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SYSTEMATIC REVIEW

Association between walkability and physical activity among children and adolescents: a systematic review

Associação entre caminhabilidade e atividade física entre crianças e adolescentes: uma revisão sistemática

Asociación entre caminabilidad y actividad física entre niños y adolescentes: una revisión sistemática

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ABSTRACT | Housing conditions in a neighborhood may be associated with physical activity among children and adolescents. This study aimed to evaluate the association between walkability and physical activity levels in children and adolescents. We conducted a systematic review, searching for articles published until April 2023 in the following databases: PubMed, SPORTDiscus, LILACS, Web of Science, Scopus, Embase, and Cochrane. It included studies that evaluated the association between walkability and physical activity among children and adolescents. The Newcastle Ottawa scale was used to assess the individual quality of the studies. In total, 35 studies were included, 5 longitudinal. The sample size ranged from 143 to 45,392 participants. Most of the studies found a positive association between walkability and physical activity, ~86%. Of the 19 studies that evaluated physical activity using objective methods (most of them accelerometers), 74% found positive results; for subjective methods, the percentage was 94%. Walkability was positively associated with higher levels of physical activity among children and adolescents.

Keywords | Walkability; Physical Activity; Children; Adolescents; Systematic Review.

RESUMO | As condições de moradia em um bairro podem estar associadas à prática de atividade física entre crianças e adolescentes. Este estudo teve como objetivo avaliar a associação entre caminhabilidade e níveis de atividade física em crianças e adolescentes. Realizou-se uma revisão sistemática buscando artigos publicados até abril de 2023 nas seguintes bases de dados: PubMed, SPORTDiscus, LILACS, Web of Science, Scopus, Embase e Cochrane. Foram incluídos estudos que avaliaram a associação entre caminhabilidade *(walkability)* e atividade física entre crianças e adolescentes. A escala Newcastle Ottawa foi utilizada para avaliar a qualidade individual dos estudos. No total, foram incluídos 35 estudos, sendo cinco longitudinais. O tamanho da amostra variou de 143 a 45.392 participantes. A maioria dos estudos encontrou uma associação positiva entre caminhabilidade e atividade física (~86%). Dos 19 estudos que avaliaram a atividade física por meio de métodos objetivos (a maioria deles acelerômetros), 74% encontraram resultados positivos; para métodos subjetivos, o percentual foi de 94%. A caminhabilidade esteve positivamente associada a maiores níveis de atividade física entre crianças e adolescentes.

Descritores | Caminhabilidade; Atividade Física; Crianças; Adolescentes; Artigo de Revisão.

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RESUMEN | Las condiciones de vivienda en un barrio pueden asociarse con la práctica de actividad física entre niños y adolescentes. Este estudio tuvo el objetivo de evaluar la asociación entre caminabilidad y niveles de actividad física en niños y adolescentes. Se realizó una revisión sistemática buscando artículos publicados hasta abril de 2023 en las siguientes bases de datos: PubMed, SPORTDiscus, LILACS, Web of Science, Scopus, Embase y Cochrane. Se incluyeron estudios que evaluaron la asociación entre caminabilidad y actividad física entre niños y adolescentes. Se utilizó la escala Newcastle Ottawa para evaluar la calidad individual de los estudios. En total, se incluyeron 35 estudios, de los cuales cinco son longitudinales. El tamaño de la muestra osciló entre 143 y 45392 participantes. La mayoría de los estudios encontró una asociación positiva entre caminabilidad y actividad física (aproximadamente el 86%). De los 19 estudios que evaluaron la actividad física a través de métodos objetivos (la mayoría acelerómetros), el 74% encontró resultados positivos; para métodos subjetivos, el porcentaje fue del 94%. La caminabilidad se asoció positivamente con niveles más altos de actividad física entre niños y adolescentes.

Palabras clave | Caminabilidad; Actividad Física; Niños; Adolescentes; Artículo de Revisión.

INTRODUCTION

Physical activity is essential for good health and should be practiced since early life[1]. Along with sedentary habits, it is developed during the first years, especially between the ages of 0 and 5[2]. These habits tend to last throughout adulthood, making it difficult to change them later. Among the benefits of starting physical activity early, physical conditioning and cardiorespiratory health stand out, as they provide health benefits during adulthood, especially by protecting against cardiovascular risks[3-5].

Physical activity during childhood go far beyond a moment of leisure: they create healthy life habits, granting lifelong benefits [3]. In adulthood, physical activity has been shown to be beneficial against several health outcomes, such as cardiovascular disease and all-cause mortality[6], diabetes[7], obesity[8,9], and metabolic syndrome[10]. Among older adults, physical activity is especially protective against multimorbidity[11]. This range of protection confirms the importance of physical activity since early years. However, its practice depends on suitable and available places for it to take place, meaning the urban environment in which people live must be accessible to pedestrians, providing easy, safe, and convenient areas for walking, exercising, and moving around. This is referred to as walkability[12].

