical elements	(Abildso, Zizzi, Abildso, Steele, & Gordon, 2007) (Saelens & Handy, 2008)
Street network design	- Street connectivity - Number of street intersections - Traffic volumes	(Li, Fisher, Brownson, & Bosworth, 2005)
Safety	- Residents' perceived safety - Rate of crime - Safe and lighted sidewalks and walking paths	(Li et al., 2005) (Clarke, Ailshire, Bader, Morenoff, & House, 2008) (Kahn et al., 2002) (Badiora Adewumi & Odufuwa Bashir, 2019)
Exercise facilities	- Density and proximity of green spaces or parks - Provision of signs, or encouragements for physical activity	(Bancroft et al., 2015) (Kahn et al., 2002) (Asefi & Ghanbarpour Nosrati, 2020)
Density and intensity	- Amount of population, employment, or building square in a given area	(Handy, Boarnet, Ewing, & Killingsworth, 2002)

2. Method

2.1 Literature Search

Research objectives were addressed by conducting a comprehensive systematic review that focused narrowly on the recent literature that examines the most influencing barriers and motivators of the built environment concerning physical activity range. A systematic and extensive search was conducted in several electronic databases, including articles published from 2009 to 2019 following the PRISMA statement (Moher, Liberati, Tetzlaff, & Altman, 2009). The literature search was conducted between November 2019 to January 2020, using the major databases, including Web of Science, Scopus, ScienceDirect and PubMed. The keywords 'physical activity', 'health', 'built environment', 'urban design', 'neighbourhood' and 'walking and cycling' were used.

2.2 Literature Inclusion and Exclusion Criteria

No limit was applied to the geographic location, and we attempted to include a worldwide domain. The selection process was conducted in two stages. The titles and abstracts were assessed, and then the whole text of selected articles was reviewed. A definition of inclusion criteria was conducted prior to the extensive search. The inclusion criteria for articles were as follows:

- published between 2009–2019
- published in peer-reviewed journals and written in English
- highly cited
- highest relevancy
- outcomes related to mortality, suicide, social inequity, mental health and maternal conditions were excluded

- interconnection analysis and ability to answer research questions

Our search identified 21,548 records. After title screening, approximately 200 articles remained. Consequently, based on the abstract screening, 70 records were included. Finally, 15 records were selected for detailed analysis. Figure 1 shows the study search and selection process.

