Valentin Ammann

Matrikelnummer: 20-063-459

Masterstudium Sport, Bewegung und Gesundheit (Sportwissenschaft)

Departement für Sport, Bewegung und Gesundheit (DSBG)

Universität Basel

# How does a physical activity-friendly environment affect schoolchildren's physical activity behavior?

## A systematic review of low- and middle-income countries

**Master's Thesis**

Handed in to the Department of Sport, Exercise and Health (DSBG)

of the University of Basel

First Supervisor: Dr. Ivan Müller



Basel, June 2025

## Abstract

In low- and middle-income countries (LMICs), physical inactivity among schoolchildren is an increasing public health concern shaped by social, infrastructural, and political factors. This systematic review aimed to analyze how physical activity-friendly environments influence schoolchildren's physical activity in LMICs.

A literature review in five databases led to the inclusion of 20 studies (16 cross-sectional, 3 qualitative, 1 longitudinal). Studies were categorized using a structured analysis grid and grouped into two clusters: (1) physical-infrastructural environmental factors and (2) social and educational influences.

Frequently identified factors included (a) street connectivity, (b) walkability, (c) access to parks and playgrounds, and (d) school environment characteristics. Children from low-income neighborhoods were found to be often more active despite environmental challenges, while children in wealthier areas were sometimes less active. Seven studies reported significantly lower physical activity levels among girls compared to boys.

The findings of this systematic literature review highlight the importance of infrastructure and school-based programs for the sustainable promotion of physical activity, but also emphasize the need to consider socioeconomic and cultural contexts. Future research should employ mixed-methods and longitudinal study designs to clarify causality and guide local and inter-regional policy development.

## Zusammenfassung

In Ländern mit niedrigem und mittlerem Einkommen (LMICs) ist Bewegungsmangel bei Schulkindern ein zunehmendes Problem für die öffentliche Gesundheit, das durch soziale, infrastrukturelle und politische Faktoren beeinflusst wird. Ziel dieser systematischen Übersichtsarbeit war es, zu analysieren, wie bewegungsfreundliche Umgebungen die körperliche Aktivität von Schulkindern in LMICs beeinflussen.

Eine systematische Literaturrecherche in fünf Datenbanken führte zum Einschluss von 20 Studien (16 Querschnittstudien, 3 qualitative Studien, 1 Längsschnittstudie). Die Studien wurden anhand eines strukturierten Analyserasters kategorisiert und in zwei Gruppen eingeteilt: (1) physisch-infrastrukturelle Umweltfaktoren und (2) soziale und pädagogische Einflüsse.

Zu den häufig identifizierten Faktoren gehörten (a) Strassenverbindungen, (b) Begehbarkeit, (c) Zugang zu Parks und Spielplätzen und (d) Merkmale der Schulumgebung. Es wurde festgestellt, dass Kinder aus einkommensschwachen Stadtvierteln trotz der Umweltprobleme oft aktiver sind, während Kinder in wohlhabenderen Gegenden manchmal weniger aktiv sind. Sieben Studien berichteten über ein signifikant niedrigeres Aktivitätsniveau bei Mädchen im Vergleich zu Jungen.

Die Ergebnisse dieser systematischen Literaturauswertung unterstreichen die Bedeutung von Infrastruktur und schulischen Programmen für die nachhaltige Förderung körperlicher Aktivität, betonen aber auch die Notwendigkeit, den sozioökonomischen und kulturellen Kontext zu berücksichtigen. Künftige Forschungsarbeiten sollten gemischte Methoden und Längsschnittstudien verwenden, um die Kausalität zu klären und die Entwicklung lokaler und überregionaler Strategien zu unterstützen

## Résumé

Dans les pays à revenus faibles et moyens (PRFM), l'inactivité physique des écoliers est un problème de santé publique de plus en plus préoccupant, façonné par des facteurs sociaux, infrastructurels et politiques. Cette étude systématique visait à analyser l'influence des environnements favorables à l'activité physique sur l'activité physique des écoliers dans les PRFM.

Une analyse systématique de la littérature dans cinq bases de données a permis d'inclure 20 études (16 transversales, 3 qualitatives, 1 longitudinale). Les études ont été classées à l'aide d'une grille d'analyse structurée et regroupées en deux catégories : (1) les facteurs environnementaux physiques et infrastructurels et (2) les influences sociales et éducatives.

Les facteurs fréquemment identifiés sont (a) la connectivité des rues, (b) la possibilité de marcher, (c) l'accès aux parcs et aux terrains de jeux, et (d) les caractéristiques de l'environnement scolaire. Il a été constaté que les enfants des quartiers à faibles revenus étaient souvent plus actifs malgré les difficultés environnementales, tandis que les enfants des zones plus aisées étaient parfois moins actifs. Sept études font état de niveaux d'activité physique significativement plus faibles chez les filles que chez les garçons.

Les résultats de cette analyse documentaire systématique soulignent l'importance des infrastructures et des programmes scolaires pour la promotion durable de l'activité physique, mais aussi la nécessité de prendre en compte les contextes socio-économiques et culturels. Les recherches futures devraient utiliser des méthodes mixtes et des études longitudinales pour clarifier la causalité et guider l'élaboration de politiques locales et interrégionales.

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# 1 Introduction

Physical activity (PA) is an essential part of a child's development. Exercise not only promotes physical health, but also supports cognitive skills, social interaction and emotional well-being. On average, children and young people (aged 5-17) should be physically active for at least 60 minutes a day. These activities should be moderate to high intensity and consist mainly of aerobic forms of exercise. It is also recommended that at least three days a week of intensive PA should be planned, which not only challenges the cardiovascular system, but also strengthens the muscles and bone health. Adults (18-64 years of age) should engage in at least 150 to 300 minutes of moderate-intensity aerobic exercise per week or, alternatively, 75 to 150 minutes of vigorous-intensity aerobic activity for tangible health benefits. A combination of moderate and intense exercise is also possible to achieve the recommended total activity time. In addition, it is recommended to perform muscle-strengthening exercises that work all major muscle groups at least two days a week, as these offer additional health benefits. These recommendations are based on scientific findings with moderate evidence and are explicitly endorsed by the World Health Organization (WHO) (WHO, 2020).

Nevertheless, it can be observed worldwide that children and young people are increasingly less active. Physical inactivity is a growing challenge, particularly in urban areas, but also in economically weaker regions. The WHO continuously monitors global developments in the area of physical inactivity. Strain et al. (2024) show that almost a third of the adult population, around 1.8 billion people, are now insufficiently active. This means that they fall short of the global recommendation of at least 150 minutes of moderate PA per week. Compared to 2010, the inactivity rate has risen by five percentage points and continues this negative trend. If this trend continues, the proportion of physically inactive adults could rise to an alarming 35% by 2030. Both the economy and society will suffer as a result. Worldwide, physical inactivity costs healthcare systems 27 billion US dollars a year. If this trend continues, the expenditure could rise to a total of 300 billion US dollars by 2030 (WHO, 2022). Equally alarming are the results of the study by Guthold et al. (2020), which show that 81% of young people aged 11 to 17 are physically inactive. The following graph from the WHO (2022) illustrates this worrying inactivity rate. It shows that the prevalence is fairly evenly distributed across the different regions. The prevalence of insufficient PA among girls is above 80% in all regions, while among boys it affects three out of six regions (Africa, Eastern Mediterranean, Western Pacific). Only in South-East Asia are the prevalence values just below 80% for both girls and boys.

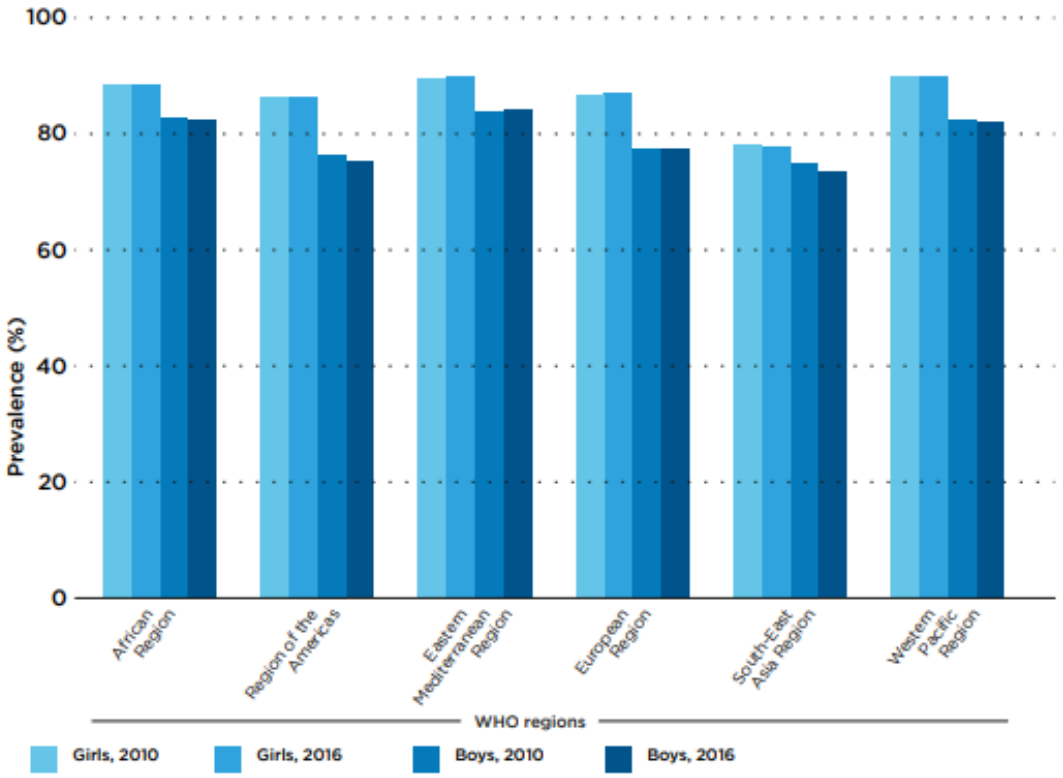


***Figure 1: Prevalence of school children aged 11–17 years not meeting WHO physical activity guidelines, by WHO region, 2010 and 2016. Source: WHO (2022)***

The consequences of inadequate exercise are reflected in the rising global figures for obesity. Overweight and obesity in children and adolescents are increasingly becoming a global health problem. Overweight and obesity are caused by an excessive accumulation of body fat, which entails health risks. The body mass index (BMI) serves as a yardstick for classification: values over 25 are considered overweight, while a BMI over 30 is defined as obesity.

