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Journal of Sport and Health Science 8 (2019) 153–169

www.jshs.org.cn

Review

Impact of built environment on physical activity and obesity among children and adolescents in China: A narrative systematic review

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Received 27 July 2018; revised 19 September 2018; accepted 4 October 2018
Available online 16 November 2018

Abstract

Background: Neighborhood built environment may profoundly influence children's physical activity (PA) and body weight. This study systematically reviewed scientific evidence regarding the impact of built environment on PA and obesity among children and adolescents in China.
Methods: A keyword and reference search was conducted in Active Living Research, Cochrane Library, PubMed, and Web of Science. Studies that met all of the following criteria were included in the review: (1) study designs—experimental studies, observational studies, and qualitative studies; (2) study subjects—Chinese children and/or adolescents aged ≤17 years; (3) exposures—neighborhood built environment; (4) outcomes—PA and/or body weight status; (5) article type—peer-reviewed publications; (6) time window of search—from the inception of an electronic bibliographic database to May 31, 2018; (7) country—China; and (8) language—articles written in English.
Results: A total of 20 studies, including 16 cross-sectional studies, 3 longitudinal studies, and 1 descriptive study, met the predetermined selection criteria and were included in the review. A total of 13 studies adopted subjective built environment measures reported by parents and/or children, 2 adopted objective measures (e.g., geographical information system, field observations), and 5 adopted both objective and subjective measures. PA behaviors included PA, physical inactivity, sedentary behavior, active/passive commuting from/to school, and park visits. Among the 16 studies that provided some quantitative estimates of the influence of built environment on PA and body weight status, all reported a statistically significant relationship in the expected direction. Availability and accessibility in proximity to greenspaces, parks, recreational facilities, and sidewalks were found to be associated with increased PA levels, reduced sedentary behaviors, and/or active commuting among Chinese children and adolescents. In contrast, the absence of bike lanes and living in higher density residential areas were associated with increased likelihood of childhood overweight and obesity.
Conclusion: Neighborhood built environment plays an important role in Chinese children's PA engagement and weight outcomes. Building new exercise facilities and enhancing the accessibility of existing facilities hold the potential to enhance PA engagement among Chinese children and adolescents. In addition, urban designs that incorporate sidewalks, bike lanes, walking paths, less motorized traffic, and lower residential density are likely to promote PA and prevent childhood obesity in China.

Keywords: Body weight; Chinese; Exercise; Literature review; Local environment; Neighborhood environment; Physical environment

1. Introduction

Obesity is a leading cause of morbidity and premature mortality worldwide.[1–4] Childhood obesity is linked to various immediate and long-term adverse health outcomes such as sleep apnea, hypertension, heart disease, stroke, type 2 diabetes, osteoarthritis, and certain types of cancer, and it leads to social and psychological problems such as stigmatization and poor self-esteem.[5,6] In 2010, 43 million children worldwide (35 million in developing countries) were estimated to be overweight or obese.[7] By 2020, the prevalence of childhood overweight/obesity is projected to reach 9%, or 60 million children worldwide.[8] Based on the 2017 Report on Childhood Obesity in China, the prevalence of childhood overweight increased from 2.1% in 1985 to 12.2% in 2014 among Chinese children aged ≥7 years, and the prevalence of childhood obesity increased from 0.5% to 7.3% during the same time period, resulting in an increase in

Peer review under responsibility of Shanghai University of Sport.
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https://doi.org/10.1016/j.jshs.2018.11.003
Cite this article: An R, Shen J, Yang Q, Yang Y. Impact of built environment on physical activity and obesity among children and adolescents in China: A narrative systematic review. *J Sport Health Sci* 2019;8:153–69.

overweight/obese children from 6.2 million to 35.0 million nationwide.[9] Based on the Physical Activity and Fitness in China—the Youth Study, the prevalence of obesity among Chinese school children and adolescents aged 9−17 years reached 12%, and approximately 37% of them did not meet screen time viewing recommendations.[10] It is projected that the prevalence of childhood overweight/obesity will reach 28%, or 49.5 million children, in 2030.[9]

An active lifestyle helps to decrease the risk of obesity in both adults and children.[11] In contrast, physical inactivity is a leading risk factor for morbidity and mortality.[12−14] A vast majority of children and adults in both developed and developing countries fall short of the meeting guidelines-recommended levels for physical activity (PA).[15] The relationship between built environment and PA among children in general has been extensively documented.[16,17] Accumulating evidence suggests that the availability of parks, playgrounds, gyms, and other facilities, as well as other neighborhood features such as walkability and safety, profoundly shape children's daily PA patterns.[18,19] Roemmich et al.[20] found that residential locations closer to parks were associated with higher PA levels in young children than those farther away from parks. Reimers et al.[21] reported that adolescent girls residing far away from a gym were less likely to engage in indoor sports activities than those residing near a gym. Molnar et al.[22] found that poorer neighborhood safety was negatively associated with PA among youth aged 11−16 years.

The majority of studies on the relationship between built environment and PA focus on adults and children in developed countries (e.g., the United States),[16−19] whereas relevant studies on the child population in developing countries remain limited. The characteristic and quality of various types of neighborhood built environment can noticeably differ between developed and developing countries,[23] which may differentially impact the PA and obesity patterns among local residents. In the coming decades, China is expected to undergo an unprecedented urbanization and urban expansion.[24] This circumstance creates a critical opportunity for urban planners to design smart cities and environments conducive to an active lifestyle among residents, including children and adolescents.[24] However, this grand goal would not be accomplished without a profound understanding of the relationship between built environment and PA. Moreover, cultural norms in China may play an important role in children's PA patterns.[25] For example, Confucian ideology regards sport and PA participation as predominantly masculine in nature, which results in Chinese women engaging in low levels of PA during childhood and adolescence.[25] Owing to the potential mediating effect of Chinese culture, the relationship between the built environment and PA in China might not resemble that in Western countries and thus warrants targeted research. One study that reviewed the built environmental correlates of PA in China, primarily among working-age and older adults, documented increased levels of PA in relation to proximal nonresidential locations, pedestrian-friendly infrastructure, aesthetics, and recreational amenities.[26]

This study is, to our knowledge, the first that systematically reviewed the existing literature regarding the impact of neighborhood built environment on PA and body weight status among children and adolescents in China. Findings from this review can be informative to policymakers and stakeholders in their efforts to design and modify certain features of the neighborhood built environment that promote PA, decrease sedentary behavior, and contribute to healthy weight among the Chinese child population. The study also identified limitations and gaps in this field that warranted future research.