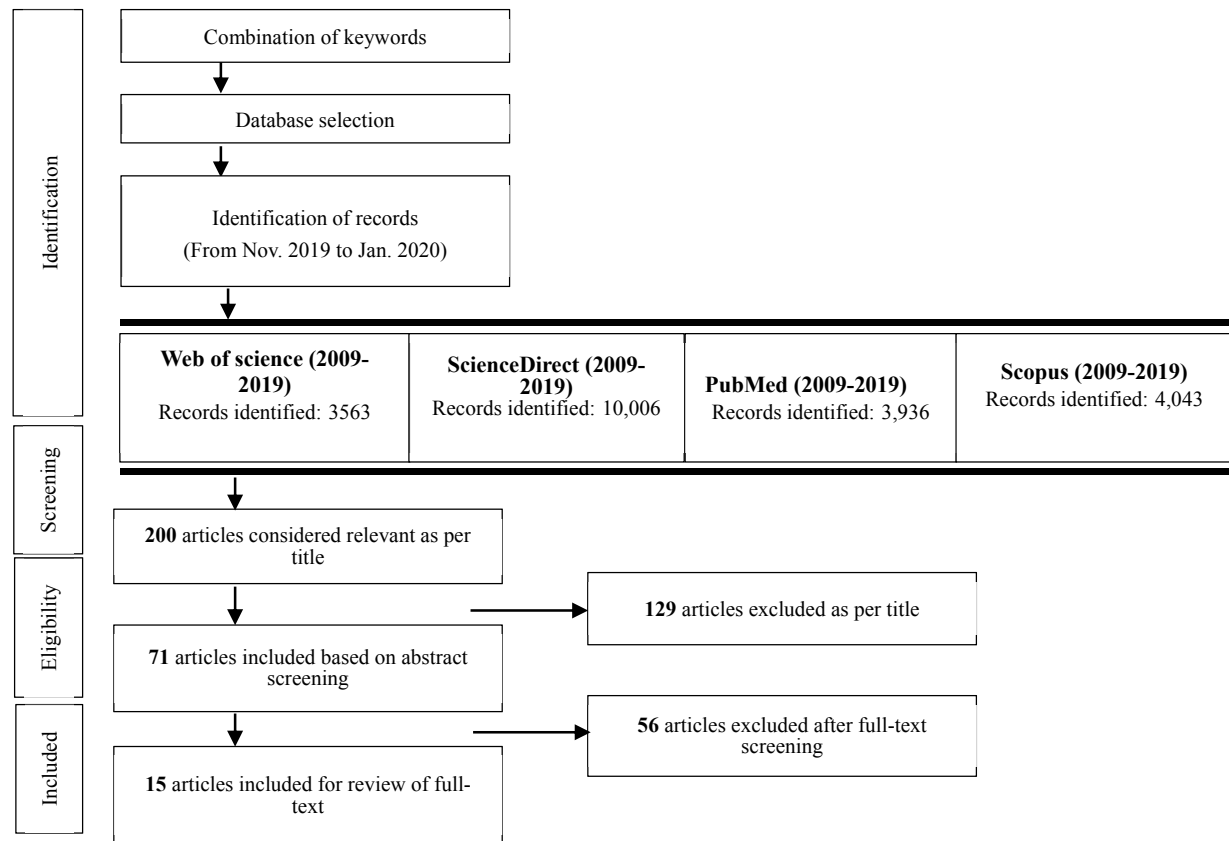


Figure 1. Flowchart of study search and selection process

After screening the full text of included articles, data extraction was systematically conducted, and the overview and main characteristics of each study were obtained. Data extraction was conducted initially by extracting the summary of the following study characteristics: study design, study location and population age, environmental intervention examined, method of physical activity measurement, major findings and recommendations. In the following section, a descriptive analysis of each research method and results is discussed, and the variables are categorised as the most important physical activity motivators or barriers by tabulating their frequencies.

3. Results

3.1 General Characteristics

The number of studies has clearly decreased during 2015–2019. Fifteen articles, highly relevant to the subject and published between 2009 and 2019, were included for detailed review. We attempted to cover all continents. The number of excluded studies and the exclusion reasons are illustrated in Figure 1. Four studies were conducted in the USA, followed by two—each in Australia and the UK; one each in Canada, New Zealand, China, Egypt, Scotland and Taiwan;. One study was multi-country, comprising 11 countries worldwide. Samples were large in terms of the participants and the geographical target. Most of the selected articles contained more than 1,000 (n = 9) samples, and four studies included more than 5,000 samples. The focus of seven studies was on vulnerable populations, including children, adolescents and older adults.

3.2 Study Design

Of the 15 studies, eight were cross-sectional. Four studies were longitudinal surveys, and only one used a mixed-method approach. One study included a descriptive method, and one used case study. The data collection method in the majority of studies was questionnaire (n = 6) or a mix of questionnaire and existing data from previous

studies or databases (n = 3). Five studies also used existing data, and two studies used a combination of existing data and observations. Finally, only two articles conducted interviews. The majority of studies (n = 9) investigated selected regions or neighbourhoods. As shown in Table 2, four studies examined nationwide samples and two included international targets.

Table 2. Summary of the selected articles

Characteristics	No. of articles	Characteristics	No. of articles
<i>Year of publication</i>		<i>Data collection method</i>	
2009- 2014	6	Questionnaire	4
2015-2019	9	Questionnaire and existing data	2
<i>Country</i>		Existing data	5
USA	4	Existing data and observation	2
Canada	1	Interview	2
Australia	2	<i>Study design</i>	
New Zealand	1	Cross-sectional	8
UK	2	Descriptive	1
China	1	Longitudinal	4
Egypt	1	Mixed mode	1
Scotland	1	Case study	1
Taiwan	1	<i>Sample size</i>	
Multi-country	1	n <100	3
<i>Age group</i>		100 < n < 1000	3
Child	1	1000 < n < 5000	5
Adolescence	1	n > 5000	4
Adults	6	<i>Geographical target</i>	
Older adults	5	Nation-wide	4
Not mentioned	2	Selected regions	9
		International	2

3.3 Physical Environmental Categories Identified in the Selected Studies

Table 2 provides brief details on the 15 reviewed studies, including the study design, study location and population age, method of physical activity measurement, major findings on environmental factors and study recommendations if existing. The built environment measured factors in the selected studies were categorised based on the presented dimensions in Table 1. The six following categories extracted from the data are infrastructure, aesthetic qualities, street network design, safety, exercise facilities, density and intensity. Corresponding subcategories and environmental factors are explained in detail in Appendix 1.