Obesity is also part of the double burden of malnutrition. While wealthy countries used to be particularly affected by this problem, today many middle-income countries also have some of the highest rates of overweight and obesity in the world. In almost all regions, except for South-east Asia, there are now more people suffering from obesity than those who are underweight (WHO, n.d.).

The prevalence depends heavily on the region and country, but overall it is steadily increasing. According to the Global Burden of Disease Obesity Collaborators (2017), 5.0% of children worldwide were obese in 2015, which corresponds to 107.7 million affected children. Forecasts by the World Obesity Federation (2023) indicate that this trend will continue: While 158 million children and young people aged 5 to 19 were already affected in 2020, this figure is expected to rise to 206 million by 2025 and even 254 million by 2030.

The increasing number of overweight children and adolescents has far-reaching health and economic consequences, both for the individuals concerned and for society as a whole. The causes of obesity are diverse and include genetic, behavioral and environmental factors. In particular, an unbalanced diet and a lack of PA are major contributory factors. As obesity is considered a disease in its own right, it also makes it more difficult to deal with other health problems such as diabetes, cardiovascular disease and mental disorders. There is also an increased risk that obesity will persist into adulthood, increasing the likelihood of chronic diseases in the long term (Zhang et al., 2024). Figures two and three show the global prevalence of obesity in men and women.

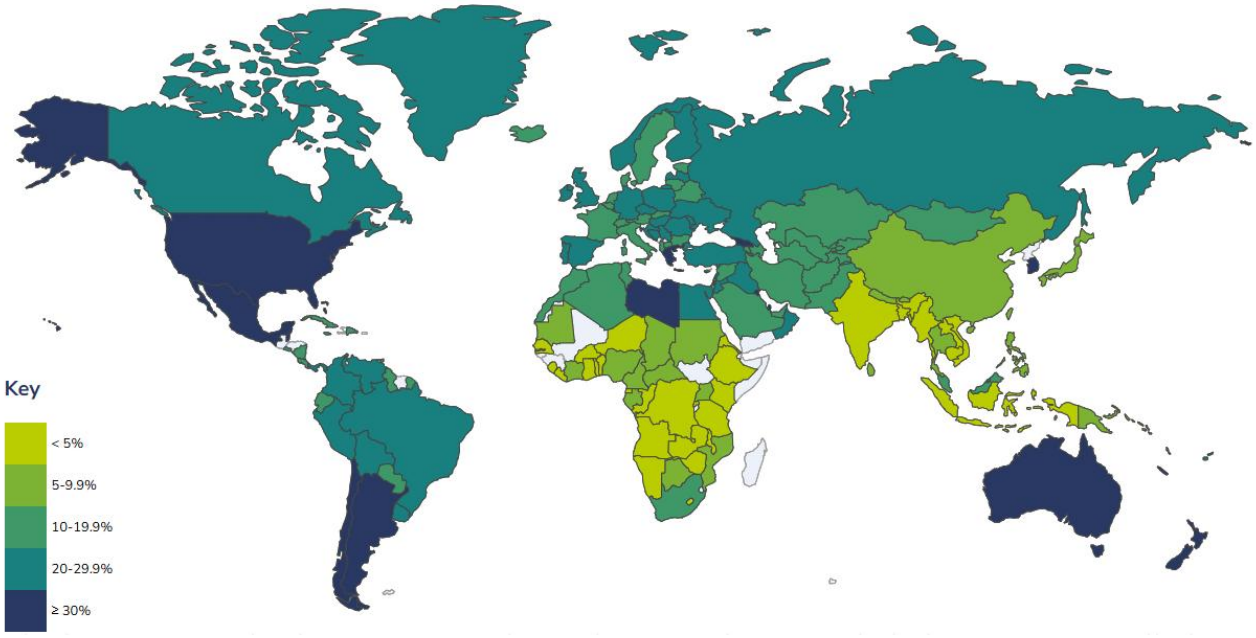


***Figure 3: Men living with obesity. Newest available data. Source: Global Obesity Observatory (n. d.)***

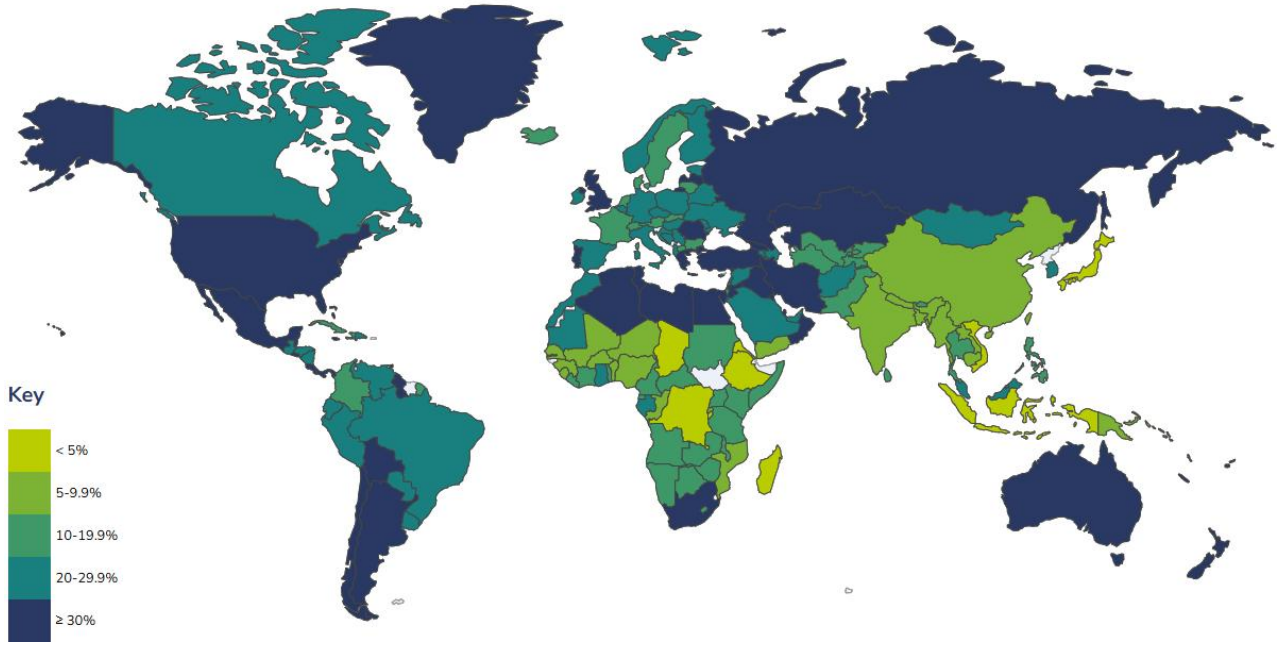


***Figure 2: Women living with obesity. Newest available data. Source: Global Obesity Observatory (n. d.)***

These maps show that women have higher obesity rates than men in many countries, particularly in Africa (e.g. South Africa, Egypt, Algeria) and the Middle East (e.g. Iraq, Iran, Oman). In Western countries, the differences are smaller, but women also have higher prevalence rates for obesity in some countries (e.g. England, Romania, Russia).

In low- and middle-income countries (LMICs), the problem of obesity is exacerbated by social, economic and infrastructural factors. According to the World Bank, 137 out of 195 countries can be classified as LMICs (World Bank Data Help Desk, n.d.) While children in some regions walk long distances due to a lack of transportation options, other areas lack safe play areas or exercise facilities. These countries face the challenge that health problems related to physical inactivity, such as obesity, diabetes and cardiovascular disease, are becoming more prevalent, although malnutrition remains a key health threat. This leads to a complex and often contradictory picture of children's PA behavior in these countries. This simultaneous burden of malnutrition and overnutrition is referred to as the “double burden of malnutrition” and shows how complex the health challenges in LMICs are.

The burden of disease in LMICs has changed significantly in recent decades. While infectious diseases such as pneumonia or diarrheal diseases used to be the main causes of illness and death, non-communicable diseases (NCDs) such as cardiovascular diseases, cancer, diabetes and chronic respiratory diseases are now rapidly increasing. This development means that LMICs are confronted with a double burden of disease: They must continue to fight infectious diseases while dealing with the increasing burden of NCDs.

Inadequate healthcare is particularly problematic. While prosperous countries have modern treatment options and well-developed healthcare systems, many LMICs lack the financial and infrastructural resources to ensure adequate care. As a result, many people, especially in rural regions or poorer sections of the population, do not have access to necessary medication or treatment. While a woman in Japan, for example, receives an average of 550 US dollars worth of medication per year, a woman in Sierra Leone has an average of only 3 US dollars at her disposal.

In addition to financial constraints, social and economic factors also exacerbate the situation. Unhealthy diets, lack of exercise, smoking and alcohol consumption contribute to the rising prevalence of NCDs, but preventative measures are not consistently implemented in many LMICs. Instead of pragmatic decisions such as smoking bans, alcohol controls or the promotion of exercise and healthy eating, many governments limit themselves to signing international agreements and recommendations without actively implementing them.

A major reason for this passivity is the economic situation of many LMICs: a large proportion of the population lives in poverty, often on less than two dollars a day, and around 1.3 billion people live in remote rural areas without adequate medical infrastructure. In addition to a lack of financial resources, however, poor administration and a lack of political will also contribute to the absence of urgently needed reforms. The high costs of treating chronic diseases also exacerbate social inequalities both between countries and within societies (Boutayeb & Boutayeb, 2005).

The main causes of death have changed considerably in recent decades. While half of the ten leading causes of death worldwide in 2000 were still attributable to communicable diseases such as infections, NCDs were clearly in the foreground in 2019. Seven of the ten leading causes of death were NCDs, while three were still caused by infectious diseases.

However, this change did not happen at the same pace everywhere. In economically strong regions such as Europe and the Western Pacific, NCDs already dominated in 2019, accounting for nine of the ten leading causes of death. Only lower respiratory tract infections remained among the leading causes. In poorer regions, particularly in Africa, infectious diseases continued to be the main cause of death: seven of the ten most common causes of death there were still communicable diseases (WHO, 2024a).