Despite this range of evidence pointing to the influence of physical activity during early years, most adolescents do not reach the recommended physical activity for their age as proposed in guidelines[13]. Data from almost 300 schools, totaling approximately 1.6 million students from the ages 11 to 17, showed 81% of this population as physically inactive. Among girls, the prevalence was even higher, reaching almost 85%[13]. Among adults in the United States, data from 2008 to 2017 showed a positive advance in physical activity, but numbers are still low and showed only about 25% of urban dwellers were physically active[14].

Studies suggest social environments and specific programs should encourage physical activity[15]. Moreover, it is important to determine the association between walkability and physical activity among children and adolescents, since healthy habits tend to last throughout an individual's life. Given the significance of physical activity throughout life, it is imperative to recognize that the surrounding environment plays a pivotal role in influencing its engagement. Conducting a systematic review is instrumental in elucidating the extent to which this relationship is established or not. Therefore, this study evaluates the association between walkability and physical activity levels in children and adolescents.

METHODOLOGY

The following systematic review and meta-analysis was carried out following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Protocols (PRISMA) guidelines[16]. The study protocol was registered in the International Prospective Register of Systematic Reviews (PROSPERO) under registration number CRD42021290914 and was published in the Brazilian Journal of Physical Activity and Health[17].

To formulate the research question, the Population, Intervention, Comparison, Outcome, and Study Design (PICOS) strategy was used, as outlined in Supplementary Table 1. Guided by this approach, the ensuing research question was formulated as follows: "What is the association between walkability and physical activity in children and adolescents?".

Table 1. Description of included studies (n=35)

Author, year, country	Study design	Participants characteristics	Physical activity measurement	Main findings
Tappe et al., 2013[18] United States Children's physical activity and parents' perception of the neighborhood environment: neighborhood impact on kids study	Cross-sectional	724 children aged 6 to 11 years old	**Subjective:** Days of the week in which participants reported 60+minutes daily	Lower street connectivity and better neighborhood aesthetics increase child activity within neighborhoods. Reported safety and walk/cycle facilities boost child activity in public recreation spaces
Carlson et al., 2015[19] United States Association between neighborhood walkability and GPS-measured walking, bicycling and vehicle time in adolescents	Cross-sectional	690 adolescents with an average age of 14 years	**Objective:** Accelerometers	Neighborhood walkability was positively related to walking and bicycling and negatively related to vehicle time
Kasehagen et al., 2012[20] United States Associations Between Neighborhood Characteristics and Physical Activity Among Youth Within Rural–Urban Commuting Areas in the US	Cross-sectional	45,392 youth aged 10-17 years old	**Subjective:** Days of the week in which adolescents practiced physical activity for at least 20 minutes	This analysis identified no association between youths' minimum physical activity attainment and neighborhood characteristics in unstratified models
Galvez et al., 2013[21] United States Associations between neighborhood resources and physical activity in inner city minority children	Cross-sectional	324 children aged at least 6 years old	**Subjective and Objective:** MET-hours of physical activity per week and steps per day	Availability of select physical activity resources was associated with reported physical activity levels but not with objective measures of physical activity
Muthuri et al., 2016[22] Kenya Associations Between Parental Perceptions of the Neighborhood Environment and Childhood Physical Activity: Results from ISCOLE-Kenya	Cross-sectional	563 children aged 9-11 years old	**Objective:** Accelerometers	Parental perception of positive neighborhood social cohesion, positive environs and connectivity, and negative child safety concerns, were associated with child physical activity
McGrath et al., 2016[23] New Zealand Associations Between the Neighborhood Environment and Moderate-to-Vigorous Walking in New Zealand Children: Findings from the URBAN Study	Cross-sectional	227 children with an average age of 9 years	**Objective:** Accelerometers	Neighborhoods with greener spaces, attractive streets, or low-walkability streets showed a moderate positive association on non-school day moderate-to-vigorous steps
Hume et al., 2007[24] Australia Associations of children's perceived neighborhood environments with walking and physical activity	Cross-sectional	280 children aged 10 years old	**Objective:** Accelerometers	Multiple linear regression analyses showed positive association between walking frequency and number of accessible destinations in the neighborhood among boys. Among girls, neighborhoods that were easy to walk/cycle around and with lots of graffiti were positively associated with walking frequency

(continues)