3.3.1 Infrastructure

Infrastructural issues were subdivided into the following categories: (i) access and close proximity to routine destinations, (ii) design of public spaces, (iii) diversity of land use, (iv) ability to provide recreation and (v) neighbourhood upkeep condition. Most studies attempted to examine more than one environmental factor in relation to physical activity. The majority of reviewed studies addressed the association of the infrastructural subcategories and people's physical activity attributes (n = 13). A high range of land use diversity is associated with the chance to engage in physical activity particularly active transports (Tewahade et al., 2019). Local amenities and facilities are longitudinally related to chronic diseases, such as type 2 diabetes, because of their impacts on routine physical activity of people during the day (Dendup, Astell-Burt, & Feng, 2019).

Neighbourhood walkability and sidewalk quality are closely related with physical activity that leads to a reduced prevalence of overweight and obesity (Carlson, Aytur, Gardner, & Rogers, 2012; Creatore et al., 2016; King et al.,

2011). Accordingly, a pedestrian-friendly design in an urban context may decrease approximately 5.5% of annual deaths due to decreases in cases of CHD, hypertension, stroke and diabetes (Gibson et al., 2015). Biking infrastructures and traffic safety in built environment attributes are significantly high in the regions that residents have a lower body mass index (BMI) range (Algoday, Ayad, & Saadallah, 2019; Sallis et al., 2009). Access to low-cost recreation facilities and locating transport stops with a short distance in the neighbourhood are highly related to meeting the guidelines of physical activity (Panter, Heinen, Mackett, & Ogilvie, 2016; Sallis et al., 2009), particularly in older adults (Frank, Kerr, Rosenberg, & King, 2010). The parents consider a direct association between the whole physical, social and upkeep conditions in the surrounding built environment and their children's health mediating physical activity (Teedon, Gillespie, Lindsay, & Baker, 2014). Distribution of functional spaces such as coffee shops, stores and markets is also highly related to reaching the sufficient amount of physical activity (Creatore et al., 2016; Huang, Kung, & Hu, 2018; Zhou, Grady, & Chen, 2017).

3.3.2 Aesthetic Qualities

Aesthetic qualities, including subcategories of (i) enjoyable sceneries and (ii) arrangement of the physical elements, were identified in three studies. Elements in the built environment which are provided by urban design strategies should enhance the environment's visual pleasure. This environmental visual pleasure is associated with adults' weight status because of its impact on their physical activity (Algoday et al., 2019; Zhou et al., 2017). Physical elements arrangement factors may influence the parents to encourage their children to have physical activities independently (Teedon et al., 2014).

3.3.3 Street Network Design

Street network design was subdivided into (i) street connectivity, (ii) number of street intersections and (iii) traffic volumes. Nine studies examined this factor in relation to the amount of physical activities.

Street layouts and connectivity is a crucial indicator that encourages people to walk for transport (Koohsari, Oka, Owen, & Sugiyama, 2019). Walkability of a neighbourhood has a direct relationship to the road connectivity and intersection density; thus, it affects obesity, overweight and accordingly disease like stroke and diabetes (Algoday et al., 2019; Creatore et al., 2016; Gibson et al., 2015).

Street connectivity within 1 kilometre from individuals' homes can affect walking levels of neighbourhood and older adults' physical activity (Frank et al., 2010). Traffic-free routes and properly connected sidewalks, roads and intersections associated active transport and moderate to vigorous physical activity (Carlson et al., 2012; King et al., 2011; Panter et al., 2016).

3.3.4 Safety

Safety included three subcategories, namely, (i) residents' perceived safety, (ii) rate of crime and (iii) safe and lighted sidewalks and walking paths. The safety characteristics of the built environment and the association with physical activity were addressed in three studies. Perceived day and night crime rates which create unsafe walking paths were closely related to higher odds of type 2 diabetes occurrence (Dendup et al., 2019). Safety at night which affects the resident's active transport positively impacts BMI (Algoday et al., 2019). However, only one study, conducted internationally in 11 countries, found that perceived crime rate was not related to physical activity prevalence (Sallis et al., 2009).