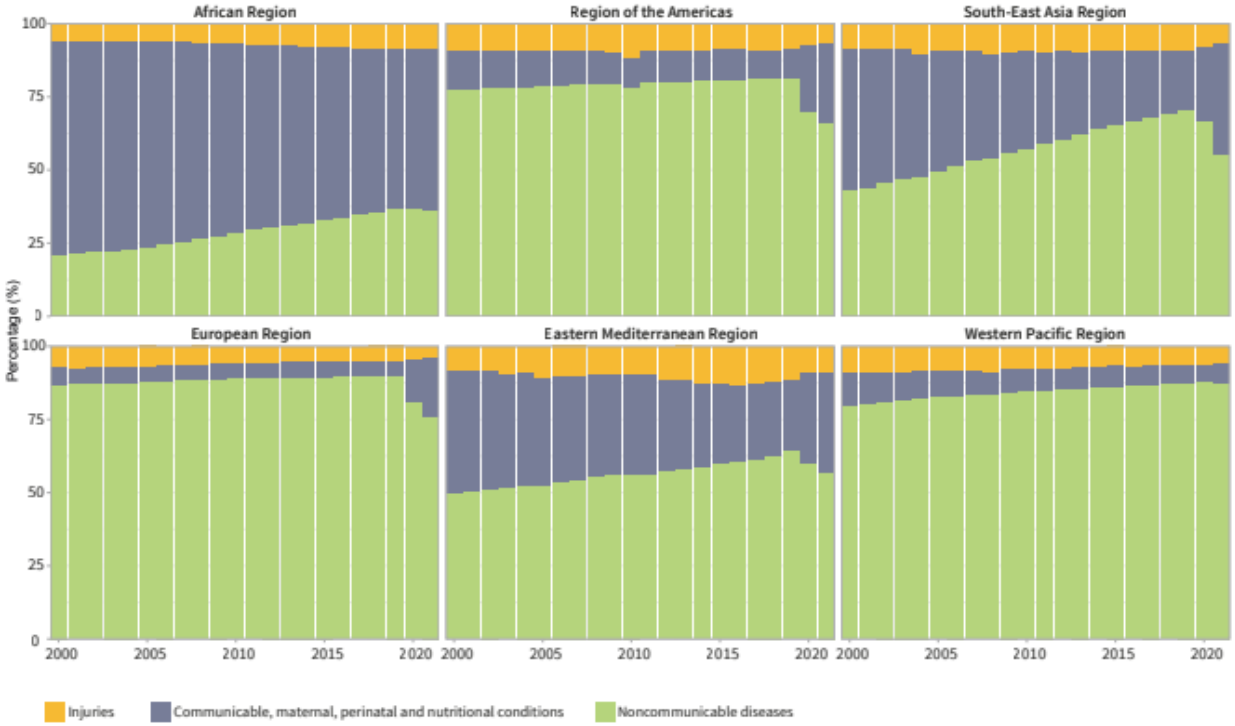


***Figure 4: Composition of causes of death, by WHO region, 2000–2021. Source: WHO (2024)***

Figure 4 shows that NCDs are the most common causes of death in high-income countries, while this is not yet the case in LMICs. Nevertheless, a steady increase in NCDs can also be observed in poorer countries. In all regions, the number of deaths from communicable diseases has increased slightly since the start of the COVID-19 pandemic in 2019.

The importance of the environment for children's PA is undisputed. Factors such as the layout of the route to school, the availability of playgrounds or sports facilities and general safety in public spaces play a decisive role in whether children exercise regularly or not. However, this relationship has not yet been sufficiently investigated in LMICs. While there are numerous studies on PA behavior and health risks in wealthier countries, in many low- and middle-income regions there is a lack of systematic analysis of environmental factors that may promote or limit PA.

With this in mind, it is important to examine in more detail how a physical activity-friendly environment influences the PA behavior of schoolchildren in LMICs. While existing research often looks at either the general health situation or the social and economic situation of children in LMICs, this master's thesis takes a specific perspective: it focuses on the direct relationship between environmental factors and the PA behavior of schoolchildren. The focus is not only on infrastructural aspects, but also on social and cultural conditions that determine whether children have sufficient opportunities for PA.

A systematic analysis of existing studies will be used to determine which environmental characteristics are particularly conducive or inhibitory to PA and what differences exist between socio-economic groups. The results of this thesis can help to develop more targeted measures to promote PA in LMICs and provide decision-makers with a solid basis for future projects. By systematically bringing together existing findings on environmental factors and PA behavior, the master's thesis makes an important contribution to the scientific debate on this topic.

## 1.1 Theory and State of Research

### 1.1.1 Effects of Physical Activity

It is now very well researched that PA is beneficial for physical and mental health. The study by Ortega et al. (2008) showed that PA and fitness play a central role in various health parameters in children, adolescents and adults. Particularly in the context of obesity, it was shown that higher cardiorespiratory fitness is associated with a lower body fat percentage. This applies to both normal-weight and overweight children who, despite their higher weight and good fitness, have on average less body fat than their unfit peers.

In addition, a good level of fitness has a positive influence on cardiovascular health. Children and adolescents with a high level of endurance and muscle strength have a more favorable cardiovascular risk profile and are less likely to have elevated blood lipid levels, insulin resistance or high blood pressure. In the long term, a high level of fitness significantly reduces the risk of cardiovascular disease. PA also plays a crucial role in bone health. Muscle strength and speed in particular are directly linked to higher bone density. Children who exercise regularly before puberty benefit from better bone health in the long term and have a lower risk of osteoporosis in adulthood.

Mental health can also benefit from PA. The review by Mahindru et al. (2023) shows that regular exercise can increase general well-being and have a positive effect on various mental illnesses. A key mechanism is the improvement of the hypothalamic-pituitary-adrenal axis (HPA axis), which plays a crucial role in stress regulation. Exercise reduces the release of cortisol, which can have a positive effect on stress, anxiety and depressive symptoms. PA also promotes the production of endorphins and endocannabinoids, which have a mood-enhancing effect and reduce the sensation of pain.

Exercise has particularly positive effects on depression and anxiety disorders. Regular PA can alleviate depressive symptoms as effectively as conventional antidepressants. It has also been shown that exercise improves the quality of sleep, which is crucial for mental regeneration.

Another factor why PA is particularly important for children and adolescents is the effect on cognition. The meta-analysis by Sibley & Etnier (2003) illustrates a positive correlation between PA and the cognitive performance of children. The results show that regular exercise is associated with improved cognitive abilities, particularly in the areas of attention, memory, problem solving and academic performance. Children in primary school and early adolescence particularly benefit from PA, as exercise not only improves blood flow to the brain, but also promotes the release of neurotransmitters and growth factors that are important for neuronal development. In addition, children who are regularly physically active often show better concentration and greater mental flexibility. The study confirms that PA does not have a negative impact on academic performance, on the contrary, programs that allow more time for exercise showed either no negative effects or even improvements in academic performance in several studies.

Another key finding is that different types of PA can have positive effects on cognition, be it endurance training, strength training or sports games. The effects are particularly clear in the case of motor and coordination challenges, which also promote cognitive processes such as spatial thinking or strategic planning.

### 1.1.2 Influence of the Environment on Movement Behavior

The following section explores the question of whether and how a physical activity-friendly environment can improve overall PA behavior in adults, adolescents, and children. The focus is primarily on studies conducted in high-income countries.

A physical activity-friendly environment can influence PA behavior. Physical activity-unfriendly environments are particularly evident in urban areas, where many people live in a confined space. The built environment tends to promote prolonged sitting. Increased traffic and unsafe neighborhoods are also characteristic of a physical activity-unfriendly environment. Many countries are attempting to counter these conditions by creating environments that are more conducive to PA. Specific measures include the development of safe walking routes, public sports fields and playgrounds, and the creation of safe neighborhoods.

The qualitative study by Perera et al. (2022) investigated the factors influencing PA in urban, physical activity-friendly environments in Sri Lanka. The findings show that despite improved infrastructure, many people remain physically inactive. A key barrier is lack of time, as long working hours, professional commitments, and family responsibilities often leave little room for PA. In addition, negative experiences such as exhaustion or discomfort after exercising, as well as misconceptions about the necessity of PA, were reported as obstacles. For example, some participants believed that a healthy diet could substitute for PA. Environmental factors such as unfavorable weather conditions or lack of traffic safety, on the other hand, were perceived less frequently as limiting factors.

Nevertheless, numerous motivational factors were identified. Many people view PA as a means of disease prevention, improving physical fitness, and enhancing general well-being. Social factors also play a significant role: support from family and friends, as well as medical advice, were cited as key incentives for adopting a more active lifestyle.

These findings illustrate that a physical activity-friendly environment alone is not sufficient to sustainably change people's PA behavior. While good infrastructure can improve the conditions for PA, structural and personal barriers persist without targeted measures to promote an active lifestyle. Educational programs to raise awareness of the health benefits of PA, flexible working hours to better balance work and PA, and social incentives could help motivate more people to adopt an active lifestyle. For cities to truly become environments that promote PA, societal and individual factors must be considered alongside infrastructure.

While Perera et al. focus on individual and social factors, the study by Saelens and Handy highlights that the physical design of the environment also plays a crucial role in influencing PA behavior. The study by Saelens & Handy (2008) examines the impact of the built environment on PA, particularly walking. The findings show that certain urban design features can promote PA. High population density, a good mix of residential and commercial areas, and high accessibility to destinations such as shops and public facilities have particularly positive effects. People in such environments are more likely to walk, as distances are shorter and walking is more convenient.

A well-developed street and path infrastructure, including safe sidewalks and well-connected streets, can also positively influence walking behavior. Especially in densely populated areas, direct and attractive routes improve access to everyday destinations and encourage people to walk more frequently. Aesthetic aspects also play a role: an appealing environment with green spaces and a pleasant atmosphere can increase motivation for PA.

For children, safe routes to school are particularly important. Good pedestrian infrastructure and traffic-calmed zones increase the likelihood that children will walk to school. Measures such as better lighting, safe crossings, and sidewalks along school routes can positively influence PA behavior.

In addition, further studies show that access to recreational facilities such as parks, playgrounds, or sports fields is associated with higher PA levels in adults, adolescents, and children. People with good access to green spaces or walkways are almost twice as likely to meet PA recommendations compared to those without such opportunities (Diez Roux et al., 2007). Sports fields, playgrounds, and walkways in particular are more effective in promoting PA than open spaces or picnic areas (see Figure 5) (Floyd et al., 2008). Among adolescents, proximity to recreational facilities, especially within one kilometer of their residence, has also been shown to positively influence PA (Frank et al., 2007). In this context, not only the mere availability but also the quality and design of these places play a role. Paths with good lighting, a well-maintained condition, and a mix of urban and natural surroundings are used more frequently than unattractive or unsafe routes (Reynolds et al., 2007).