Table 1. Continuation

Hinckson et al., 2017[25] New Zealand Associations of the perceived and objective neighborhood environment with physical activity and sedentary time in New Zealand adolescents	Cross-sectional	524 adolescents with an average age of 16 years	**Objective:** Accelerometers	There was a positive association between walkability and physical activity
Evenson et al., 2010[26] United States Examination of perceived neighborhood characteristics and transportation on changes in physical activity and sedentary behavior: The Trial of Activity in Adolescent Girls	Longitudinal	847 adolescents with an average age of 12 years	**Objective:** Accelerometers	There was no positive association between walkability and physical activity
Franzini et al., 2009[27] United States Influences of Physical and Social Neighborhood Environments on Children's Physical Activity and Obesity	Cross-sectional	650 children with an average age of 11 years	**Subjective:** Vigorous and moderate exercise, physical education or gym class, sports participation, physically active free-time activities, participation in other physical activity or lessons, and walking or biking to school	Social environment was positively associated with several measures of physical activity
Sallis et al., 2018[28] United States Neighborhood built environment and socioeconomic status in relation to physical activity, sedentary behavior, and weight status of adolescents	Cross-sectional	928 adolescents aged 12-16 years old	**Objective:** Accelerometers	Walkability was positively and significantly related to objectively measured physical activity
Goon et al., 2020[29] Canada Neighborhood Built Environment Measures and Association with Physical Activity and Sedentary Time in 9–14-Year-Old Children in Saskatoon, Canada	Cross-sectional	816 children aged 9-14 years old	**Objective:** Accelerometers	Children's perceived availability of parks and sidewalks predicted a higher accumulation of moderate-to-vigorous physical activity
Huang et al., 2020[30] United States Neighborhood characteristics associated with park use and park-based physical activity among children in low-income diverse neighborhoods in New York City	Cross-sectional	16,402 children aged 5-10 years	**Objective:** System for Observing Play and Recreation in Communities (SOPARC)	Higher levels of LUM and pedestrian-friendly streets were associated with greater numbers of children in parks and higher moderate-to-vigorous physical activity across all three groups
Huang et al., 2010[31] Taiwan Neighborhood environment and physical activity among Urban and Rural Schoolchildren in Taiwan	Cross-sectional	726 children aged 11-12 years old	**Subjective:** MET-h/week and various physical activities by area	Accessibility to facilities had a significant impact on the children's physical activity

(continues)

Table 1. Continuation

Weimann et al., 2015[32] Sweden Neighborhood environment and physical activity among young children: a cross-sectional study from Sweden	Cross-sectional	205 children aged 4-11 years old	**Objective:** Accelerometers	Children were more physically active in areas with intermediate access to neighborhood resources for physical activity compared to areas with poor access
Dias et al., 2020[33] Brazil	Cross-sectional	1,130 school students aged 14-20 years old	**Subjective:** Self-reported leisure walking	Leisure walking was positively associated environmental factors
Babey et al., 2015[34] United States Neighborhood, family and individual characteristics related to adolescent park-based physical activity	Cross-sectional	3,638 adolescents aged 12-17 years old	**Subjective:** Practice of physical activity in a park	Adolescents with a park within walking distance of home and those with a safe park nearby were more likely to be physically active during a park visit
Grigsby-Toussaint et al., 2011[35] United States Where they live, how they play: Neighborhood greenness and outdoor physical activity among preschoolers	Cross-sectional	365 children aged 2-5 years old	**Subjective:** Questions about minutes that children spend on active playing, indoor quiet playing, outdoor active playing, and outdoor quiet playing	Higher levels of neighborhood greenness were associated with higher levels of outdoor playing time among preschool children
Markevych et al., 2016[36] Germany Neighbourhood and physical activity in German adolescents: GINIplus and LISAplus	Cross-sectional	1,192 adolescents aged 16 years old	**Objective:** Accelerometers	Residing in a neighborhood with high normalized difference vegetation index was associated with 9% more leisure moderate-to-vigorous physical activity
Datar et al., 2013[37] United States Parent perceptions of neighborhood safety and children's physical activity, sedentary behavior, and obesity: evidence from a national longitudinal study	Longitudinal	18,900 school-aged children	**Subjective:** Number of days per week on which the child engaged in at least 20 minutes of vigorous exercise	Children whose parents perceived their neighborhoods as unsafe watched more television and participated in less physical activity
Esteban-Cornejo et al., 2016[38] United States Parental and Adolescent Perceptions of Neighborhood Safety Related to Adolescents' Physical Activity in Their Neighborhood	Cross-sectional	928 adolescents aged 12-16 years old	**Subjective:** Frequency of physical activity in various locations	Parent-perceived traffic safety was positively associated with adolescents reported physical activity in the neighborhood
De Meester et al., 2014[39] Belgium Parental perceived neighborhood attributes: associations with active transport and physical activity among 10-12 year old children and the mediating role of independent mobility	Cross-sectional	736 children aged 10-12 years old	**Subjective:** Questionnaire determining different types of physical activity	Parental perceptions of neighborhood environmental characteristics were associated with their level of active transport and total physical activity
Zhang et al., 2021[40] Hong Kong Park environment and moderate-to-vigorous physical activity in parks among adolescents in a high-density city: the moderating role of neighbourhood income	Cross-sectional	2,397 adolescents	**Subjective:** Moderate-to-vigorous physical activity was measured using an observation tool for assessing physical activity in recreational places such as urban parks	There was a significant positive association between the quality of amenities and park-based moderate-to-vigorous physical activity

(continues)