3.3.5 Exercise Facilities

Exercise facilities are divided into two subcategories, namely, (i) density and proximity of green spaces or parks and (ii) provision of signs or encouragements for physical activity. Five studies investigated the association between physical activity and exercise facilities. Park and green space density was positively correlated with active transportation and the recommended range of physical activity (Huang et al., 2018; Tewahade et al., 2019). By contrast, two of the five studies concluded that the number of park and green space density has no significant impact on residents' physical activity or their BMI, possibly because of the lack of services or encouraging signs and even security (Algoday et al., 2019; Creatore et al., 2016; Richardson, Pearce, Mitchell, & Kingham, 2013). Creating park and green spaces with good provision of facilities is valued by parents for physical activity and health benefits in their children (Teedon et al., 2014).

3.3.6 Density and Intensity

Density and intensity consist of the number of population, employment, or building squares in a given area. Of the 15 studies, five examined the factor correlates of physical activity. Residence density was significantly associated with neighbourhood walkability and active transportation (Creatore et al., 2016; Tewahade et al., 2019). In one of the five relevant studies, which developed a computer simulation for neighbourhood features to promote walking,

population density was introduced as a variable in functions that positively impact walkability (Gibson et al., 2015). Population density and retail density are some of the determinants of a neighbourhood that promotes active transport (Frank et al., 2010; King et al., 2011).

4. Discussion

In the review of the association between built environment and physical activity attributes, we included 15 studies that could be reviewed in detail and varied considerably in design and methodology. The following environmental categories significantly affected public physical activities: infrastructure, aesthetic qualities, street network design, safety, exercise facilities and density and intensity. The focus of the majority of studies was based on infrastructural issues. The infrastructural facilities should be in good condition to encourage physical activity in residents. For example, providing sidewalks without a good design or erecting a park without being concerned with toilets does not promote physical activity or walking outdoors. Aesthetic issues in urban design have not been thoroughly investigated though it is positively associated with people's outdoor physical activity. By contrast, the street design network substantially impacts public physical activity which can be examined more precisely due to current techniques, such as space syntax. As shown in Table 3, the investigated factors were classified into two main groups, namely, motivators and barriers of physical activities.

Table 3. Motivators and barriers of physical activity attributes associated with the built environment

Physical activity attributes	Corresponding factors
Motivators	<ol style="list-style-type: none"> 1. Proportion of number of residential units to the neighbourhood area 2. Number of retail outlets or any other businesses or services in area 3. Variety of types of land use per unit group (i.e. residential, office, shops, entertainment and institutional) 4. Population per neighbourhood area 5. Walkable destinations 6. Greater street connectivity (i.e. the ratio of three-legged or greater intersections divided by the neighbourhood area) 7. Presence and quality of sidewalks 8. Lighting of the walking paths 9. Liveliness by population movements 10. Streetscape form quality (i.e. street width and buildings height) 11. Biking routes, parking and safety 12. Visual pleasure (e.g. trees, façade designs and water and electricity elements) 13. Presence and condition of public or private recreational spaces (i.e. gyms, playgrounds and workout elements in parks)
Barriers	<ol style="list-style-type: none"> 1. Mean distance to nearest park and green spaces 2. Distance to functional spaces 3. Distance to transport stations 4. Day and night crime rate

5. Conclusion

The investigation of built environment factors affecting physical activity attributes is becoming increasingly important in recent years. Few review studies were conducted on the relationship between the built environment and physical activity. However, the detailed distinction and classification of interventions into categories of motivators and barriers have not been presented yet. In this study, firstly, a categorised summary of major dimensions explaining how the built environment may affect physical activity was presented. A wide range of interventions was then reviewed, focusing on neighbourhood areas worldwide with large sample sizes. In this

review, 15 papers published between 2009 and 2019 were examined in detail. In conclusion, this review provided a detailed classification of built environment characteristics in every relevant dimension that led to increase physical activity and accordingly public health. Motivators and barriers were also mentioned.

Findings showed that the proportion of number of residential units to the neighbourhood area, variety of types of land use per unit group (i.e. residential, office, shops, entertainment and institutional), population per neighbourhood area, lighting in the walking paths, liveliness by population movements, streetscape form quality (i.e. street width and building height), biking routes, parking and safety, visual pleasure (e.g. trees, façade designs and water and electricity elements) and presence and condition of public or private recreational spaces (i.e. gyms, playgrounds and workout elements in parks) are the most influencing motivators in neighbourhoods, encouraging residents to take part in physical activities. By contrast, mean distance to the nearest park and green spaces, distance to functional spaces, distance to transport stations and day and night crime rate are the factors that play a barrier role for physical activity in residents.