2. Methods

2.1. Study selection criteria

Studies that met all of the following criteria were included in our review: (1) study designs—experimental studies (e.g., randomized, controlled trials or pre−post studies), observational studies (e.g., longitudinal studies, case-control studies, or cross-sectional studies), and qualitative studies; (2) study subjects—Chinese children and/or adolescents aged ≤17 years; (3) exposures—neighborhood built environment (e.g., sports facilities, parks, greenspaces, bike lanes, and sidewalks); (4) outcomes—PA and/or body weight status; (5) article type—peer-reviewed publications; (6) time window of search—from the inception of an electronic bibliographic database to May 31, 2018; (7) country—China; and (8) language—articles written in English.

Studies that met any of the following criteria were excluded from the review: (1) studies that incorporated no outcome pertaining to PA and/or body weight status; (2) studies that evaluated an area substantially larger than a neighborhood, such as a city or province; (3) studies that evaluated a resident's transportation mode but that had no evaluation of the neighborhood's transportation system; (4) studies that did not include human participants; (5) controlled experiments conducted in manipulated rather than naturalistic settings; (6) articles not written in English; (7) letters, editorials, study/review protocols, or review articles; or (8) studies involving Chinese participants who lived outside the Mainland of China, Hong Kong, China, or Macao, China.

2.2. Search strategy

A keyword search was performed in 4 electronic bibliographic databases: Active Living Research (ALR), Cochrane Library, PubMed, and Web of Science. Administered by the University of California, San Diego, ALR was founded in 2001 by an interdisciplinary team with research-and-practice expertise in public health, transportation, planning, parks and recreation, school activity programs, behavioral science, and obesity prevention. Over the past 2 decades, ALR has established a rich database of articles covering community designs that promote PA, physical/mental health, economic vitality, and environmental sustainability. The Cochrane Library is a collection of databases in medicine and other health specialties.

The search algorithm included all possible combinations of keywords associated with the 4 groups: (1) "environment", "environments", "environmental", "neighborhood", "neighbourhood", "neighborhoods", "neighbourhoods", "place", "places",

"residence", "residential", "area", "areas", "space", "spaces", "spatial", "greenspace", "land", "lands", "landscape", "landscaping", "park", "parks", "community", "communities", "municipal", "garden", "gardens", "wood", "woods", "forest", "forests", "facility", "facilities", "gym", "gyms", "gymnasium", "gymnasiums", "path", "paths", "trail", "trails", "resource", "resources", "amenity", "amenities", "urban", "city", "cities", "town", "towns", "county", "counties", "walkability", "built", "building", "buildings", "street", "streets", "streetscape", "road", "roads", "highway", "highways", "freeway", "freeways", "expressway", "expressways", "sidewalk", "sidewalks", "footway", "footways", "footpath", "footpaths", "track", "tracks", "walkway", "walkways", "passage", "passages", "passageway", "passageways", "block", "blocks", "transport", "transportation", "transit", "geography", "geographies", "geographic", or "geographical"; (2) "motor activity", "motor activities", "sport", "sports", "physical fitness", "physical exertion", "physical activity", "physical activities", "physical inactivity", "sedentary behavior", "sedentary behaviors", "sedentary behaviors", "sedentary behaviors", "sedentary lifestyle", "sedentary lifestyles", "inactive lifestyle", "inactive lifestyles", "exercise", "exercises", "active living", "active lifestyle", "active lifestyles", "play", "outdoor activity", "outdoor activities", "step", "steps", "walk", "walking", "run", "running", "bike", "biking", "bicycle", "bicycling", "cycle", "cycling", "stroll", "strolling", "active transport", "active transportation", "active transit", "active commuting", "travel mode", "mode of travel", "physically active", "physically inactive", "obesity", "obese", "adiposity", "overweight", "body mass index", "BMI", "body weight", "waist circumference", "waist to hip", "waist-to-hip", or "body fat"; (3) "China" or "Chinese"; and (4) "child", "children", "childhood", "juvenile", "pubescent", "pubertal", "puberty", "adolescent", "adolescents", "adolescence", "youth", "teen", "teens", "teenage", "teen-age", "teenaged", "teen-aged", "teenager", "teenagers", "teen-ager", "teen-agers", "kid", "kids", "youngster", "youngsters", "minor", "minors", "student", "students", "preschooler", or "preschoolers". The MeSH terms "environment design", "exercise", "overweight", "obesity", "child", "adolescent", "China", and "Chinese" were included in the PubMed search. All keywords in PubMed were searched with the "[All fields]" tag, which are processed using Automatic Term Mapping.[27] The search function TS = Topic was used in Web of Science, which launches a search for topic terms in the fields of title, abstract, keywords, and Keywords Plus®.[28] Titles and abstracts of the articles identified through the keywords search were screened against the study selection criteria. Potentially relevant articles were retrieved for evaluation of the full text. Two coauthors of this review (JS and QY) independently conducted title and abstract screening and identified potentially relevant articles. Inter rater agreement was assessed using the Cohen's kappa ($\kappa = 0.74$). Discrepancies were resolved through discussion with a third coauthor (RA).

A reference list search (i.e., backward reference search) and a cited reference search (i.e., forward reference search) were conducted based on the full-text articles meeting the study selection criteria that were identified from the keyword search. Articles identified from the backward and forward reference searches were further screened and evaluated using the same study selection criteria. The reference search was repeated on newly identified articles until no additional relevant articles were found.

2.3. Data extraction and preparation

A standardized data extraction form was used to collect the following methodologic and outcome variables from each article included authors, publication year, country, study design, sample size, age range, proportion of female participants, sample characteristics, statistical model, nonresponse rate, geographical coverage, setting, type of built environment measure, detailed measure of built environment, type of PA measure, detailed measure of PA, type of body weight status measure, detailed measure of body weight status, estimated effects of built environment on PA or body weight status, and key findings on the relationship between built environment and PA or body weight status.

2.4. Data synthesis

A tabulation of extracted data by 2 coauthors of this review (YY and RA) revealed that no studies used the same measures for built environment, PA, and body weight to provide quantitative estimates for the impact of neighborhood built environment on PA and/or body weight status. This finding precluded a meta-analysis. Therefore, in this article we have summarized the common themes and findings of the included studies narratively. The data extraction, theme identification, and narrative summarization were independently conducted by 2 coauthors of this review (JS and QY). Discrepancies were resolved through discussion with a third coauthor (RA).

2.5. Study quality assessment

We used the National Institutes of Health's Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies to assess the quality of each included study.[29] This assessment tool rates each study based on 14 criteria (Table 1). For each criterion, a score of 1 was assigned if "yes" was the response, whereas a score of 0 was assigned otherwise (i.e., if an answer of "no", "not applicable", "not reported", or "cannot determine" resulted). A study-specific global score ranging from 0 to 14 was calculated by summing the scores across all criteria. The study quality assessment helped measure the strength of scientific evidence but was not used to determine the inclusion of studies. Two coauthors of this review (JS and QY) independently conducted the study quality assessment, with discrepancies resolved through discussion with a third coauthor (RA).