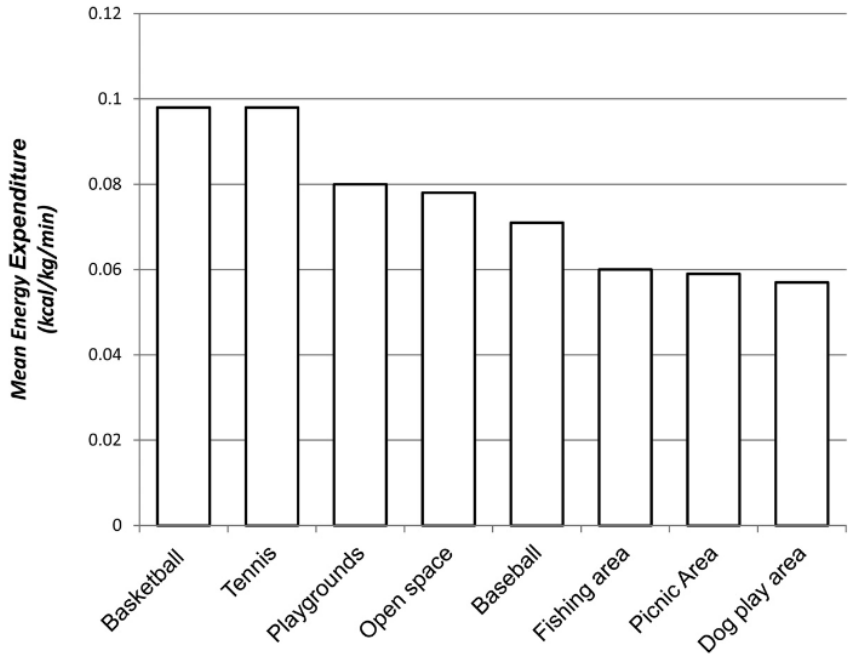


***Figure 5: Mean energy expenditure (kcal x kg $^{-1}$ x min$^{-1}$) per park in 10 Tampa, FL, neighborhood parks by activity zones (N 6922). Source: Floyd et al. (2008)***

### 1.1.3 Physical Activity Behavior in LMICs

While the previous chapter explained the general relationship between the built environment and PA behavior, this chapter focuses specifically on PA behavior in LMICs. This includes, among other things, an examination of how LMICs differ from wealthier countries with regard to PA behavior, infrastructure, and political measures.

The Global Action Plan on Physical Activity 2018–2030 (GAPPA) by the WHO pursues the goal of reducing physical inactivity worldwide by 15% by the year 2030. The plan provides a comprehensive political framework to implement effective strategies to increase PA in LMICs. In this context, four strategic areas are particularly emphasized: active societies, active environments, active people, and active systems. GAPPA acknowledges that LMICs have different starting conditions and that the proposed measures must be flexibly adapted to local circumstances and resources. Comprehensive strategies are recommended that take into account social, cultural, economic, and environmental factors in order to achieve sustainable change.

However, the practical implementation in LMICs reveals significant challenges. According to a WHO report, most countries do have national guidelines on PA, but only about 40% have derived concrete measures. It is particularly critical that only one of these countries is an LMIC. Reasons for this include a lack of financial resources, insufficient understanding of the local context, and inadequate cross-sector collaboration (Aguilar-Farias & Miranda-Marquez, 2021).

LMICs face particular challenges that have a significant impact on the PA behavior of their populations. These countries often struggle with socioeconomic difficulties such as high unemployment and underemployment, poor housing conditions, as well as high crime and violence rates. In addition, unstable political conditions and conflicts hinder the creation of a safe

and supportive environment for PA. Particularly critical in LMICs is the availability of public spaces for recreational activities as well as the quality of infrastructure for school sports.

Another important factor is that in LMICs, PA is mainly shaped by work-related or household-related activities and less by voluntary leisure activities, as is more common in wealthier countries. Transport-related PA in LMICs is also often not a conscious, health-oriented lifestyle, but rather a necessity due to the lack of or high costs of alternatives such as motorized transport.

The unequal living conditions mean that leisure activities should be brought to the forefront as a domain for targeted promotion measures. This is because leisure activities have the potential to provide not only health benefits but also social benefits, such as social cohesion and improved well-being. Therefore, leisure activities, if they are culturally adapted and socially accepted, can effectively contribute to a long-term increase in PA behavior (Crochemore-Silva et al., 2021).

In LMICs, PA is often not performed intentionally but rather arises as a consequence of occupational, household, or transport-related necessities. Although these domains account for the majority of moderate-to-vigorous PA in LMICs (96% in low-income countries, 92% in middle-income countries), they typically involve what are referred to as “incidental physical activities” - activities not undertaken for health-related purposes but driven by economic constraints or everyday necessities. Examples include household chores, work-related tasks, or the need to travel by inexpensive means.

At the same time, it raises the question of how effective strategies to promote activities such as housework or active transportation can be, when the basic living conditions of many people in LMICs are already difficult and concerns about road safety persist. For this reason, Crochemore-Silva et al. (2021) emphasize that efforts to promote PA in LMICs must be context-sensitive and must simultaneously address broader social and economic conditions in order to achieve sustainable success. Without this comprehensive approach, opportunities to effectively promote PA remain severely limited.

The systematic review by Elshahat et al. (2020) shows that certain characteristics of the built environment can influence PA behavior in LMICs, although not all features are equally effective. Mixed land use and proximity to public facilities such as parks and green spaces have particularly positive effects on daily PA. The availability of recreational facilities, in particular, leads to an increase in leisure-time PA. Another relevant factor is perceived safety from crime at night, which is consistently associated with higher overall activity levels and increased walking. In contrast, factors such as population density, aesthetics, or pedestrian and cycling infrastructure often show inconsistent associations and no consistent effects. Moreover, the study highlights a research gap: most findings are based on cross-sectional studies, limiting the ability to draw conclusions about causal relationships. The authors therefore recommend conducting longitudinal studies with objective measurement methods to generate robust evidence and develop effective interventions for LMICs.

In summary, Schulenkorf et al. (2021) emphasize that physical inactivity plays a central role in the global burden of NCDs, which are becoming an increasing health challenge, particularly in LMICs. Despite existing evidence on the health benefits of PA, significant gaps remain between theory and practice, especially due to limited financial resources, lack of infrastructure, and insufficient political prioritization.

It is clearly emphasized that interventions to promote PA in LMICs must be adapted to local contexts. Simply transferring successful approaches from high-income countries is often ineffective. Achieving meaningful change requires multisectoral collaboration, including policymakers, urban planners, educational institutions, and civil society. The authors call for greater investment in infrastructure, the creation of safe and attractive spaces for PA, and comprehensive political strategies to promote PA in a long-term and sustainable manner.

### 1.1.4 The Role of Schools in Promoting Physical Activity

Promoting PA in childhood has several long-term positive effects on health. First, it directly improves children's health status, which also enhances their quality of life. Furthermore, regular PA helps delay the onset of chronic diseases in adulthood. Another advantage is the increased likelihood that adults will maintain their activity levels later in life, which in turn positively affects their health. Schools play a central role in this process, as they are key institutions that lay the foundation for an active lifestyle by not only providing opportunities for PA but also fostering awareness of the importance of movement in daily life (Boreham & Riddoch, 2001).

How the school environment can specifically contribute to promoting a physically active lifestyle among schoolchildren is highlighted by Wechsler et al. (2000). The article by Wechsler et al. (2000) emphasizes that schools play a crucial role in promoting PA through the targeted design of the school environment. Schools can influence students' PA behavior in various ways. These include, in particular, measures such as introducing regular breaks in which children can engage in playful activities. By having a supervisor present to structure and guide the play, children's PA behavior could be effectively promoted (Kraft, 1989).

Another opportunity lies in the organization of intramural sports programs. Unlike competitive sports, which often focus on high-performing students, intramural programs enable the participation of students of all ability levels, providing an important source of motivation, especially for less sports-inclined or hesitant adolescents.

In addition, it has been shown that the accessibility and quality of school sports facilities have a significant impact on PA behavior. When students have access to diverse, safe, and appealing facilities, their willingness to be physically active increases. Examples include gymnasiums, sports fields, or swimming pools that are also available outside regular school hours (Garcia et al., 1995).

Finally, the article emphasizes that schools can also make a crucial contribution to promoting PA through psychosocial support. This includes clear school policies, administrative commitment, teacher role modeling, as well as incentives and reminders to encourage health-promoting behavior.

## 1.2 Research Question

The central research question of this master's thesis is: **"How does a physical activity-friendly environment affect schoolchildren's physical activity behavior in low- and middle-income countries (LMICs)?"**

The relevance of this question arises from the global challenge of increasing physical inactivity, particularly in LMICs, where economic, infrastructural, and social barriers limit the PA behavior of schoolchildren. The findings of this thesis aim to contribute to the development of evidence-based recommendations for targeted interventions to promote PA.

In order to comprehensively address the main research question, the following sub-questions are considered:

• Which specific environmental factors promote or hinder PA among schoolchildren in LMICs?
• What role do social, cultural, and infrastructural factors play?
• Are there gender differences in the effects of a physical activity-friendly environment?

## 1.3 Definitions

In order to clearly address the research question, the following key terms are defined:

### 1.3.1 Physical Activity

The WHO defines physical activity as any bodily movement produced by skeletal muscles that results in energy expenditure. This definition includes not only sports activities but also daily movements, leisure activities, play, and active transportation such as walking or cycling. PA can be performed at varying intensity levels and by individuals of all ages and ability levels (WHO, 2024). In this thesis, PA is considered in all its forms and intensity levels.

To further categorize the diverse forms of PA, the so-called SLOTH model is used. This model divides PA into five key life domains: sleep and rest, leisure and sports, occupational and school activities, transport and mobility, and home-based activities. The SLOTH model is particularly relevant to this thesis because it illustrates that PA is not limited to structured sports but also includes everyday activities such as walking to school or household chores. This is especially important in LMICs, where access to structured sports programs is often limited and children primarily engage in PA through daily activities such as active mobility (e.g., walking to school). The SLOTH model thus enables a differentiated perspective on how the design of a physical activity-friendly environment can influence different life domains and thereby increase the overall PA of children and adolescents (Pratt et al., 2004).

### 1.3.2 Physical Activity-Friendly Environment

The term “physical activity-friendly environment” is multifaceted and can have various meanings, which are explained in more detail below.

The built environment refers to the human-made part of the physical environment, shaped by architecture, infrastructure, and urban planning. It essentially comprises three key components: the spatial structure of land use, meaning the arrangement of residential, work, and recreational spaces; the transport system, which includes roads, sidewalks, and bicycle paths as well as public transportation; and urban design, which influences the layout and aesthetics of these elements.