The primary strength of this review is the comprehensive search in numerous databases that reflected the subject. Another particular strength of this study is the global scope and the large samples covered by this review. These strengths assist designers and planners worldwide in making decisions. Furthermore, the level of detailed interventions classification in motivator and barrier types can facilitate the process of urban design. Nonetheless, limitations in the present study should be acknowledged. This study was a review of a limited number of studies in a limited time period. However, other factors related to the built environment, such as climate and gender, were not examined. The number of qualitative studies and studies that examined children was small. Furthermore, different types of physical activity were not categorised because some of the selected studies did not precisely define physical activity. Accordingly, future studies should consider factors like local climate and gender. Additional studies should be conducted on children below 15, and the definition and classification of physical activity should also be provided for consideration during data collection.

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Appendix

Detailed analysis of 15 included studies

Author(s) and year	Study design	Study location and population age	Environmental intervention examined	Method of physical activity measurement	Major findings	Recommendation
(Sallis et al., 2009)	Cross-sectional; Questionnaire for both environmental attributes and physical activity.	11 countries including Belgium, Brazil, Canada, Colombia, China (Hong Kong), Japan, Lithuania, New Zealand, Norway, Sweden, and the U.S.; N=11,541 adults 18–65 years.	Housing type, shops density within walking distance, transit stop (10–15 minutes distance from home), sidewalks, biking facilities, low-cost recreation facilities, and crime rate at night	International Physical Activity Questionnaire (IPAQ)	Five out of seven interventions (except house type and perceived crime) significantly correlated meeting physical activity guidelines.	The study generalized the previous studies findings, conducted in some developing countries, correlating built environments and physical activity to a wide range of countries. Designing the neighbourhood which supports physical activity should be considered as a worldwide health issue.
(Frank et al., 2010)	Cross-sectional; Existing data of a previous study.	U.S. and Atlanta; N= 1970 adults aged 65 years or older.	Street connectivity, land use mix, and residential density within a kilometre from each participant's house.	Self-reported	Walking levels can increase if there are accessible destinations in a short distance and walkable neighbourhoods.	Financial incentives to consider the location of, and build functional spaces such as senior centres, social services, or medical facilities in a neighbourhood.
(King et al., 2011)	Cross-sectional; CHAMPS physical activity questionnaire.	U.S. (Seattle-King County, Washington and Baltimore-Washington DC regions); N= 719 Adults aged 66 years and older.	Residential density, retail floor area ratio, land-use mix, intersection density.	Accelerometer measured physical activity	Neighbourhoods were associated with more active transport and lower body weight irrespective of neighbourhood income and moving disability levels.	There should be alarms from the public health organizations for the enhancement of those environmental features that can support physical activity and healthy aging.
(Carlson et al., 2012)	Cross-sectional; Leyden Ireland survey & BRFSS health questions; Paper-copy surveys door-to-door.	U.K. (Manchester, Portsmouth and New Hampshire); N=679 in 24 neighbourhoods.	Presence and quality of sidewalks, street connectivity, proximity to services, road lane-miles, and lot size.	Self-reported	The strongest correlation of destination walking were found for sidewalks and connectivity.	Altering strategies to support capitalising on important effects to promote walkability of neighbourhoods. Besides, examining the built environment changes which can impact on physical activity and health.
(Richardson et al., 2013)	Cross-sectional; Used existing data including the analysis of anonymized individual health survey responses.	New Zealand Nationwide; N= 8157 among >15 years of age.	Neighbourhood-level green space availability.	Self-reported	Overall physical activity levels were higher in greener neighbourhood residents.	Greener neighbourhoods are likely to be effective for public physical activity and health.