Table 1. Continuation

Mendonça et al., 2018[41] Brazil Perceived neighborhood environmental characteristics and different types of physical activity among Brazilian adolescents	Cross-sectional	2,874 adolescents aged 14-19 years old	**Subjective:** Measured using questionnaires, classifying adolescents as physically active or inactive	There was a positive association between some environmental variables and different types of exercises
Zhang et al., 2021[42] Chine Psychosocial Characteristics, Perceived Neighborhood Environment, and Physical Activity Among Chinese Adolescents	Cross-sectional	4,027 adolescents aged 10-20 years old	**Subjective:** Self-reported moderate-to-vigorous physical activity	There was a positive association between availability of physical activity resources and physical activity
D'Haese et al., 2014[43] Belgium The association between objective walkability, neighborhood socio-economic status, and physical activity in Belgian children	Cross-sectional	606 children aged 9-12 years old	**Objective:** Accelerometers	No univocal relation between neighborhood walkability and physical activity was found in 9-12-year-old children
Colley et al., 2019[44] Canada The association between walkable neighbourhoods and physical activity across the lifespan	Cross-sectional	4,030 children aged 3-11 years old and another sample with participants aged 12-79 years old	**Objective:** Accelerometers	Walkability was positively associated with accelerometer-measured moderate-to-vigorous physical activity in youth (12-17 years)
Cheng et al., 2022[45] China The relationship between neighborhood environment and physical activity in Chinese youth: a retrospective cross-sectional study	Cross-sectional	3,424 participants with an average age of 19 years	**Subjective:** Questionnaire regarding physical activity using the Global Physical Activity Questionnaire	One scale score increases in neighborhood walkable environmental was associated with an increase in moderate physical activity
Mitáš et al., 2018[46] Poland and the Czech Republic The Safety of the Neighborhood Environment and Physical Activity in Czech and Polish Adolescents	Cross-sectional	2,001 adolescents with an average age of 16 years	**Objective:** Pedometers	A safe neighborhood environment significantly predicts walking activities among girls
Timperio et al., 2017[47] Australia Typologies of neighbourhood environments and children's physical activity, sedentary time and television viewing	Cross-sectional and Longitudinal	1,210 children aged 5-6 years old and 10-12 years old	**Objective:** Accelerometers	Some cross-sectional associations with behavior were found. Longitudinally, the cluster characterized by mixed land use and many playgrounds and sport venues was associated with less television viewing on weekends three years later
Wayas et al., 2023[48] South Africa Association of Perceived Neighbourhood Walkability with Self-Reported Physical Activity and Body Mass Index in South African Adolescents	Cross-sectional	143 adolescents aged 13-18 years old	**Subjective:** Measured using questionnaire validated against objectively measured physical activity	The association between neighborhood walkability and physical activity was inconsistent
Carver et al., 2023[49] United States Associations of home and neighborhood environments with children's physical activity in the U.S.-based Neighborhood Impact on Kids (NIK) longitudinal cohort study	Cross-sectional and Longitudinal	727 children aged 6-12 years old	**Objective:** Accelerometers	There were no significant total or direct effects of environmental attributes and physical activity, both in cross-sectional and longitudinal analysis

(continues)

Table 1. Continuation

Bird et al., 2022[50] Canada Associations of neighborhood walkability with moderate to vigorous physical activity: an application of compositional data analysis comparing compositional and non-compositional approaches	Longitudinal	409 participants aged 8-10 years old	**Objective:** Accelerometers	Girls who lived in more walkable neighborhoods had 10% higher daily moderate-to-vigorous physical activity
de Castro et al., 2022[51] Brazil Perceived neighborhood characteristics and practice of physical activity among adolescents and young adults: a model with distal outcomes	Cross-sectional	1,637 participants aged 15-24 years old	**Subjective:** Measured the International Physical Activity Questionnaire (IPAQ), short version	Neighborhoods with attributes favorable to practice physical activity and elements of urbanization increase the chance of active behavior during leisure time among adolescents
Nakabazzi et al., 2021[52] Uganda Parental-perceived home and neighborhood environmental correlates of accelerometer-measured physical activity among school-going children in Uganda	Cross-sectional	256 children aged 10-12 years	**Objective:** Accelerometers	There was a negative association between neighborhood and physical activity. A better perception of crime safety was associated with less Moderate-to-vigorous physical activity among boys and girls

Supplementary Table 1. PICOS criteria for inclusion and exclusion of studies

	Inclusion criteria	Exclusion criteria
Participants	Children and adolescents	Studies with animals or in vitro, review and opinion articles, repeated studies
Intervention	Walkability	Not applied
Comparison	Subgroup's analysis according to age (children and adolescents)	None
Outcomes	Physical activity	Studies that did not evaluate physical activity levels
Study type	Observational: cross-sectional and longitudinal	Studies that were not carried out on humans, conference abstracts, and reviews
Language	No limit	
Year of publication	No limit	

Search strategy and databases

The searches were conducted until December 2021 and updated in April 2023, encompassing databases such as PubMed, SPORTDiscus, LILACS, Web of Science, Scopus, Embase, and Cochrane. We also searched Google Scholar to include studies from grey literature. Furthermore, a comprehensive screening of references from the included studies was conducted, along with relevant systematic reviews.