This definition of the built environment is central to the concept of a physical activity-friendly environment. Such an environment promotes active mobility through well-developed infrastructure with safe sidewalks and bicycle paths, traffic-calmed areas, and urban planning that integrates movement as a natural part of everyday life. For children and adolescents in particular, the design of their surroundings is crucial, as it significantly influences how often and how naturally PA is incorporated into their daily routines (diez & Handy, 2008).

A physical activity-friendly environment can therefore be defined as a physical setting intentionally designed to integrate health and well-being as core components of the community.

This includes elements such as open spaces, sidewalks, bicycle paths, parks, and recreational areas that support active movement and improve the population's quality of life (Renalds et al., 2010).

The versatility of the term "physical activity-friendly environment" is illustrated below. It encompasses a wide range of factors located in different areas of the environment that support PA at various levels. At the individual level, biological and psychological factors as well as personal abilities play a role. However, these individual preconditions are strongly influenced by external environmental levels.

The first environmental level concerns the PA domains, those areas where movement typically takes place: recreational activities, transport (active mobility such as walking or cycling), occupational and school-related activities, and household tasks. At a broader level, the social and cultural environment is crucial. Social support, societal norms, and media role models significantly influence the extent to which PA is perceived as an integral part of daily life. The location of schools and workplaces also plays a role, particularly if they provide easy access to public transportation, sidewalks, and bicycle paths. The built environment includes a variety of infrastructural conditions that can either facilitate or hinder movement. Key elements are well-developed sidewalks and bicycle paths, optimized by factors such as accessibility, connectivity, design, quality, and safety. Parks and recreational facilities must be both easily accessible and attractively designed. The design of schoolyards and sports facilities, as well as the provision of PA programs, are also central components of a physical activity-friendly environment. At the highest level stands the political environment, which creates the framework for an active environment through regulations and policies. Zoning and development regulations influence land use density and diversity, which can lead to walkable neighborhoods. Standards for road construction, traffic safety, and infrastructure measures also directly affect opportunities for active transportation. In addition, political measures such as tax incentives for sports equipment or funding programs for expanding pedestrian and cycling infrastructure play a role in promoting an active society (Sallis et al., 2012).

### 1.3.3 Schoolchildren

The term "schoolchildren" refers to children and adolescents who attend an educational institution. In this thesis, the definition includes students aged 6 to approximately 19 years, as this typically represents the period during which children attend primary or secondary school.

This age group is particularly relevant for examining the influence of a physical activity-friendly environment, as children and adolescents are strongly shaped by their surroundings during their school years. The route to school, the design of the school grounds, and school-based opportunities for PA play a crucial role in their PA behavior.

This thesis considers both primary school children (6–12 years) and adolescents in secondary education (13–19 years), as their PA behavior may vary depending on their age group.

### 1.3.4 LMICs

The term "Low- and Middle-Income Countries" (LMICs) is based on the World Bank's income classification for the fiscal year 2025. This classification is determined according to gross national income (GNI) per capita. LMICs include three income groups:

- Low-Income Countries (LICs): countries with a GNI per capita of USD 1,145 or less (as of 2023).
- Lower-Middle-Income Countries: countries with a GNI per capita between USD 1,146 and 4,515.
- Upper-Middle-Income Countries: countries with a GNI per capita between USD 4,516 and 14,005 (World Bank Country and Lending Groups, n.d.).

LMICs comprise a wide range of countries in Africa, Asia, Latin America, and parts of Europe. Examples of LICs include Chad, Afghanistan, and Mozambique, while countries such as India, Nigeria, and the Philippines fall into the category of Lower-Middle-Income Countries. Upper-Middle-Income Countries include, among others, Brazil, South Africa, and China. These countries display considerable differences in economic development, infrastructure, and health systems, but often share structural challenges in public health provision and urban planning.

## 1.4 Structure of the Thesis

The first chapter (see above), the introduction, provides an overview of the topic and explains the relevance of the study. It describes the importance of PA for children and adolescents, as well as the global challenges associated with physical inactivity, particularly in LMICs. In addition, it addresses the double burden of disease in these countries, which includes both communicable and NCDs. The central research question is derived and justified, explaining its scientific and societal significance.

The second section of the introduction presents the theoretical background (see above). It first explains the positive effects of PA on physical and mental health. This is followed by an analysis of how various environmental factors can influence PA behavior, considering findings from both high-income countries and LMICs. Particular attention is paid to infrastructural, social, and economic factors, as well as the role of schools as promoters of PA.

The third part of the introduction is dedicated to the research question and the definitions of key terms (see above). In addition to formulating the research question in detail, essential concepts such as PA, physical activity-friendly environment, schoolchildren, and LMICs are defined. These definitions are based on internationally recognized sources, such as the WHO and the World Bank.

The second chapter describes the methodology of the thesis and explains the approach of the systematic literature review. It outlines the databases used, the search strategy, the inclusion and exclusion criteria, as well as the procedure for analyzing and categorizing the identified studies. Furthermore, it explains the criteria used to assess the methodological quality of the included studies. This chapter ensures the transparency and reproducibility of the study and allows the results to be replicated.

The third chapter presents the results of the analysis. The findings are organized in a structured manner and categorized according to the identified factors of a physical activity-friendly environment influencing the PA behavior of schoolchildren in LMICs. A table is used to clearly present the key findings. The focus of this chapter is on the presentation of the results, while interpretation is initially set aside.

The discussion in the fourth chapter places the results within the existing body of research and situates them in a broader context. Possible explanations for differences between the analyzed studies are discussed, as well as the limitations of the study. Furthermore, the practical implications that can be derived from the findings are analyzed.

The concluding fifth chapter summarizes the main findings and provides an outlook on potential future research directions.

## 2 Methods

This systematic literature review was conducted using the PRISMA 2020 Flow Diagram (see below). In developing the search terms for the literature review in this master's thesis, a systematic and structured approach was adopted, drawing on the information literacy skills acquired during the first semester of the bachelor's program (see Table 1).

First, a component breakdown was applied, in which the research question was divided into separate blocks. In this case, the blocks were "physical activity-friendly environment," "physical activity behavior," "schoolchildren," and "LMICs." This approach facilitated the identification of relevant keywords, along with synonyms, headings, and subheadings for each component, thereby enabling a broader range of search terms. Thesauri were consulted to identify synonyms and related terms. This method allowed the expansion of the initial vocabulary and the discovery of additional relevant terms commonly used in the scientific literature.

| **Question: How does a physical activity-friendly environment affect schoolchildren's physical activity behavior?** | | | | |
|---|---|---|---|---|
| **Key terms of the topic** | Physical activity-friendly environment | Physical activity behavior | schoolchildren | Low- and middle-income countries (LMIC's) |
| **Synonyms** | Active environment, activity promoting environment | Active behavior, exercise behavior, active lifestyle behavior | Pupils, school kids | Global south, developing countries |
| **General Terms** | Built environment, environment, urban planning, infrastructure, urban design, community design, public spaces, safe environment | Health behavior, exercise habits, movement behavior, exercise | Youth, young people, students, adolescents, children | Global south, developing countries |
| **Sub-terms** | Active transportation, playgrounds, parks, green spaces, neighborhood safety, walkability | Physical fitness, active commuting, sedentary behavior | Elementary school children, middle school students, high school students, preschoolers | Lower-middle-income countries (LMICs), upper-middle-income countries (UMICs) |
| **Related Terms** | Active lifestyle environment, walkable communities | Active living, movement habits, participation, patterns | School-aged youth, young learners | |

***Table 1: Component decomposition of the research. Source: author's own work, Ammann (2024)***

### 2.1 Search Terms

Boolean search operators were used to further enhance the relevance of the search queries. The targeted use of AND, OR, and NOT allowed the terms to be combined in a way that yielded more precise results. For example, combinations such as "physical activity-friendly environment AND physical activity behavior AND schoolchildren" were used to ensure that the search

results covered all aspects of the research question. This methodological approach is essential for creating a comprehensive and high-quality literature base that serves as the foundation for the master's thesis. "Low- and middle-income countries" was rarely included in the search terms, as the results became too imprecise and no additional relevant studies for the research question were identified.

The following search terms were used for this master's thesis.

### 2.1.1 PubMed

- environment AND physical activity AND schoolchildren
- ("urban design" OR "public spaces" OR "school infrastructure") AND "physical activity" AND "children"
- ("safe environment" OR "active transportation") AND "children" AND "physical activity"

- ("physical activity" OR "exercise" OR "active lifestyle") AND ("children" OR "schoolchildren" OR "students" OR "youth") AND ("environment" OR "built environment" OR "activity-friendly environment") AND ("LMIC" OR "low-income countries" OR "developing countries" OR "Global South") AND ("behavior" OR "habits" OR "patterns" OR "participation")

### 2.1.2 Scopus

- TITLE-ABS-KEY ("urban design" OR "public spaces" OR "school infrastructure") AND "physical activity" AND "children")
- ("physical environment" AND "physical activity" AND "children" AND "schools")
- (("green spaces" OR "playgrounds") AND "physical activity" AND "schoolchildren")
- "built environment" AND "physical activity" AND "schools" AND "developing countries"
- TITLE-ABS-KEY ( ( "community design" OR "infrastructure" OR "neighborhood safety" ) AND "physical activity" AND "children" ) AND ( LIMIT-TO ( AFFILCOUNTRY , "Brazil", "China", "Mexico", "India", "South Africa", "Nigeria", "Kenya", "Colombia", "Ghana", "Malaysia", "Iran", "Mozambique", "Indonesia", "Chile", "Venezuela", "Ethiopia", "Ecuador", "Bangladesh", "Vietnam", "Uzbekistan", "Uruguay", "Uganda", "Tanzania", "Peru", "Guatemala", "Cameroon" ) ) AND ( LIMIT-TO ( LANGUAGE , "English" ) ) AND ( LIMIT-TO ( DOCTYPE , "ar" ) )
- TITLE-ABS-KEY ( children OR adolescents OR schoolchildren AND physical AND activity AND environment AND developing AND countries ) AND ( LIMIT-TO ( EXACTKEYWORD , "Developing Country" ) OR LIMIT-TO ( EXACTKEYWORD , "Developing Countries" ) OR LIMIT-TO ( EXACTKEYWORD , "Environment" ) OR LIMIT-TO ( EXACTKEYWORD , "Child, Preschool" ) OR LIMIT-TO ( EXACTKEYWORD , "Children" ) OR LIMIT-TO ( EXACTKEYWORD , "School" ) OR LIMIT-TO ( EXACTKEYWORD , "Environment Design" ) OR LIMIT-TO ( EXACTKEYWORD , "Health Behavior" ) OR LIMIT-TO ( EXACTKEYWORD , "Environmental Planning" ) OR LIMIT-TO ( EXACTKEYWORD , "Urban Area" ) OR LIMIT-TO ( EXACTKEYWORD , "Built Environment" ) OR LIMIT-TO ( EXACTKEYWORD , "Traffic And Transport" ) ) AND ( LIMIT-TO ( DOCTYPE , "ar" ) ) AND ( LIMIT-TO ( LANGUAGE , "English" ) )