3. Results

3.1. Identification of studies

Fig. 1 shows the study selection flowchart. We identified 8286 articles total through the keywords and references search. After removing duplications, 7922 unique articles underwent title and abstract screening, after which 7879 articles were

Table 1
Study quality assessment.

Criterion	Study ID																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1. Was the research question or objective in this paper clearly stated?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
2. Was the study population clearly specified and defined?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
3. Was the participation rate of eligible persons ≥50%?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
4. Were all the subjects selected or recruited from the same or similar populations (including the same time period)? Were inclusion and exclusion criteria for being in the study prespecified and applied uniformly to all participants?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
5. Was a sample size justification, power description, or variance and effect estimates provided?	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
6. For the analyses in this paper, were the exposure(s) of interest measured before the outcome(s) being measured?	N	N	N	N	N	Y	N	N	N	N	N	Y	N	N	N	N	N	N	N	Y
7. Was the timeframe sufficient so that one could reasonably expect to see an association between exposure and outcome if it existed?	N	N	N	N	N	Y	N	N	N	N	N	Y	N	N	N	N	N	N	N	Y
8. For exposures that can vary in amount or level, did the study examine different levels of the exposure as related to the outcome (e.g., categories of exposure, or exposure measured as continuous variable)?	N	N	N	Y	Y	N	N	N	N	N	N	Y	Y	Y	Y	Y	N	Y	Y	Y
9. Were the exposure measures (independent variables) clearly defined, valid, reliable, and implemented consistently across all study participants?	N	N	N	Y	Y	N	Y	N	N	N	N	N	N	Y	N	Y	N	Y	N	N
10. Was the exposure(s) assessed more than once over time?	N	N	N	N	N	Y	N	N	N	Y	N	Y	N	N	N	N	N	N	N	Y
11. Were the outcome measures (dependent variables) clearly defined, valid, reliable, and implemented consistently across all study participants?	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	Y	Y	N	N	N
12. Were the outcome assessors blinded to the exposure status of participants?	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
13. Was loss to follow-up after baseline ≤20%?	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	N
14. Were key potential confounding variables measured and adjusted statistically for their impact on the relationship between exposure(s) and outcome(s)?	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	N	Y	Y	N	Y	N
Total score	7	6	6	8	8	8	7	6	5	7	6	9	7	8	6	9	7	7	7	8

Notes: This study quality assessment tool was adopted from the National Institutes of Health's Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies.[28] For each criterion, a score of 1 was assigned if "yes" was the response, whereas a score of 0 was assigned otherwise. A study-specific global score, ranging from 0 to 14, was calculated by summing up scores across all 14 criteria. Study quality assessment helped measure strength of scientific evidence, but was not used to determine whether a study was included in the review.
Abbreviations: N = no; Y = yes.

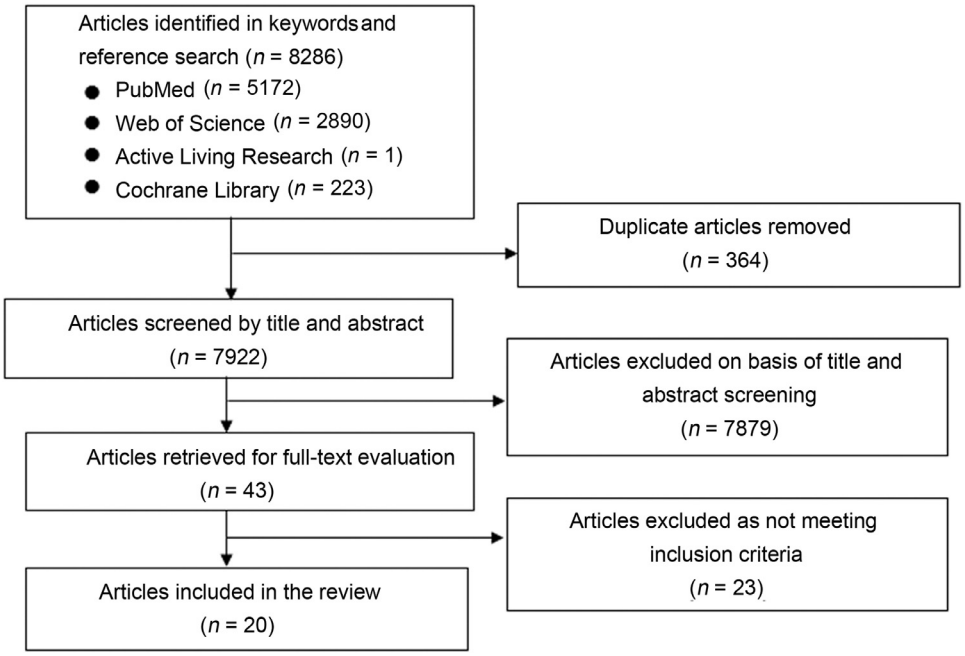

Fig. 1. Study selection flowchart.

excluded. The full texts of the remaining 43 articles were reviewed against the study selection criteria. Of these, 23 articles were excluded. The primary reasons for exclusion were lack of neighborhood environment measures, no outcome reported on PA and childhood obesity, and adult sample instead of children and/or adolescents. The remaining 20 studies that examined the relationship between built environment and children's PA and/or body weight status were included in our review.[30–49]

3.2. *Basic characteristics of the included studies*

Table 2 summarizes the basic characteristics of the 20 included studies. A total of 5 studies were conducted in Hong Kong, China, and the remaining studies were conducted in the Mainland of China. All included studies were published in or after 2006 — 1 each in 2006, 2008, 2009, 2011, 2012, and 2016; 2 each in 2010 and 2015; 4 in 2017; and 6 in 2014. A total of 14 studies exclusively focused on PA, 2 studies exclusively focused on body weight status, and the remaining 4 studies examined both PA and body weight status. A single study adopted a qualitative study design, 3 adopted a longitudinal study design, and the remaining 16 studies adopted a cross-sectional study design. Sample sizes were generally large but varied substantially across studies. A total of 4 studies had a sample size between 20 and 99; 5 had a sample size between 100 and 999; 9 had a sample size between 1000 and 9999; and the remaining 2 studies had a sample size of >10,000. The mean and median sample sizes were 7498 and 1359, respectively, with a standard deviation of 18,545 and a range from 20 to 80,928. The majority of studies ($n = 12$) recruited adolescents aged 11–17 years, 4 recruited children aged 6–10 years, and the remaining 4 recruited both children and adolescents. All included studies recruited both girls and boys, with the 2 sexes largely equally distributed in the samples. A variety of statistical models were applied across studies, including generalized estimating equation, logistic regression, hierarchical logistic regression, mixed-effects logistic regression, ordinal logistic regression, generalized linear model, hierarchical linear regression, multilevel Poisson regression, and multilevel path modeling. The majority of studies ($n = 15$) adjusted for some individual sociodemographics in the statistical analysis. A total of 9 studies adjusted for certain environment and/or PA characteristics (e.g., greenspace and sedentary behavior) in the statistical analysis.