Search terms and their combinations were meticulously optimized based on distinctive characteristics of each individual database. We prioritized using terms from Medical Subject Heading (MeSH), along with searches encompassing titles and abstracts whenever feasible. The amalgamation of terms related to walkability and the outcome of interest, physical activity, was achieved using Boolean operators 'OR' and 'AND'. A detailed outline of the complete search strategy implemented across each database is available in Supplementary Table 2.

Table 2. Quality of evidence in included studies in the systematic review. Newcastle-Ottawa Scale (NOS) (n=35)

Perspectives									
Study	**Selection**				**Comparability**	**Outcome**			**Score**
Longitudinal Studies	Representativeness of the exposed cohort	Selection of the non-exposed cohort	Ascertainment of exposure	Demonstration that outcome of interest was not present at start of study	Comparability of cohorts based on design or analysis	Assessment of outcome	Was follow-up long enough for outcomes to occur?	Adequacy of follow up of cohorts	0 to 9
Evenson et al., 2010	1	1	0	1	1	1	1	1	7
Datar et al., 2013	1	1	0	1	2	0	1	0	6
Timperio et al., 2017	1	1	0	1	2	1	1	0	7
Carver et al., 2023	1	1	1	1	0	1	1	0	6
Bird et al., 2022	1	1	1	1	0	1	0	1	6
Study	**Selection**				**Comparability**	**Outcome**			**Score**
Cross-sectional studies	Representativeness of the sample	Sample size	Non-respondents	Assessment of exposure	The subjects in different outcome groups are comparable, based on the study design or analysis.	Assessment of outcome	Statistical analysis		0 to 8
Tappe et al., 2013	1	0	0	1	1	1	1		5
Carlson et al., 2015	1	0	0	1	2	1	1		6
Kasehagen et al., 2012	1	0	1	0	2	0	1		5
Galvez et al., 2013	1	0	0	0	2	1	1		5
Muthuri et al., 2016	1	0	1	1	0	1	1		5
McGrath et al., 2016	1	0	1	1	2	1	1		7
Hume et al., 2007	1	0	0	1	2	1	1		6
Hinckson et al., 217	1	0	0	1	2	1	1		6

(continues)

Table 2. Continuation

Franzini et al., 2009	1	0	1	0	1	0	1	4
Sallis et al., 2018	1	0	0	1	2	1	1	6
Goon et al., 2020	1	0	0	1	2	1	1	6
Huang et al., 2020	1	1	0	1	1	0	1	5
Huang et al., 2010	1	1	0	0	1	0	1	4
Weimann et al., 2015	1	0	0	0	2	1	1	5
Dias et al., 2020	1	1	1	1	1	0	1	6
Babey et al., 2015	1	1	0	0	2	0	1	5
Grigsby-Toussaint et al., 2011	1	0	1	0	2	1	1	6
Markevych et al., 2016	1	0	0	0	2	1	1	5
Esteban-Cornejo et al., 2016	1	0	0	1	2	0	1	5
De Meester et al., 2014	1	0	0	1	1	1	1	5
Zhang et al., 2021	1	1	0	1	0	0	1	4
Mendonça et al., 2018	1	1	1	0	2	0	1	6
Zhang et al., 2021	1	0	0	1	1	1	1	5
D'Haese et al., 2014	1	0	0	1	1	1	1	5
Colley et al., 2019	1	0	0	1	2	1	1	6
Cheng et al., 2022	1	0	0	1	2	0	1	5
Mitáš et al., 2018	1	0	0	0	0	1	1	3
Wayas et al., 2023	1	0	0	1	2	0	1	5
de Castro et al., 2022	1	1	1	0	1	0	1	5
Nakabazzi et al., 2021	1	1	0	1	1	1	1	6