### 2.1.3 VHL

- ("built environment") AND ("physical activity") AND ("schools") AND mj:("Schools" OR "Environment Design" OR "Health Promotion" OR "Transportation" OR "Walking" OR "Built

Environment" OR "Health Behavior" OR "Environment" OR "Students" OR "Bicycling" OR "Safety") AND instance:"regional"

### 2.1.4 BASE

- ("physical activity" OR "exercise" OR "active lifestyle") AND ("children" OR "schoolchildren" OR "students" OR "youth") AND ("environment" OR "built environment" OR "activity-friendly environment") AND ("LMIC" OR "low-income countries" OR "developing countries" OR "Global South") AND ("behavior" OR "habits" OR "patterns" OR "participation")
- ("community design" OR "infrastructure" OR "neighborhood safety") AND "physical activity" AND "children" Limit to English

### 2.1.5 EBSCO

- "physical environment" AND "physical activity" AND "children" AND "schools"
- ("urban design" OR "public spaces" OR "school infrastructure") AND "physical activity" AND "children"
- "built environment" AND "physical activity" AND "schools"
- ("safe environment" OR "active transportation") AND "children" AND "physical activity"
- ("community design" OR "infrastructure" OR "neighborhood safety") AND "physical activity" AND "children"

## 2.2 Prisma 2020 Flow Diagram

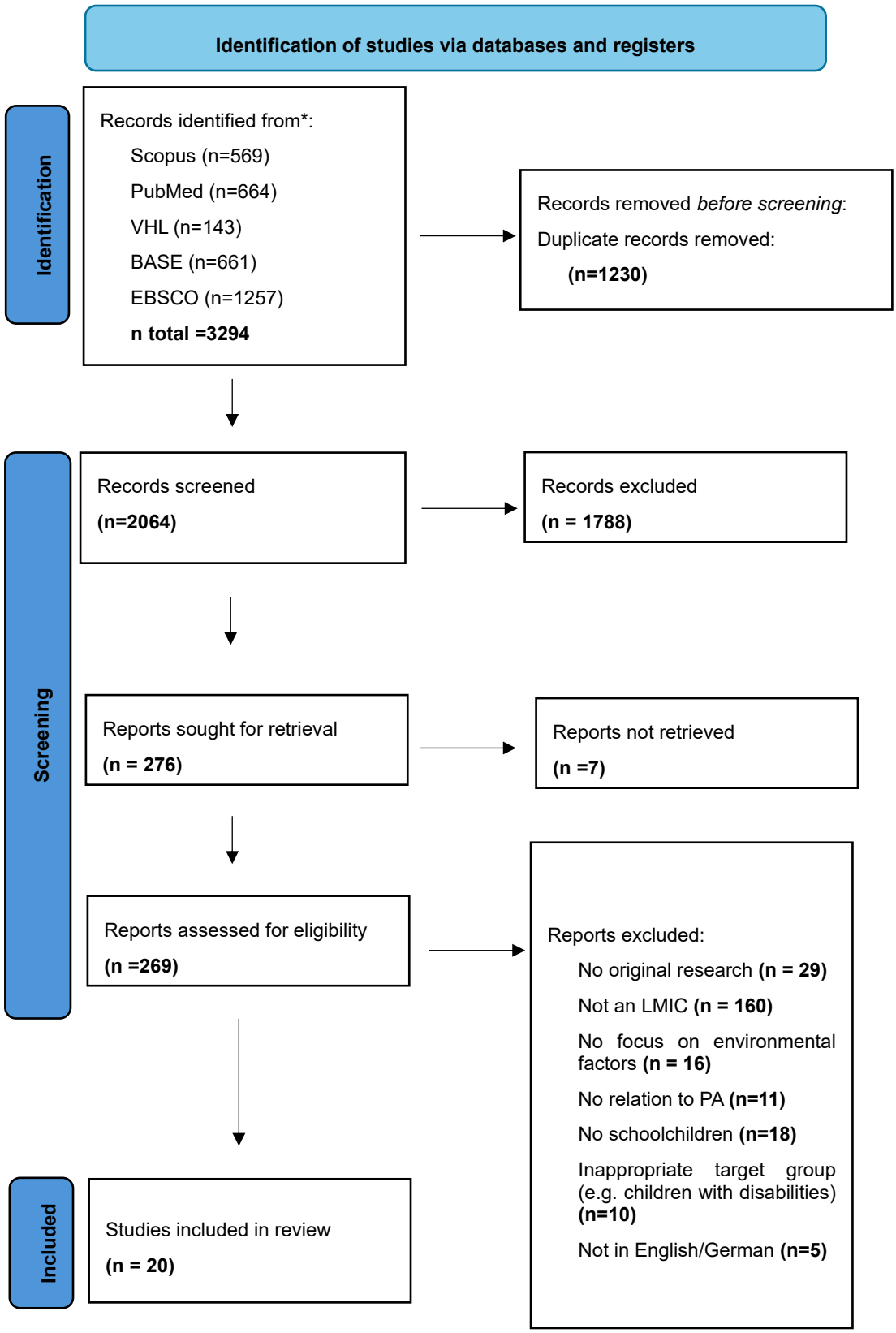


***Table 2 Prisma 2020 Flow Diagram for systematic reviews. Source: Page et al. (2021).***

To systematically examine how a physical activity-friendly environment influences the PA behavior of schoolchildren in LMICs, the process of selecting the literature was documented using the PRISMA flow diagram. This internationally recognized tool enables a transparent, standardized, and traceable presentation of the selection process for scientific studies, ensuring that all steps, from identification to final inclusion, can be methodologically tracked.

The literature search was conducted between December 2024 and February 2025 across five scientific databases: Scopus, PubMed, VHL (Virtual Health Library), BASE, and EBSCO. In total, 3,294 publications were identified: 569 from Scopus, 664 from PubMed, 143 from VHL, 661 from BASE, and 1,257 from EBSCO. All search results were then consolidated, and duplicate records were removed using Zotero. A total of 1,230 duplicates were eliminated, leaving 2,064 unique studies.

In the next step, the titles and abstracts of these 2,064 studies were screened, resulting in the exclusion of 1,788 studies that did not meet the basic inclusion criteria at this stage. After abstract screening, 276 studies were assessed for full-text eligibility. Seven of these could not be obtained in full text despite extensive efforts, leaving 269 studies for detailed full-text analysis.

As part of this full-text analysis, 248 studies were excluded. The most common reasons for exclusion were:

- In 160 cases, the study was not conducted in a LMIC and therefore did not meet the LMIC criteria.
- 29 studies did not constitute original research but were review articles, conceptual papers, or commentaries.
- In 18 cases, the study did not target the population of schoolchildren.
- 16 studies did not examine environmental factors in relation to PA.
- 11 studies focused on children but not on PA (e.g., focusing solely on nutrition or screen time).
- 10 studies investigated specific subgroups, such as children with disabilities, who were not part of the target population of this thesis.
- 5 studies were not available in English or German and could not be considered.

The selection of studies was carried out in several steps. Both the screening of titles and abstracts and the assessment of full texts for inclusion criteria were conducted by a single reviewer. No automated screening or selection tool was used in the process.

To improve the structure and enable comparative analysis, the identified studies were categorized into two thematic clusters, depending on the type of environmental factor they focused on. Cluster 1 includes studies focusing on physical and infrastructural environmental factors (e.g., parks, playgrounds, street infrastructure, traffic safety, etc.). Cluster 2 comprises studies focusing on social and educational environmental conditions (e.g., school-based programs, peer effects, school policies, etc.). This classification served to systematically organize the studies for the subsequent presentation and discussion of results.

For the systematic analysis, all findings were considered that related to the following outcome variables:

- PA (e.g., MVPA, active commuting to school, leisure-time sports activities)
- physical inactivity (e.g., sedentary behavior)
- anthropometric data (e.g., BMI, body fat percentage)
- perceived or objectively measured environmental conditions
- gender-specific or socioeconomic differences in physical activity behavior

All reported results were included, provided they could be categorized within these five domains. Different measurement instruments and analysis periods were accepted.

The findings of these studies are presented in a tabular overview to provide a quick summary of key data and results. The table includes the following characteristics: authors' names, year of publication, country, study design, sample size and age group of the target population, type of environmental factors or interventions assessed, method of measuring PA, main findings, and classification into one of the two clusters. The studies are listed alphabetically by the author's name. In the results column, summary statistics (e.g., odds ratios, regression coefficients, or percentages) were also included wherever possible and meaningful to enhance the interpretability of the findings.

## 2.3 Risk of Bias

To assess the risk of bias in the included studies, an evaluation framework based on the AXIS tool (Appraisal tool for Cross-Sectional Studies) was applied. The AXIS tool was originally developed for the critical appraisal of cross-sectional studies and comprises 20 individual questions. For the present study, the tool was used in a slightly modified form to allow for a clearer presentation of the results and analysis using the visualization tool robvis (Risk of Bias Visualization). Another reason for this adaptation was that only 16 of the 20 studies were cross-sectional studies; three were qualitative studies and one was a longitudinal study.

Instead of the 20 individual questions, six overarching evaluation domains were defined to capture key quality aspects of the studies (see Table 3). These categories combine multiple items from the AXIS tool to enable a more systematic and visualized assessment. Each domain was rated using one of four possible judgments: low, moderate, serious, or no information. In addition, an overall risk of bias rating was provided for each study.