Table 3 summarizes the measures for built environment, PA, and body weight status used in the included studies. The majority ($n = 13$) of the studies adopted subjective built environment measures reported by parents and/or the children themselves, 2 studies adopted objective built environment measures, and 5 studies used both objective and subjective built environment measures. Specific measures of the built environment varied substantially across studies. Parent- and/or self-reported subjective built environment measures included both general questions (e.g., "Whether or not you have sports facilities in your neighborhood?" or "How long does it take to walk to the nearest exercise facility?") and more specific questions pertaining to the built environment (e.g., accessibility and availability of sports/recreational facilities, greenspace, parks, playgrounds, and video game shops, as well as questions about neighborhood aesthetics and attractive natural sights in the neighborhood). Among the subjective built environment measures, only 2 studies used measures known to be validated in previous research (e.g., the Neighborhood Environment Walkability Scale).[39,40] Objective built environment measures (e.g., population density, road density, street intersection density, and distance to nearest park and/or recreational facility) were constructed based on geographical

Table 2
Basic characteristics of the studies included in the review.

Study ID	First author (year)	Region	Study design	Sample size	Age (year)	Female (%)	Sample characteristics	Statistical model	Nonresponse rate (%)	Geographical coverage	Setting
1	Li et al. (2006)[30]	The Mainland of China	Cross-sectional	1787	11−17	49.8	Junior high school students	Hierarchical logistic regression	0.9	Household, school and community in a city	Urban
2	Li et al. (2008)[31]	The Mainland of China	Cross-sectional	1792	11−17	49.8	Junior high school students	Hierarchical logistic regression	0.7	Household, school and community in a city	Urban, suburban, and rural
3	Wong et al. (2010)[32]	Hong Kong, China	Cross-sectional	29,139	Boys: 14.5 ± 0.1 Girls: 14.6 ± 0.1	56.0	Grades 7−13 students	Logistic regression	15.3	Home and neighborhood in a city	Urban
4	Xu et al. (2010)[33]	The Mainland of China	Cross-sectional	2375	13−15	53.8	Grades 7−9 junior high school students	Mixed effects logistic regression	10.7	Residential density and green space in a city	Urban
5	Xu et al. (2010)[34]	The Mainland of China	Cross-sectional	2375	13−15	53.8	Grades 7−9 junior high school students	Mixed effects logistic regression	10.7	Residential density in a city	Urban
6	Cui et al. (2011)[35]	The Mainland of China	Longitudinal	6935	6−18	Urban: 49.0 Rural: 46.0	Children and adolescents	Generalized estimating equations	3.9	Household and community in 9 provinces	Urban and rural
7	Huang et al. (2013)[36]	Hong Kong, China	Cross-sectional	280	Boys: 11.1 ± 0.9 Girls: 11.2 ± 0.9	52.8	Grades 4−6 primary school students	Hierarchical linear regression	7.6	Home and neighborhood in a city	Urban
8	An et al. (2014)[37]	The Mainland of China	Cross-sectional	487	<18	51.4	Residents	Multivariate regression	NA	Home proximity to an exercise facility in 10 provinces	Urban and rural
9	He et al. (2014)[38]	Hong Kong, China	Qualitative	34	10−11	50.0	Grades 5−6 primary school students	NA	NA	Household and neighborhood in a city	Urban and rural
10	Jia et al. (2014)[39]	The Mainland of China	Cross-sectional	1528	15−19	50.8	Community residents	Logistic regression	15.1	Community and park in a city	Suburban
11	Li et al. (2014)[40]	The Mainland of China	Cross-sectional	497	8−10	48.3	Grade 3 primary school-aged students	Logistic regression	10.3	Family and neighborhood in 2 cities	Urban
12	Wong et al. (2014)[41]	Hong Kong, China	Longitudinal	9993	14.0 ± 1.7	63.2	Grades 7−12 secondary school students	Generalized linear model	22.7	Neighborhood in a city	Urban
13	Guo et al. (2014)[42]	The Mainland of China	Cross-sectional	463	<18	51.2	Permanent residents	Logistic regression	21.5	Community in 10 provinces	Urban and rural
14	Liu et al. (2015)[43]	The Mainland of China	Cross-sectional	29	11−20	51.6	Community residents	Hierarchical linear regression	32.9	Community and park in a city	Urban and suburban

(*continued on next page*)

Table 2 (Continued).

Study ID	First author (year)	Region	Study design	Sample size	Age (year)	Female (%)	Sample characteristics	Statistical model	Nonresponse rate (%)	Geographical coverage	Setting
15	Zhang et al. (2015)[44]	The Mainland of China	Cross-sectional	75	15–20	53.0	Permanent residents	Ordinal logistic regression	58.3	Green space in a city	Urban and suburban
16	Wong et al. (2016)[45]	Hong Kong, China	Cross-sectional	1189	8–12	46.0	Grades 3–5 primary school students	Generalized linear mixed model	6.0	Home and neighborhood in a city	Urban
17	Gomes et al. (2017)[46]	The Mainland of China	Cross-sectional	552	9–11	46.9	School students	Multilevel Poisson model	6.7	School in a city	Urban
18	Liu et al. (2017)[47]	The Mainland of China	Cross-sectional	20	11–20	51.5	Community residents	Hierarchical linear regression	61.5	Community and park in a city	Urban and suburban
19	Wang et al. (2017)[48]	The Mainland of China	Cross-sectional	80,928	13.71 ± 2.94	50.9	Grades 4–12 school-aged students	Multilevel path modeling	32.9	School and community nationwide	Urban and rural
20	Yang et al. (2017)[49]	The Mainland of China	Longitudinal	9487	6–17	47.1	School-age students	Logistic regression	NA	School and community nationwide	Urban, suburban, and rural

Abbreviation: NA = not applicable.

information systems, whereas other built environment measures such as walking paths, playgrounds, jogging/cycling lanes, transportation, schools, and parks were tabulated in field observations by trained observers in the community under study.