Supplementary Table 2. Search results

Database	Terms	Results
PubMed	Search: ((((((((((Neighborhood[Title]) OR (Neighborhood buffer[Title])) OR (Neighborhood context[Title])) OR (Walking locations[Title])) OR (Space syntax[Title])) OR (Street layout[Title])) OR (Street design[Title])) OR (Urban design[Title])) OR (Urban form[Title])) OR (Urban planning[Title])) OR (Walkability[Title])) OR (Walkable[Title])) AND (((((((((physical activity[Title]) OR (motor activity[Title])) OR (exercise[Title])) OR (walking[Title])) OR (sports[Title])) OR (fitness[Title])) OR (inactivity[Title])) OR (sedentarism[Title])) OR (sedentary[Title]))	707
SPORTDiscus	S1: TI Neighborhood OR TI Neighborhood buffer OR TI Neighborhood context OR TI Walking locations OR TI Space syntax OR TI Street layout OR TI Street design OR TI Urban design OR TI Urban form OR TI Urban planning OR TI Walkability OR TI Walkable S2: TI physical activity OR TI motor activity OR TI exercise OR TI walking OR TI sports OR TI fitness OR TI inactivity OR TI sedentarism OR TI sedentary S3: (TI physical activity OR TI motor activity OR TI exercise OR TI walking OR TI sports OR TI fitness OR TI inactivity OR TI sedentarism OR TI sedentary) AND (S2 AND S3)	284
LILACS	((ti:(Neighborhood)) OR (ti:(Neighborhood buffer)) OR (ti:(Neighborhood context)) OR (ti:(Walking locations)) OR (ti:(Space syntax)) OR (ti:(Street layout)) OR (ti:(Street design)) OR (ti:(Urban design)) OR (ti:(Urban form)) OR (ti:(Urban planning)) OR (ti:(Walkability)) OR (ti:(Walkable))) AND ((ti:(physical activity)) OR (ti:(motor activity)) OR (ti:(exercise)) OR (ti:(walking)) OR (ti:(sports)) OR (ti:(fitness)) OR (ti:(inactivity)) OR (ti:(sedentarism)) OR (ti:(sedentary)))	13
Web of Science	#1 Neighborhood (Título) or Neighborhood buffer (Título) or Neighborhood context (Título) or Walking locations (Título) or Space syntax (Título) or Street layout (Título) or Street design (Título) or Urban design (Título) or Urban form (Título) or Urban planning (Título) or Walkability (Título) or Walkable (Título) #2 physical activity (Título) or motor activity (Título) or walking (Título) or sports (Título) or fitness (Título) or inactivity (Título) or sedentarism (Título) or sedentary (Título) and exercise (Todos os campos) #1 AND #2	1.555
Scopus	((TITLE (neighborhood) OR TITLE (neighborhood AND buffer) OR TITLE (neighborhood AND context) OR TITLE (walking AND locations) OR TITLE (space AND syntax) OR TITLE (street AND layout) OR TITLE (street AND design) OR TITLE (urban AND design) OR SRCTITLE (urban AND form) AND TITLE (urban AND planning) OR TITLE (walkability) OR TITLE (walkable))) AND ((TITLE (physical AND activity) OR TITLE (motor AND activity) OR TITLE (exercise) OR TITLE (walking) OR TITLE (sports) OR TITLE (fitness) OR TITLE (inactivity) OR TITLE (sedentarism) OR SRCTITLE (sedentary)))	130
Embase	#1 neighborhood:ti OR 'neighborhood buffer':ti OR 'neighborhood context':ti OR 'walking locations':ti OR 'space syntax':ti OR 'street layout':ti OR 'street design':ti OR 'urban design':ti OR 'urban form':ti OR 'urban planning':ti OR walkability:ti OR walkable:ti #2 'physical activity':ti OR 'motor activity':ti OR exercise:ti OR walking:ti OR sports:ti OR fitness:ti OR inactivity:ti OR sedentarism:ti OR sedentary:ti #3 #1 AND #2	758

(continues)

Cochrane	#1 (Neighborhood):ti OR (Neighborhood buffer):ti OR (Neighborhood context):ti OR (Walking locations):ti OR (Space syntax):ti #2 (Street layout):ti OR (Street design):ti OR (Urban design):ti OR (Urban form):ti OR (Urban planning):ti #3 (Walkability):ti OR (Walkable):ti #4 (physical activity):ti OR (motor activity):ti OR (exercise):ti OR (walking):ti OR (sports):ti #5 (fitness):ti OR (inactivity):ti OR (sedentarism):ti OR (sedentary):ti #6 #1 OR #2 OR #3 #7 #4 OR #5 #8 #6 AND #7	59
Total		**3.506**

Inclusion and exclusion criteria

Studies meeting the following criteria were eligible for inclusion: observational design encompassing either cross-sectional or longitudinal design; primary focus on walkability, or its criteria, as the independent variable; examination of its association with physical activity.

We excluded studies conducted with animals or in vitro models, studies with patients with specific diseases, studies with adults or older adults, review, and opinion articles.

Review process

Initially, two reviewers gathered virtually to streamline the study selection procedure, aimed at enhancing uniformity and optimizing outcomes. As part of this endeavor, a pilot phase involving 50 titles and abstracts was executed before the official commencement of the review. The main goal was to establish standardization and, if necessary, to effect potential refinements to the inclusion and exclusion criteria.

After conducting the searches, results were imported into the EndNote x7 tool to facilitate the exclusion of duplicates. Then, the reviewers transferred the titles to the Rayyan tool, which served as a platform for the comprehensive study selection process. The initial step encompassed screening titles and abstracts, followed by involving a thorough examination of articles meeting the criteria for inclusion and exclusion. The study selection process was executed in an independently by two reviewers, with any discrepancies being fixed by a third party. Following these steps, a review of the references within the included studies was undertaken, supplemented by a search using Google Scholar. This meticulous course of action was planned to ensure the inclusion of all pertinent studies available in the literature.