Author(s) and year	Study design	Study location and population age	Environmental intervention examined	Method of physical activity measurement	Major findings	Recommendation
(Teedon et al., 2014)	Cross-sectional; Qualitative examination through neighbourhood-based conversations and workshop interaction.	Scotland Nationwide; N=85 parents of children aged under nine and age of parents <34 years.	Local community, public and green space, housing, and service provision.	Reported by parents	Parents reported significant relations with the environment where they live, and both physical and social activities of their children.	There should be agendas to create and promote more sustainable behaviours at a local level including housing strategies and environmental design.
(Gibson et al., 2015)	Case study; Used existing data to create a computer simulation model.	U.S. (North California); N=1200 residents of Raleigh's BRRC neighbourhood.	Different urban designs including intersection density, land-use mix, residential density and retail floor area.	Current walking time by mailed questionnaire; Simulate changes in transportation by computing formulas.	Pedestrian-friendly neighbourhoods can cause reduction of deaths occurred because of stroke, CDH, diabetes and hypertension.	Constructing more sidewalks throughout the neighbourhoods.
(Creatore et al., 2016)	Longitudinal; Used existing data from national databases; Observation method for environmental measures.	Canada (Southern Ontario cities); N=8777 about 4 million adults, age 30-64 years.	Neighbourhood walkability (population density, residential density, walkable destinations, street connectivity, access to local parks, gyms and coffee shops)	Data collected from national databases.	Neighbourhood higher walkability has a significant association with the reduction in the prevalence of obesity and diabetes.	-
(Panter et al., 2016)	Longitudinal; Used existing data.	UK; N=496, Age >16 years of residents within 30 kilometres of Cambridge.	Exposure to the new bus network.	Recent Physical Activity Questionnaire (RPAQ)	Provision of new transport infrastructure associated with promoting active commuting, particularly biking.	Supporting the reconfiguration of transport systems as a part of policies to improve public health.
(Zhou et al., 2017)	Mixed mode; In qualitative phase, older adults were interviewed about their PA; In quantitative phase, data obtained from health survey dataset of the local hospitals.	China (3 neighbourhoods in Huainan, a mid-sized city in Anhui); Adults age 55 + years; Qualitative phase (N= 42) and quantitative phase (N=3094).	Liveliness of an apartment site and the closeness of an apartment site to functional spaces.	Physical activity was measured as the frequency of PA per week, the length of time participating in each activity, and the intensity of each activity during the year.	Liveliness of the neighbourhood or the apartment site and the closeness of the houses to functional spaces can encourage sedentary older people to have physical activity.	Assist older adults to choose their houses after their retirement, close to functional places. On the other side, investments in infrastructures and urban planning would increase the accessibility of functional spaces.
(Huang et al., 2018)	Cross-sectional; Individual Level used NHIS dataset; Ecological Level used data of National land-use dataset.	Taiwan Nationwide; N=2214, Age +65 years	Parks, greeneries, squares, playgrounds and sport venues, and schools which are often used for physical activities.	Physical activity (minutes/week) was calculated based on self-report using questionnaire.	Township median income, and the built environment were positively associated with the older adults' physical activity. The mentioned association still	To older adults take part in physical activities, governments, urban decision-makers, and designers had better identify and analyse the obstacles and advantages of the built environment characteristics in

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					existed after individual-level factors controlling.	different urbanisation levels.
(Algoday et al., 2019)	Cross-sectional; Onsite questionnaire.	Egypt (Alexandria); N=309, Adults 18–55 years old, Two neighbourhoods, 91 street segments.	Connectivity, aesthetics, pedestrian amenities, bike Infrastructure and traffic safety.	Self-reported using onsite questionnaire concerning preferred modes of transportation.	Built environment attributes including urban determinants related to connectivity, traffic safety, aesthetics, and form were significantly higher in the neighbourhood with residents having lower BMI.	Urban design need to enhance more walkable and safe environments to take part in tackling obesity.
(Dendup et al., 2019)	Longitudinal Questionnaire for environment status and existing data for health status.	Australia (New South Wales); N=36,224, Middle to older age adults.	Recreation facilities, footpaths, markets within easy walking distance of one’s home, transport stop within 10–15 min walk from home, and crime rate in the neighbourhood.	Self-reported	There is a significant association between perceived crime rates and neighbourhoods’ amenities and type 2 diabetes, due to the impact on public physical activity during day and night.	Change the features of residential neighbourhoods to enhance crime prevention and proximity to local facilities in collaboration with crime prevention agencies and urban designers.
(Tewahade et al., 2019)	Longitudinal; Used existing data; Used multistage sampling.	U.S. nation-wide; N=2,785, Adolescents and emerging adults.	Land-use mix, street connectivity, residence density, park density, recreational density and walkability.	Self-reported	Participants who live in a high land-use diversity had more active transportation. Higher residence density is related to active transport, walkability, higher densities of parks and recreation area had significantly higher chance of reporting active transport.	Built environment characteristics need to be addressed in order to build neighbourhoods with higher range of walkability and liveability to increase physical activity.
(Koohsari et al., 2019)	Descriptive	-	Street layouts and connectivity.	Natural movement in built environment using space syntax method to predict pedestrian movement.	Using space syntax in urban design can help policy-makers to predict the people natural movements and to know where to locate the functional space or other commercial or residential land-uses.	Better to use space syntax techniques to apply urban planning practices and strategies which motivate walking for transport.

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