PA behaviors measured in the studies included PA ($n = 13$), physical inactivity ($n = 2$), sedentary behavior ($n = 2$), active/passive commuting from/to school ($n = 2$), and park visits ($n = 1$). Most studies ($n = 17$) measured PA levels using questionnaires administered to parents and/or children, whereas 1 study adopted an objective measure by having participants wear an accelerometer, 1 study adopted an objective measure through both a parent-reported questionnaire and participant use of a wearable accelerometer, and 1 study collected qualitative data from a focus group of children. Parent- and/or self-reported PA questionnaires included both standardized questionnaires (e.g., the International Physical Activity Questionnaire (IPAQ)) and general questions (e.g., "How often do you do exercises continuously for at least 30 min?"). Among the studies that adopted subjective PA measures, 8 used measures known to be validated in previous researches (i.e., the Adolescent Physical Activity Recall Questionnaire, Physical Activity Questionnaire for Children, IPAQ, IPAQ Short Form, and Godin Exercise Leisure-time Questionnaire). A total of 18 studies included body weight status measured as body mass index ($n = 12$), overweight ($n = 4$), and obesity ($n = 2$). Body mass index (BMI)-related measures were based on both objectively measured ($n = 7$) and self-reported ($n = 5$) height and weight.

3.3. Key findings

Table 4 summarizes the estimated effects of built environment on PA and/or body weight status among Chinese children and adolescents. Among the 16 studies that provided some quantitative estimates of the relationship between built environment measures and PA, all of them reported a statistically significant relationship in the expected direction. A lack of recreational facilities in a community was found to be positively associated with physical inactivity among local children.[30] In contrast, perceived availability of sport facilities in a neighborhood was positively associated with leisure time overall PA level[32,41] as well as moderate-to-vigorous PA level.[36,48] Commuting time to the nearest sport facility played an essential role in PA engagement. Longer commuting time was found to be negatively associated with the likelihood of meeting the PA recommendation[42] and using walking paths.[39] In contrast, children living within a 10-min walking distance and/or 500 m of an exercise facility tended to engage in more leisure-time PA.[37,47]

In addition to exercise facilities, other environmental characteristics were found to be associated with PA. For instance, adolescents living in residential neighborhoods without sidewalks or without vacant fields were 30% and 70% more likely to be physically inactive, respectively.[30] The proportion of residential greenspace was found to be negatively correlated with monthly park visits.[43] Adolescents living in a neighborhood with a higher residential density were more likely to spend

Table 3
Measures of built environment, PA, and body weight status in the studies included in the review.

Study ID	First author (year)	Type of built environment measure	Detailed measure of built environment	Type of PA measure	Detailed measure of PA	Type of body weight status measure	Detailed measure of body weight status
1	Li et al. (2006)[30]	Self-report questionnaire	1. Recreational facilities in the community 2. Places around the home for children to play 3. Transportation 4. Urbanicity 5. Sidewalks around house 6. Video game shops around house	Self-report questionnaire	1. Intensity of PA 2. Duration of PA 3. Physical inactivity	Objective measure	1. Height 2. Weight 3. BMI
2	Li et al. (2008)[31]	Self-report questionnaire	Houses with bike lanes nearby	Self-report questionnaire (Adolescents Physical Activity Recall Questionnaire)	Sedentary time 1. Watching TV 2. Playing computer games or video games 3. Doing homework after school 4. Listening to music 5. Other sedentary habits	Objective measure	1. Height 2. Weight 3. BMI
3	Wong et al. (2010)[32]	Self-report questionnaire	1. Sport grounds 2. Cycling/jogging lanes 3. Table tennis courts 4. Swimming pools accessibility	Self-report questionnaire	The frequency of participation in moderate-to-vigorous nonschool leisure-time PA	Self-report	1. Height 2. Weight 3. BMI
4	Xu et al. (2010)[33]	Objective measure	Residential density	Self-report questionnaire	1. Time spent in recreational PA 2. Sedentary behavior time	Self-report	1. Height 2. Weight 3. BMI
5	Xu et al. (2010)[34]	Objective measure	Residential density	Self-report questionnaire	1. Time spent in recreational PA 2. Sedentary behavior time	Self-report	1. Weight 2. Height 3. BMI
6	Cui et al. (2011)[35]	Self-report questionnaire	1. Schools in the local community 2. Bus stops in the neighborhood	Self-report questionnaire	Commuting type 1. Walking 2. Bicycle use 3. Motorized transportation		
7	Huang et al. (2013)[36]	Self-report questionnaire Objective measure	1. Sports facilities in the neighborhood (self-report questionnaire) 2. Population density of residence districts (objective measure)	1. Self-report questionnaire (Children's Leisure Activities Study Survey, Chinese version) 2. Parent-report questionnaire	1. Time spent in physical activities (self-report questionnaire) 2. Time spent in screen-based behaviors (parent-report questionnaire)	Objective measure	1. Height 2. Weight 3. BMI
8	An et al. (2014)[37]	Self-report questionnaire	Walking distance to the nearest exercise facility	Self-report questionnaire	Leisure-time PA		
9	He et al. (2014)[38]	Focus group of children	Neighborhood environment	Focus group of children	1. All body movements including exercise 2. Lifestyle activities		
10	Jia et al. (2014)[39]	Observation self-report questionnaire	1. Walking paths in the community and park (observation) 2. Accessibility to services (questionnaire) 3. Neighborhood surroundings/aesthetics (questionnaire)	Self-report questionnaire (IPAQ)	1. Time spent in PA 2. Time spent sitting	Self-report	1. Height 2. Weight

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Table 3 (Continued).

Study ID	First author (year)	Type of built environment measure	Detailed measure of built environment	Type of PA measure	Detailed measure of PA	Type of body weight status measure	Detailed measure of body weight status
11	Li et al. (2014)[40]	Parent-report questionnaire	Walkability of the neighborhood environment	Parent-report questionnaire (Godin leisure-time exercise questionnaire)	1. Sedentary 2. Light, moderate, and vigorous activities	Objective measure	1. Height 2. Weight 3. BMI
12	Wong et al. (2014)[41]	Self-report questionnaire	1. Sport facility accessibility 2. Sport facility availability	Self-report questionnaire	Frequency of moderate-to-vigorous leisure-time PA	Self-report	1. Weight 2. Height 3. BMI
13	Guo et al. (2014)[42]	Self-report questionnaire	Sport facility proximity	Self-report questionnaire	Frequency of moderate or vigorous PA		
14	Liu et al. (2015)[43]	Self-report questionnaire Objective measure (Internet and Gaode map)	1. Proportion of residential greenspace (objective measure) 2. Park accessibility (self-report questionnaire and objective measure)	Self-report questionnaire	Park visitation		
15	Zhang et al. (2015)[44]	Self-report questionnaire	1. Quality vegetation 2. Time to park 3. Availability and accessibility of urban greenspaces	Self-report questionnaire	Use of urban greenspaces for physical activities		
16	Wong et al. (2016)[45]	Objective measure (Geographic Information System) Parent-report questionnaire	1. Accessibility of facilities 2. Availability of sports facilities 3. Attractive natural sights 4. Local destinations 5. Road density 6. Street intersections	1. Objective measure (accelerometers) 2. Parent-report questionnaire	MVPA	Objective measure	1. Height 2. Weight
17	Gomes et al. (2017)[46]	Self-report questionnaire	1. Access to school facilities 2. Indoor and outdoor facilities 3. Playground and sport equipment	Objective measure (accelerometers)	Time spent in MVPA	Objective measure	1. Standing height 2. Sitting height 3. Weight 4. BMI
18	Liu et al. (2017)[47]	Self-report questionnaire Objective measure (Gaode map)	1. Park accessibility 2. Proportion of residential greenspace 3. Perceived quality of the nearest park	Self-report questionnaire (IPAQ)	1. Time spent being physically active 2. Vigorous-intensity activity 3. Moderate-intensity activity 4. Walking activity 5. Sitting		
19	Wang et al. (2017)[48]	Self-report questionnaire	1. Access to PA facilities 2. Availability of sports clubs and organizations	Self-report questionnaire (IPAQ)	1. Time spent sitting 2. Walking 3. Moderate-intensity and vigorous-intensity activities	Objective measure	1. Height 2. Weight 3. BMI
20	Yang et al. (2017)[49]	Self-report questionnaire	Distance to school	Self-report questionnaire	1. Active travel to school 2. PA		