Data extraction and quality of evidence

For each included study, we gathered key details, including identification particulars (author and year), sample description (e.g., 1500 participants from Brazil), age (average age of participants), study design (cross-sectional or longitudinal), method employed to measure physical activity (subjective or objective), and main findings (e.g., positive correlation observed between walkability and increased engagement in physical activity).

The evaluation of evidence quality was executed using the Newcastle Ottawa Scale (NOS)[53]. Two independent reviewers conducted the assessment of individual study quality, with any discrepancies being fixed by a third party. For longitudinal studies, the original NOS scale was employed, encompassing eight distinct items pertaining to aspects such as study selection, comparability, and outcome evaluation. Each item was awarded a point denoting high quality, except for the comparability item, which could receive up to two points. In the context of cross-sectional designs, an adapted version of the scale was used, based on a prior publication[54]. This scale comprises seven items addressing study selection, comparability, and outcome assessment, with points indicating high quality on each respective item. Consequently, the cumulative NOS scale score ranges from 0 to 9 for cohort studies and 0 to 8 for cross-sectional studies.

RESULTS

Study selection

Figure 1 presents the flowchart of studies selection. Considering the seven databases, we found 5125 articles and 3312 after excluding duplicates. In the process of titles and abstracts reading, we selected 298 manuscripts, of which 262 were excluded for the following reasons: did not evaluated walkability (n=67); evaluated different outcomes (n=67); repeated study (n=32); congress abstracts (n=12); participants with specific diseases (n=13); review study (n=2); participants adults (n=76). Thus, 35 studies were included in the present review, totaling approximately 120 thousand participants.