The evaluation of the individual studies was conducted by a single reviewer. No automated tools were used in the assessment process. The results of the bias assessment were then processed using the robvis tool to enhance the transparency and traceability of the evaluation.

| Domain | Description |
|---|---|
| Target group and sampling | Clearly defined and appropriate population |
| Representativeness | Does the sample match the target population? |
| Validity of measurement instruments | Were reliable methods used? |
| Handling of confounders | Were influencing factors identified/considered? |
| Data completeness | Handling of missing data |
| Transparency of reporting | Were all results reported without selective reporting? |

***Table 3: Definition of the criteria for the risk of bias assessment of the included studies. Source: author's own work, Ammann (2024)***

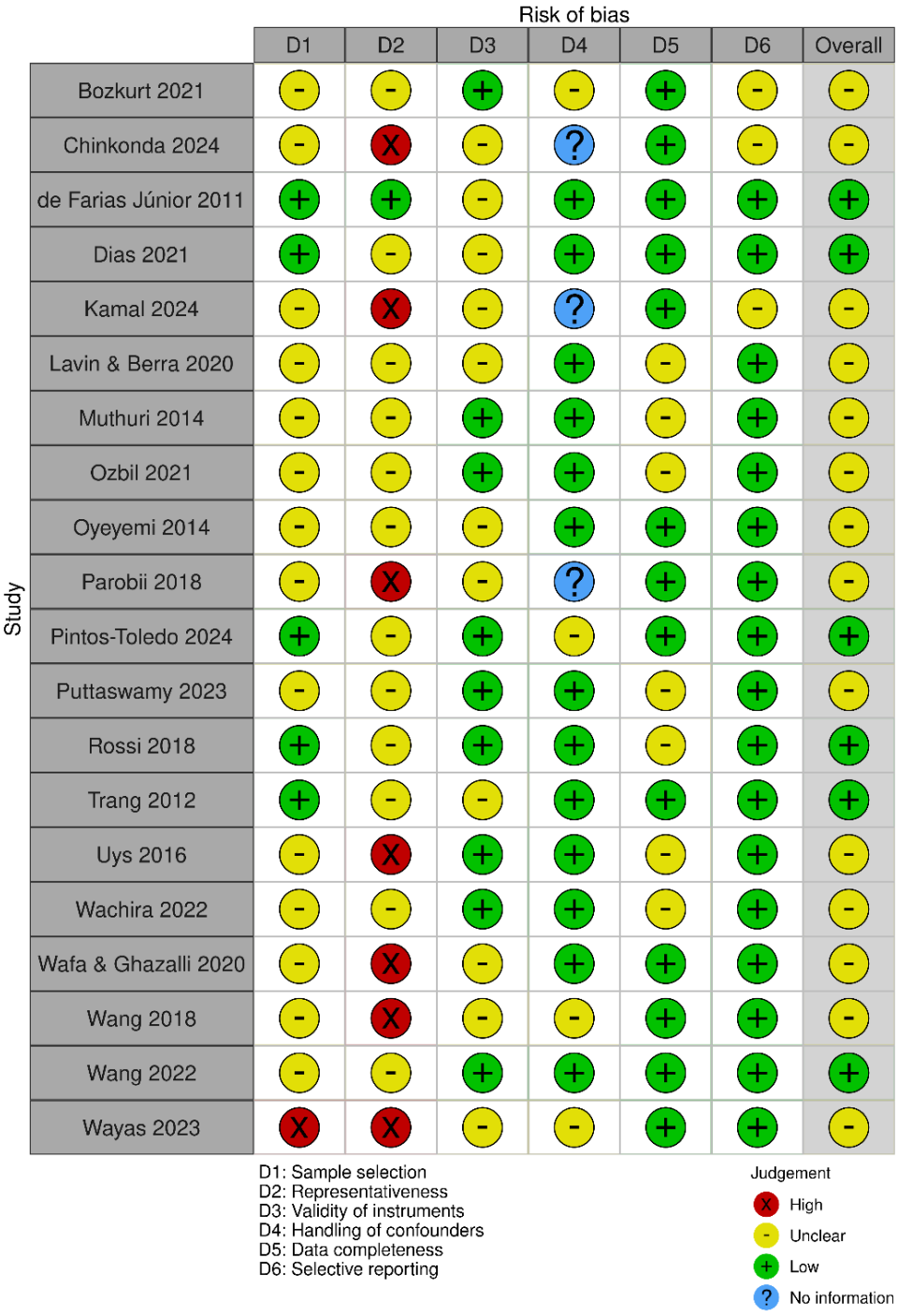


***Table 4: Traffic light plot, made with robvis. Source: McGuinness & Higgins (2020)***

## 3 Results

The results of the 20 included studies are presented below starting on page 30 in tabular form. As previously mentioned, the table organizes the following characteristics: author, country, study design, sample size, age, type of environmental factors, method for assessing PA, results, and thematic cluster.

| Author(s) (year) | Country (City) | Study design | Sample size | Age | Type of environmental factors or interventions assessed | Method for assessing PA | Results (incl. summary statistics) | Cluster |
|---|---|---|---|---|---|---|---|---|
| Bozkurt (2021) | Turkey (Istanbul) | Cross-sectional study | N=2668 (24 schools, 4 districts) | 6-18 years | Proximity to and use of urban green spaces; quality of green spaces; type of housing (gated vs. non-gated communities) | Self-reported use of green spaces via questionnaire; measurement of BMI | ▪ Higher use of green spaces was linked to lower odds of overweight (OR = 0.71; p = 0.032).<br>▪ Proximity to green spaces increased use (OR = 0.19; p < 0.001).<br>▪ Higher perceived quality increased use (OR = 0.23; p < 0.001).<br>▪ Living in gated communities was linked to higher odds of overweight (OR = 1.29; p = 0.048). | 1 |
| (Chinkonda et al., 2024) | Malawi (Blantyre) | Qualitative study | 24 participants (12 parents, 12 teachers) | Children as focus: 12–16 years | Traffic safety (e.g., driver behavior, condition of infrastructure), personal safety, and air pollution from traffic emissions | No direct measurement. The study focuses on risks and barriers to walking to school from the community's perspective | ▪ Risky driver and motorcyclist behavior increased perceived danger for school travel.<br>▪ Lack of infrastructure (e.g. sidewalks, crossings) contributed to unsafe school travel.<br>▪ Limited parental supervision increased risks for younger children.<br>▪ Suggested solutions included improved education, stronger law enforcement, and better infrastructure. | 1/2 |
| De Farias Júnior et al. (2011) | Brasil (João Pessoa) | Cross-sectional study | N=2874 (16 public, 14 private schools | 14-19 years | Subjectively perceived characteristics of the social and built environment (assessed using a Likert scale): infrastructure (e.g., well-maintained facilities, bike paths), social environment (e.g., presence of other active adolescents), proximity to preferred places, safety, cleanliness, and accessibility | Questionnaire on frequency and duration of 24 activities (self-reported) | ▪ A positive environmental perception was associated with higher physical activity.<br>▪ Seeing other active boys increased PA (OR = 1.20; 95% CI: 1.05–1.56).<br>▪ Living closer to frequented places increased PA (boys: OR = 1.96; 95% CI: 1.40–2.78; girls: OR = 1.33; 95% CI: 1.10–1.74). | 1 |

| Author(s) (year) | Country (City) | Study design | Sample size | Age | Type of environmental factors or interventions assessed | Method for assessing PA | Results (incl. summary statistics) | Cluster |
|---|---|---|---|---|---|---|---|---|
| Dias et al. (2021) | Brasil (Porto Alegre) | Cross-sectional study | N=1130 | 14-20 years | Perceived environmental characteristics (via NEWS-Y): land use, recreational opportunities, access to services, aesthetics, safety, connectivity (measured with Likert scales); GIS-based objective assessment of residential density and street connectivity (1 km network buffer around the home address) | Questionnaire on school commuting (active vs. passive transportation, self-reported) | ▪ A positive environmental perception combined with high residential density was associated with higher active commuting.<br>▪ Residential density mediated the effect of land-use mix diversity (32%), recreation facilities (15%), and access to services (14%) on active commuting (all $p < 0.05$).<br>▪ Street connectivity was not significantly associated with active commuting. | 1 |
| Kamal et al. (2024) | Egypt (Kairo) | Qualitative study | N=25 | 6-8 years | Difference between conventional and nature-based playgrounds with a focus on natural elements (trees, grass, water, sand, animals, etc.) | Observation of play-related motor activities (e.g., running, climbing, balancing) in a natural setting – no direct measurement of activity in minutes or energy expenditure | ▪ Children on nature-based playgrounds were more physically active (e.g., running, climbing, balancing).<br>▪ Natural elements (trees, sand, water, grass) promoted more diverse motor activities.<br>▪ Nature play supported social skills (e.g., cooperation) and cognitive skills (e.g., imagination, problem-solving).<br>▪ Authors recommended enhancing conventional playgrounds with natural features. | 1 |
| (Lavin & Berra, 2020) | Argentina (Cordoba) | Cross-sectional study | N=1466 (19 schools) | 9-11 years | Socioeconomic context of neighborhoods (based on Unsatisfied Basic Needs, UBN), reflecting neighborhood-level poverty. Neighborhoods were categorized as favorable, intermediate, or critical residential areas | Frequency of public park use for PA was assessed | ▪ Children from wealthier neighborhoods used parks more for PA (boys: +48%; girls: +60%).<br>▪ Girls in critical neighborhoods had significantly lower park use (IRR = 0.58; 95% CI: 0.33–1.00).<br>▪ Socioeconomic inequality affected girls' activity more than boys'.<br>▪ Obesity was more prevalent in boys than in girls.<br>▪ Higher screen time was associated with lower PA. | 2 |

| Author(s) (year) | Country (City) | Study design | Sample size | Age | Type of environmental factors or interventions assessed | Method for assessing PA | Results (incl. summary statistics) | Cluster |
|---|---|---|---|---|---|---|---|---|
| (Muthuri et al., 2014) | Kenya (Nairobi) | Cross-sectional study | N=563 | 9-11 years | Via questionnaire: school environment (e.g., policies), neighborhood (trust, infrastructure, crime) | Measurement of BMI, objective measurement using accelerometer (ActiGraph GT3X+), supplemented by questionnaires | ▪ Only 12.6% of children met the MVPA guideline (≥60 min/day).<br>▪ 45.7% used active school travel (ACT).<br>▪ Higher SES (parental education, household income, private school attendance) was associated with higher odds of overweight/obesity and lower odds of meeting PA guidelines.<br>▪ Private school attendance was linked to higher odds of overweight/obesity (OR = 4.18; $p < 0.0001$).<br>▪ Private school attendance was linked to lower odds of meeting PA guidelines (OR = 0.04; $p < 0.0001$).<br>▪ Boys were more likely to meet MVPA guidelines than girls (OR = 2.63; $p = 0.0009$). | 1 |
| (Ozbil et al., 2021) | Turkey (Istanbul) | Cross-sectional study | N=1802 (20 schools) | 12-14 years | Both objective environmental factors (e.g., street connectivity) and subjective environmental factors (e.g., perceived sidewalk quality and presence of shade-providing trees) were assessed. Additionally, socioeconomic aspects and parental attitudes were taken into account | Self-reported school commute (active vs. motorized transportation) via student and parent questionnaires | ▪ Objective street connectivity (metric reach) was the strongest predictor of ACT.<br>▪ Parental perceptions of maintained sidewalks and shade-casting trees were associated with ACT ($p = 0.04$).<br>▪ Combining objective and perceived environmental factors predicted ACT better than individual factors. | 1 |
| (Oyeyemi et al., 2014) | Nigeria (Maiduguri City) | Cross-sectional study | N=1006 (11 schools) | 12-19 years | Perceived neighborhood characteristics assessed using PANES-N: residential density, access to destinations, street connectivity, infrastructure for PA, social environment, aesthetics, safety; additionally: moderation by neighborhood income | Self-report via AQuAA; assessment of active commuting time (min/week) and leisure-time MVPA | ▪ Boys were more active than girls (AT: 72.5 vs. 51.4 min/wk; MVPA: 408.2 vs. 153.9 min/wk).<br>▪ Among boys, access to destinations increased AT ($\beta = 0.18$; 95% CI: 0.67–2.24).<br>▪ Higher density and infrastructure increased leisure MVPA ($\beta = 0.10$; $\beta = 0.14$).<br>▪ In high-income boys, perceived safety reduced leisure MVPA ($\beta = –0.16$; 95% CI: –0.01 to –0.70).<br>▪ In low-income boys, perceived safety increased leisure MVPA ($\beta = 0.11$; 95% CI: –0.04 to 2.88).<br>▪ No significant associations in girls. | 1 |