Abbreviations: BMI = body mass index; IPAQ = International Physical Activity Questionnaire; MVPA = moderate-to-vigorous physical activity; PA = physical activity.

Table 4
Estimated effects of built environment on PA and body weight status in the studies included in the review.

Study ID	First author (year)	Estimated effects of built environment		Main findings of study	
		PA	Body weight status	PA	Body weight status
1	Li et al. (2006)[30]	1. The access to public facilities (OR = 1.4, 95%CI: 1.0−1.9 for moderate and OR = 1.7, 95%CI: 1.2−2.4 for difficult) were positively associated with inactivity. 2. Adolescents living in a neighborhood without sidewalks were 1.3 times more likely to be inactive (OR = 1.3, 95%CI: 1.0−1.6). 3. Adolescent boys living in surroundings without vacant fields were 1.7 times (95%CI: 1.2−2.5) more likely to be inactive. 4. Unavailability of video game shops near their home was associated with inactivity in boys by 50% (OR = 1.5, 95%CI: 1.1−2.1).		1. Lack of sidewalks and facilities in the community were significantly associated with physical inactivity. 2. Having video game shops in the community was associated with increased PA in boys.	
2	Li et al. (2008)[31]		1. The risk of overweight and obesity in adolescents was associated with place of residence. In comparison with those living in a rural area, adolescents in suburban areas (OR = 2.5, 95%CI: 1.8−3.4) or urban areas (OR = 4.0, 95%CI: 2.7−6.0) had greater risks of being overweight/obese. 2. Boys living in houses without bike lanes nearby were 1.6 times (95%CI: 1.04−2.40) more likely to be overweight and obese.		In urban and suburban areas, adolescents were more likely to be overweight or obese.
3	Wong et al. (2010)[32]	1. Perceived availability of sport facilities was positively (OR_{boys} = 1.17, OR_{girls} = 1.26) associated with being sufficiently active. 2. A significant interaction effect of perceived availability of neighborhood sport facilities and video game console on the odds of being physically active was found (p = 0.046 for boys and p = 0.049 for girls). 3. Perceived availability of sport facilities in the neighborhood was positively associated with the odds of being physically active only in the absence of video game consoles in the home (OR_{boys} = 1.26, 95%CI: 1.10−1.46, p = 0.001; OR_{girls} = 1.34, 95%CI: 1.15−1.56, $p < 0.001$). 4. No significant associations were found between perceived availability of sport facilities and being physically active in the presence of video game console (OR_{boys} =		1. Perceived availability of sport facilities in the neighborhood may have a positive impact on adolescents' level of PA. 2. Having a computer/Internet may cancel out the effects of active opportunities in the neighborhood.	

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Table 4 (Continued).

Study ID	First author (year)	Estimated effects of built environment		Main findings of study	
		PA	Body weight status	PA	Body weight status
		1.01, 95%CI: 0.84−1.21, $p = 0.94$; OR_{girls} = 1.06, 95%CI: 0.81−1.41, $p = 0.63$).			
4	Xu et al. (2010)[33]	1. Compared with students from the lower residential density tertile, students in the higher and middle residential tertile had lower odds (OR = 0.64, 95%CI: 0.42−0.97; OR = 0.83, 95%CI: 0.59−1.18, respectively) of being in the higher PA category, after adjusting for potential confounding variables including sedentary behavior time and greenspace. 2. Students in the higher residential density tertile spent significantly less time on PA but more time on sedentary behaviors ($p < 0.01$).		There may be a negative association between population density and recreational PA for adolescents in a rapidly expanding urban area of China.	Students in the higher residential population density tertile were also more likely to be overweight compared with their counterparts in the low population density areas.
5	Xu et al. (2010)[34]		Students in the higher and middle tertiles of residential density had a 1.87-fold (95%CI: 1.23−2.85) and 1.71-fold (95%CI: 1.12−2.61) higher likelihood of being overweight, respectively, compared with those in the lower tertile.	Students in the higher residential density tertile spent significantly less time on PA and more time on sedentary behaviors than their counterparts in the lowest residential density areas.	Residential density was positively associated with overweight among urban Chinese adolescents.
6	Cui et al. (2011)[35]	1. In urban areas, after adjusting for other cofactors, children whose school was not in the community, were nearly twice (aOR = 1.94, 95%CI: 1.42−2.66) as likely to passively commute as were children whose school was in the local community. 2. In rural areas, children whose school was not in the community were nearly 4 times more likely (aOR = 3.73, 95%CI: 2.81−4.96) to passively commute to school than were children whose school was in the community.		Children whose school was not in the local community were more likely to commute passively.	
7	Huang et al. (2013)[36]	1. For girls, positive associations with MVPA were found in sports facilities in the neighborhood in the univariable analyses ($\beta = 0.37$, 95%CI: 0.01−0.73, $p < 0.05$). 2. For boys, higher density was associated with higher TV viewing time in the crude model ($\beta = 1.02$, 95%CI: −0.05 to 2.10, $p < 0.1$), density was positively associated with Internet use and e-games playing in hierarchical model ($\beta = 1.16$, 95%CI: 0.24−2.08, $p < 0.05$).		1. There were no significant associations between neighborhood environmental variables and children's PA. 2. Boys living in a neighborhood with higher population density reported more time using the Internet and playing e-games.	

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Table 4 (Continued).