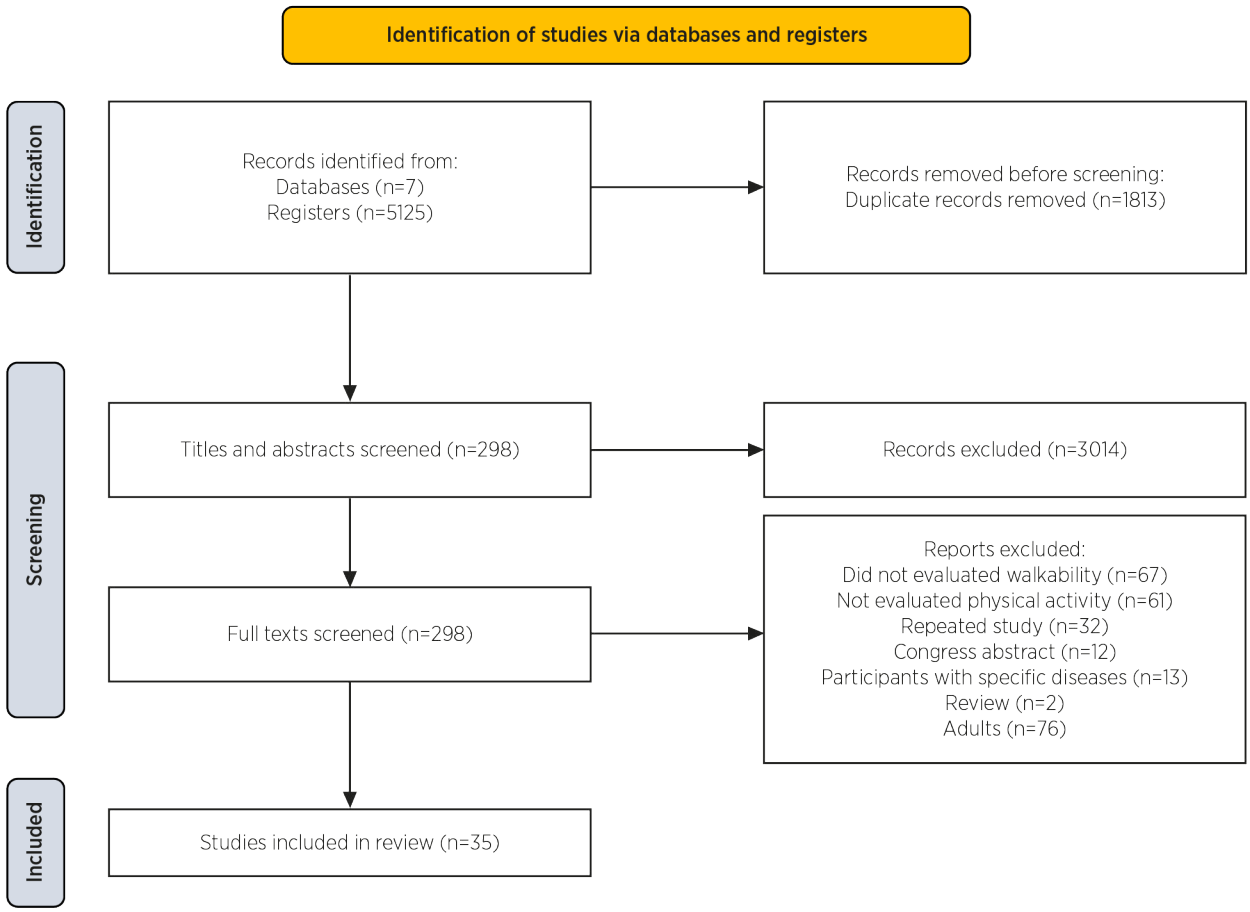

Figure 1. Flow diagram of articles selection stages

Study characteristics

Most studies were published in the United States (n=13)[18-21,26-28,30,34,35,37,38,49], from 2007[24] to 2023[48,49]. Five studies were longitudinal and, mostly, cross-sectional (n=30). The smallest sample size was 143 adolescents aged 13-18 years old in one study published in South Africa[48], while the largest was 45.392 youth aged 10-17 years old in a study conducted in the United States, in 2012[20]. Most studies (n=19) assessed physical activity using objective methods, such as accelerometers. Alternatively, 16 studies assessed physical activity using subjective methods, such as questionnaires.

Risk of bias in studies

Table 2 presents the NOS scale with the individual quality of risk of each study. Of the four longitudinal studies, three scored 6 points and two scored 7 points. Regarding cross-sectional studies, the score ranged from 3 points in one study to 7 in another, totaling anhe average score of 5.

Main findings

Of the 35 studies included, 30 found at least one significant result between walkability or some of its components and levels of physical activity among children and adolescents, which represents around 86% of the studies. Of the five longitudinal studies, three found a significant association between walkability and higher levels of physical activity[37,47,50].

Of the 19 studies that assessed physical activity using objective methods, 14 found positive results between walkability and physical activity[19,22,24,25,28,29,32,36,37,39,44,46,47,50], representing around 74% of the studies. Four studies found null results between walkability and physical activity levels[20,21,49,55]. On the other hand, the study by Nakabazzi et al.[64], found a negative result between walkability and physical activity.

Of the 16 studies that assessed physical activity using a questionnaire, 15 (94%) found a positive association between walkability and physical activity[18,27,31,33-35,37-42,45,48,51], while only one study found a null result between walkability and physical activity[20].

DISCUSSION

This systematic review included 35 studies that evaluated the association between walkability, or one of its components, and physical activity among children and adolescents. The results showed most of the studies, 86%, found a positive association between walkability and physical activity, suggesting that living near places that facilitate physical activity increases physical activity levels among children and adolescents.

Our findings could be fundamental to create public policies and redirect resources towards building suitable environments in neighborhoods that encourage greater physical activity. The literature corroborates these findings, and a study in Turkey found most of the sample associated lack of time as a barrier to physical activity[56]. In other words, an environment that allowed people to do physical activity without commuting would increase the chances of fewer students giving up physical activity, regardless of age. A study of adults aged 55 years old and over showed neighborhood walkability can contribute to greater physical activity[57], increasing levels of movement.

With our results, we expect public policies to be carried out, encouraging the implementation of appropriate areas for physical activity. It is likely that investments in neighborhoods with greater walkability will result in increased levels of physical activity among children and adolescents, which, in the future, will develop protection against chronic diseases and health problems. Among adults and older adults, higher levels of physical activity could be a healthy alternative to administer chronic diseases[58]. However, parents need to be aware and encourage their children to do more outdoor activities and limit screen time, especially among the youngest.

Excessive screen time should be especially discouraged among children and adolescents, as it can have a negative impact on physical activity[59]. A cross-sectional study found that higher levels of physical activity and less screen time were positively associated with increased mental health among children during the pandemic[60]. Corroborating these hypotheses, a cluster randomized clinical trial with 86 children showed reducing recreational screen time resulted in a substantial increase in physical activity levels among children[61].

Children's and adolescents' mental health requires special attention from everyone, and physical activity can be a positive influence[60]. Physical activity among children and adolescents releases excess energy, reduces anxiety and depression, relieves tension, and increases self-esteem[63]. A meta-analysis of adolescents and young people, including 24 studies, found the presence of mental disorders was associated with a higher risk of suicide, as was attempted suicide, which reinforces the importance of physical activity at this age[64].

To the best of our knowledge, we are the first systematic review to evaluate the association between walkability and physical activity in children and adolescents. Results are promising and show the living environment is associated with greater physical activity among this population. However, the studies are very heterogeneous and include important differences, such as sample size, characterization of walkability, assessment of physical activity, design (only five studies were longitudinal), among others. This facilitated a meta-analysis to assess grouped results. Finally, no studies achieved the maximum score on the NOS scale, either for longitudinal or cross-sectional studies. It is recommended that future cohorts be conducted to assess longitudinal effects of walkability on physical activity levels, which will allow a meta-analysis to be conducted in the future.

CONCLUSION

Walkability was positively associated with higher levels of physical activity among children and adolescents. Implementing public policies and creating suitable environments for physical activity could result in higher levels of physical activity in the future.

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