Study ID	First author (year)	Estimated effects of built environment		Main findings of study	
		PA	Body weight status	PA	Body weight status
8	An et al. (2014)[37]	Compared with those living further away, individuals within 10-min walking distance to an exercise facility were 6.79% (95%CI: 3.67−10.01) more likely to have some leisure-time PA.		Proximity to an exercise facility was found to be positively associated with leisure time PA.	
9	He et al. (2014)[38]			Factors perceived as PA facilitators included sufficient lighting, bridge or tunnel, convenient transportation, subway station, recreation grounds, shopping malls with air conditioning, and perfume shops. Factors perceived as PA barriers included hard to find toilets in shopping malls and too many people in recreation grounds.	
10	Jia et al. (2014)[39]	1. Roads and aesthetics scores were significantly positively correlated with walking path use (OR = 1.044, 95%CI: 1.017−1.072). 2. Participants who reported the distance from neighborhood to a park >1 km were less likely to use the walking paths (OR = 0.703, 95%CI: 0.530−0.933). 3. In males, the roads and aesthetics scores were positively and significantly correlated with walking path use (OR = 1.078, 95%CI: 1.036−1.123).		Those who reported a distance to a park <1 km and those who perceived better roads and aesthetics were more likely to have used walking paths.	
11	Li et al. (2014)[40]		There was a relationship between land-use-mix access and childhood overweight (OR = 1.22, 95%CI: 0.85−1.75, $p > 0.05$).		No evidence was found for associations between perceived neighborhood environmental characteristics and children's weight status and obesogenic behaviors in this study.
12	Wong et al. (2014)[41]	Increased perceived availability of sport facilities from baseline to follow-up predicted more leisure-time PA at follow-up ($\beta = 1.029$, 95%CI: 1.011−1.047, $p < 0.01$) overall. This effect was modified by baseline PA, with a significant effect observed only among those who had engaged in leisure-time PA >3 times a week ($\beta = 1.068$, 95%CI: 1.022−1.116, $p < 0.01$).		Increasing awareness of neighborhood sport facilities or building more such facilities may help active adolescents to maintain or increase their leisure-time PA.	No significant interactions of sex, school grade, and weight status were found with the perceived availability of neighborhood sport facilities.
13	Guo et al. (2014)[42]	Participants who spent ≥30 min in commuting time to the nearest sport facility had 80% odds (OR = 0.80, 95%CI: 0.65−0.98) of meeting the PA recommendation compared with those who spent <10 min. For every 10-min increment in commuting time, the		An inverse association between the commuting time to the nearest sport facility and the likelihood of meeting the PA recommendation was found.	

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Table 4 (Continued).

Study ID	First author (year)	Estimated effects of built environment		Main findings of study	
		PA	Body weight status	PA	Body weight status
		odds were decreased by 6% (OR = 0.94, 95%CI: 0.88−0.99).			
14	Liu et al. (2015)[43]	Associations and relative importance of proportion of residential greenspace on citizens' park visitation ($\beta = -0.17$, $p = 0.010$), shortest road distance to nearest park on citizens' park visitation ($\beta = -0.12$, $p = 0.020$), walking time to nearest park on citizens' park visitation ($\beta = -0.11$, $p = 0.010$).		The proportion of residential greenspace, walking time to the nearest park, and distance grade (with the grade increasing with the distance of the shortest route between the residence and the nearest park) were negatively correlated with monthly park visitation.	
15	Zhang et al. (2015)[44]	1. The less time to reach a park, the higher the satisfaction level of use of urban greenspace for PA ($\beta = -0.42$, SE = 0.07). 2. The more availability of greenspaces and parks, the higher the satisfaction level ($\beta = 0.19$, SE = 0.09). 3. The higher the quality of the vegetation, the higher the satisfaction level ($\beta = 1.49$, SE = 0.09).		Quality of vegetation, accessibility of greenspaces, and availability of greenspaces and parks significantly affected the residents' satisfaction levels and use of urban greenspaces for PA.	
16	Wong et al. (2016)[45]	Attractive natural sights in the neighborhood were associated with objectively assessed %MVPA (coefficient = 0.101, SE = 0.042).	1. Children living in a neighborhood farther away from a park and with fewer trees were more likely to be obese. ($\beta = 0.863$, 95%CI: 0.210 to −1.517; $\beta = -0.345$, 95%CI: −0.655 to −0.035). 2. The influence of neighborhood variables seemed to exist only for children with less educated parents.	Children living in a neighborhood with more attractive buildings or natural sights spent more time in PA.	1. The aesthetics of the neighborhood environment (presence of trees) were related to a reduced risk of being obese. 2. The likelihood of being obese was positively associated with nearest distance to a park in the neighborhood, but only in children with parents who had completed a secondary education.
17	Gomes et al. (2017)[46]	Children with access to a gymnasium outside the school hours complied more with the MVPA guidelines (RR = 1.14).		The availability of a school gymnasium outside of school hours was positively associated with children's MVPA compliance.	
18	Liu et al. (2017)[47]	The number of parks within 500 m was associated with PA ($\beta = 1.2$, St. $\beta = 0.1$, $p = 0.046$).		Park accessibility was significantly and positively correlated with residents' PA.	
19	Wang et al. (2017)[48]	Children who reported high scores on availability of sports clubs and organizations ($\beta = 4.489$, $p < 0.001$) and convenient access to PA facilities ($\beta = 5.278$, $p < 0.001$) were significantly more likely to report high levels of MVPA.		Children's perceptions of availability of clubs and organizations and convenient access to PA facilities were associated with a high level of participation in MVPA	

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Table 4 (Continued).

Study ID	First author (year)	Estimated effects of built environment		Main findings of study	
		PA	Body weight status	PA	Body weight status
20	Yang et al. (2017)[49]	Distance to school was strongly associated with ATS with a dose-response relationship and statistical significance ($p < 0.001$). Compared with children who lived >2 miles away from school, those who lived the closest (<0.5 miles), the second closest (0.5–1.0 mile), and the third closest (1–2 miles) were 41, 26, and 8 times as likely to engage in ATS, respectively (OR = 40.6, 95%CI: 24.7–67.0; OR = 26.0, 95%CI: 18.6–36.4, and OR = 8.10, 95%CI: 6.33–10.40).		1. The decrease of ATS was concurrent with the increase of children living a farther distance from school. 2. Children who were living in a metropolitan area were less likely to report ATS.	

Abbreviations: aOR = adjusted odds ratio; ATS = active travel to and from school; CI = confidence interval; OR = odds ratio; MVPA = moderate-to-vigorous physical activity; PA = physical activity; RR = risk ratio; SE = standard error.

less time on PA and more time on sedentary behaviors such as television viewing.[33,36] Among the 3 studies that estimated the longitudinal relationship between the built environment and body weight status, 2 reported a statistically significant association, whereas the remaining study reported no association. Boys living in places lacking bike lanes were 60% more likely to be overweight or obese.[31] Adolescents living in a higher residential density area were 87% more likely to be overweight.[34] In contrast, no association was found between neighborhood mixed land use and childhood overweight.[40]

3.4. Study quality assessment

Table 1 reports criterion-specific and global ratings from the study quality assessment. The included studies on average scored 7 out of 14 (range: 5–9). All studies included in the review clearly stated the research question/objective, specified and defined the study population, had a participation rate of ≥50%, recruited participants from the same or similar populations during the same time period, and prespecified and uniformly applied inclusion and exclusion criteria to all potential participants. Most studies measured and statistically adjusted key potential confounding variables for their impact on the relationship between exposures and outcomes ($n = 16$), had an attrition rate of ≤20% ($n = 17$), and examined different levels of the exposure in relation to the outcome ($n = 10$). In contrast, none of the studies had the outcome assessors blinded to the exposure status of the participants. Only 1 study provided a sample size justification using power analysis. Exposures of interest (e.g., built environment and other environment characteristics) before the outcomes were measured in 3 studies. A total of 3 studies had a reasonably long follow-up period that was sufficient for changes in outcomes to be observed, 4 studies assessed the exposures more than once during the study period, and 6 studies implemented valid and reliable exposure measures.

4. Discussion

This analysis systematically reviewed scientific evidence regarding the influence of neighborhood built environment on PA and body weight status among Chinese children and adolescents. A total of 20 studies, including 16 cross-sectional, 3 longitudinal, and 1 descriptive, met the selection criteria and were included in this review. A total of 13 studies adopted subjective built environment measures reported by parents and/or children, 2 adopted objective measures (e.g., geographical information systems, field observations), and 5 adopted both objective and subjective measures. PA behaviors included PA, physical inactivity, sedentary behavior, active/passive commuting from/to school, and park visits. Body weight status included BMI overweight, and obesity. The 16 studies that provided some quantitative estimates of the influence of built environment on PA and body weight status all reported a statistically significant relationship in the expected direction.

Findings from this review confirmed the documented relationship between neighborhood built environment and PA among children and adults in developed countries. For

example, Reed and Phillips[50] reported increased duration and intensity of PA among American college students residing close to exercise facilities. Jilcott et al.[51] found that perceived distance to gyms was negatively associated with PA among low-income, middle-aged women in the United States. Hanibuchi et al.[52] documented that proximity to parks or greenspaces was positively associated with PA frequency among older Japanese adults. Edwards et al.[53] reported that proximity to parks and beaches was positively associated with use of those environments for PA among Australian adolescents. Findings from this review add a data point to the literature on the importance of designing new physical environments and/or modifying existing environments in a way that promotes an active lifestyle for children and adolescents in China.

Childhood obesity in China has reached an alarmingly high level. It has become critical that interventions be designed to target the root causes of obesity and its risk factors. Physical inactivity is a major modifiable risk factor for childhood obesity.[54] A majority of children and adolescents in China fail to meet the recommended guidelines for PA levels.[55–57] Although the traditional perspective mainly blamed individuals themselves for their sedentary lifestyles, increasing attention has now shifted to the environmental determinants of health behavior, in particular, how neighborhood built environments may impact local residents' engagement with PA. Two systematic reviews have investigated the associations between various built environment attributes and childhood obesity.[56,58] Neighborhood features such as walkability, bikeability, and proximity to parks and recreational facilities were found to be associated with increased PA and active commuting. Interventions providing safe, walkable neighborhood with access to necessary destinations have been recommended in an effort to combat the epidemic of childhood obesity. A recent study reviewed the built environmental correlates of PA in China and documented a positive association between PA and proximal nonresidential locations, pedestrian infrastructure, aesthetics, and recreational facilities, as well as a negative association between PA and living in an urban setting.[26] Findings from that review are largely consistent with ours, except that our review focused more on the built environment as it pertained to locations for children's daily activities (e.g., parks, greenspaces, and recreational facilities), whereas the afore mentioned review, which predominantly examined PA among Chinese adults aged ≥18 years, focused more on work-related built environments PA (e.g., transportation systems and proximity to the workplace).[26] Our review adds to the scientific evidence by systematically identifying and synthesizing literature regarding the impact of neighborhood environments on child and adolescent populations in China.

Improving the availability of local exercise facilities in communities has become a national policy, as highlighted in China's 13th Five-Year Plan (2016–2020) for the Sport Industry.[59] The plan includes building new exercise facilities (e.g., community fitness centers, parks, roadside open spaces with exercise equipments) and enhances the accessibility of existing facilities (e.g., extending the operating hours of school gyms/playgrounds and opening them to the public). Findings from this review suggest that these policy-level interventions can enhance PA engagement among Chinese children and adolescents. In the meantime, urban designs that incorporate sidewalks, bike lanes, and walking paths, reduce motorized traffic, and encourage lower population densities are likely to promote PA and prevent childhood obesity in China.

A few limitations pertaining to this review and the studies it includes should be noted. All studies adopted an observational study design. The absence of experimental designs prevents a causal interpretation regarding the impact of neighborhood built environment on PA and body weight status; therefore, the estimated relationships are correlational in nature. In addition, only 3 of the 20 studies included in this review adopted a longitudinal study design, which is necessary to examine the change in PA or body weight in response to changes in built environment. No studies included in this review reported quantitative estimates focusing on the same built environments, physical activities, and body weight measures, which presented a situation that precluded meta-analysis. The literature search identified articles written in English only and excluded articles written in Chinese and other languages. This decision was made in part owing to concerns about potential discrepancies in study quality, as well as concerns about the lack of heterogeneity in built environment measures and study designs existing in the literature written in English versus Chinese. Also, this review only included published literature; thus, useful and relevant unpublished studies may have been overlooked. Future reviews could explore the unpublished, or "grey" literature to determine whether it is useful in building on our findings.

5. Conclusion

This study systematically reviewed the scientific evidence regarding the influence of neighborhood built environment on PA and body weight status among Chinese children and adolescents. A total of 20 studies met the selection criteria and were included in the review. Availability, accessibility, and proximity to greenspaces, parks, recreational facilities, and sidewalks were associated with increased PA, reduced sedentary behavior, and/or active commuting. In contrast, the absence of bike lanes and living in higher density residential areas were associated with increased likelihood of childhood obesity. Research on the environmental correlates of PA in China and other countries is rapidly increasing, so future reviews may be able to analyze more studies in this field. Future reviews should also include articles written in Chinese and other languages, as well as unpublished studies in the "grey" literature. Longitudinal or experimental study designs and objective environmental and PA measures should also be part of future research into the influence of the neighborhood built environment on PA and body weight status among children and adolescents in China.

Authors' contributions

RA conceived of the study, conducted the systematic review, and wrote the manuscript; JS and QY contributed to

literature review, data synthesis, and manuscript drafting; YY contributed to data synthesis and manuscript drafting. All authors have read and approved the final version of the manuscript, and agree with the order of presentation of the authors.

Competing interests

The authors declare that they have no competing interests.

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