| Author(s) (year) | Country (City) | Study design | Sample size | Age | Type of environmental factors or interventions assessed | Method for assessing PA | Results (incl. summary statistics) | Cluster |
|---|---|---|---|---|---|---|---|---|
| (Parobii et al., 2018) | Uruguay (Montevideo) | Cross-sectional study | N=65 | 11-15 years | Perceptions of spaces for PA (e.g., access to sports fields, equipment, after-school programs, safety, gender-specific access, social support) | Qualitative survey using focus groups on perceptions, behaviors, and barriers to PA | ▪ Students showed positive attitudes toward PA but low activity levels.<br>▪ Reported barriers included lack of infrastructure, limited time, and screen time (e.g., video games).<br>▪ Gender and SES differences emerged: girls reported embarrassment; lower SES schools lacked facilities and equipment.<br>▪ Students requested more extracurricular PA opportunities. | 2 |
| (Pintos-Toledo et al., 2024) | Uruguay (Rivera) | Cross-sectional study | 798 observed children and adolescents in 792 scans across 88 target areas | 0–18 years (divided into 0–5, 6–12, 13–18 years) | Use and features of public open spaces with at least one of the following characteristics: sidewalks, playgrounds, sports fields, multifunctional areas, or sports-related facilities. Additionally assessed: accessibility, usability, equipment, organization, lighting, supervision | SOPARC; observation and classification of activity intensity (sedentary, moderate, vigorous) | ▪ Most users were adolescents (59.8%) and male (67.2%).<br>▪ Sedentary behavior was 50.1%; 49.9% were active.<br>▪ Use was concentrated on weekends (96.2%) and evenings (99.2%).<br>▪ Activity was higher in the afternoon (girls: OR = 3.10; boys: OR = 5.79) and evening (girls: OR = 5.80; boys: OR = 8.63).<br>▪ Activity was higher in organized/equipped areas (boys: OR = 13.09).<br>▪ Girls were significantly less active than boys. | 1 |
| (Puttaswamy et al., 2023) | India (Bengaluru) | Cross-sectional study based on cohort data | N=292 | 6-15 years | GIS-based walkability index, consisting of: residential density, street connectivity, land use mix (residential, commercial, parks/open space, public/semi-public) | No direct assessment of physical activity; instead: objective anthropometric measurements of BMI, body fat percentage (%), and WC | ▪ Higher walkability index was associated with lower BMI (β = –0.41; 95% CI: –0.53 to –0.30).<br>▪ Higher walkability index was associated with lower % body fat (β = –0.72; 95% CI: –1.05 to –0.40).<br>▪ The effect decreased with age.<br>▪ No significant effect on waist-to-height ratio (WHtR).<br>▪ No effect modification by sex. | 1 |

| Author(s) (year) | Country (City) | Study design | Sample size | Age | Type of environmental factors or interventions assessed | Method for assessing PA | Results (incl. summary statistics) | Cluster |
|---|---|---|---|---|---|---|---|---|
| (Rossi et al., 2018) | Brasil (Florianópolis) | Cross-sectional study | N=2152 (30 schools) | 7-14 years | Use and perceived walking distance (1–10, 11–19, ≥20 minutes) to: beaches, parks/playgrounds, sports fields, soccer fields – stratified by income group (high-, medium-, or low-income families) | No direct measure of PA – instead, BMI and WC as indicators of obesity; questionnaire on the frequency of PAAL | ▪ In low-income children, living closer to parks/playgrounds was linked to lower BMI and lower WC.<br>▪ Living closer to football pitches was linked to higher BMI and higher WC.<br>▪ Living an intermediate distance from beaches was linked to lower BMI.<br>▪ No significant associations were found in medium or high-income groups. | 1 |
| (Trang et al., 2012) | Vietnam (Ho Chi Minh) | Longitudinal cohort study (5 years) | N=759 (18 schools) | Mean age at baseline: 11.8 years; follow-up until approximately 16 years | Distance to school, school location (affluent vs. less affluent districts), place of residence (urban, suburban), traffic conditions, sidewalks, parental safety concerns | Self-reported commuting behavior (walking/cycling at least 4 days/week = "active commuters") using validated questionnaires (PAQ); objective measurement of distance (GPS); measurement of BMI | ▪ Active commuting decreased from 27.8% (2004) to 19.6% (2009).<br>▪ Boys were more likely to actively commute (OR = 1.50; 95% CI: 1.12–2.00).<br>▪ Children from the poorest families were 4.5 times more likely to actively commute (OR = 4.55; 95% CI: 3.58–7.07).<br>▪ Living ≤800 m from school increased odds of active commuting (OR = 3.11; 95% CI: 1.82–5.29).<br>▪ Suburban residence (vs. wealthy urban) increased odds of active commuting (OR = 3.53; 95% CI: 1.43–6.69).<br>▪ Attending schools in less-wealthy districts increased odds of active commuting (OR = 2.09; 95% CI: 1.40–5.82). | 1 |
| (Uys et al., 2016) | South Africa (Cape Town) | Cross-sectional study within the ISCOLE framework | N=258 | 9-11 years | Perceived neighborhood characteristics: proximity to PA facilities, neighborhood safety, traffic safety, walkability, social cohesion; objective neighborhood characteristics: number of PA facilities (within 500 m), crime rate, traffic accidents | Objective measurement using accelerometers (ActiGraph GT3X+), worn for 7 days (including weekends); analysis of MVPA time before and after school as well as on weekends | ▪ Perceived availability of PA facilities was associated with higher before-school MVPA in low SES children (β = 1.50; p = 0.003).<br>▪ Higher objective crime rates were associated with lower after-school MVPA (β = –2.72; p = 0.044).<br>▪ Higher traffic risk was associated with lower after-school MVPA (β = –2.63; p = 0.038).<br>▪ Parental transport to PA venues was associated with higher after-school MVPA (β = 2.41; p = 0.026).<br>▪ ACT was 58% in low SES children vs. 24% in high SES children. | 1/2 |

| Author(s) (year) | Country (City) | Study design | Sample size | Age | Type of environmental factors or interventions assessed | Method for assessing PA | Results (incl. summary statistics) | Cluster |
|---|---|---|---|---|---|---|---|---|
| (Wachira et al., 2022) | Kenya, Mozambique, Nigeria | Cross-sectional study | N=3205 | 10-12 years | Degree of urbanization (rural, peri-urban, urban), parental education, ownership of vehicles/motorcycles, perceived barriers to active mobility by children and parents (e.g., traffic, safety, distance) | Objective measurement using PiezoRx pedometer (7 days), calculation of MVPA (min/day) and steps/day; additionally: questionnaires on school commuting behavior | ▪ Average MVPA was 45.6 min/day; average steps were 11,215/day.<br>▪ Only 23% met the MVPA guideline (≥60 min/day).<br>▪ ACT was 65.1% to school and 67.8% from school.<br>▪ No gender difference in ACT, but girls had lower MVPA than boys in all countries.<br>▪ Rural or peri-urban residence was linked to higher PA.<br>▪ Lower parental education and no car ownership were linked to higher ACT.<br>▪ Parent-perceived barriers were linked to lower MVPA in Nigeria only. | 2 |
| (Wafa & Ghazalli, 2020) | Malaysia (Terengganu) | Cross-sectional study | N=400 children, 32 teachers | 9-11 years | Comprehensive school environment mapping across four domains: 1. physical (e.g., gymnasium, sports programs, physical activity promotion), 2. economic (e.g., availability and price of healthy food), 3. political (e.g., policies on PA and nutrition), 4. sociocultural (e.g., teachers as role models) | PAQ-C questionnaire, validated Malaysian version; additionally: objective measurement of BMI (WHO standard) and dietary data (FFQ) | ▪ Seven school factors were significantly linked to BMI (adjusted for calories and PA):<br>– Health professional visits, exercise before class, no high-calorie food, healthy tuck shop, and PA policy were linked to lower BMI ($\beta = -1.75$ to $-3.75$; all $p \leq 0.001$).<br>– Encouraging active commuting and teacher as role model were linked to higher BMI ($\beta = +1.12$; $\beta = +1.50$; $p < 0.05$).<br>▪ School environment explained 33.4% of BMI variance ($R^2 = 0.334$). | 2 |
| (J.-J. Wang et al., 2018) | China (Hong Kong) | Cross-sectional study | N=661 | 13-18 years | Perceived availability and importance of PA-related environmental resources: 1. home environment (e.g., sports equipment, space), 2. neighborhood (e.g., traffic), 3. school environment (e.g., sports fields, infrastructure), 4. convenient facilities (facilities along daily routes such as parks) | PAQ-C validated, 7-day recall; BMI obtained from school records | ▪ PA was linked to lower BMI ($\beta = -0.14$; $p < 0.001$).<br>▪ Boys were more active and had higher BMI than girls.<br>▪ PA mediated effects of perceived availability of home environment (46.2%; $\beta = -0.03$; $p = 0.002$), convenient facilities (37.1%; $\beta = -0.02$; $p = 0.006$), and school environment importance (37.5%; $\beta = -0.02$; $p = 0.003$) on BMI.<br>▪ No direct effect of environmental factors on BMI. | 1 |

| Author(s) (year) | Country (City) | Study design | Sample size | Age | Type of environmental factors or interventions assessed | Method for assessing PA | Results (incl. summary statistics) | Cluster |
|---|---|---|---|---|---|---|---|---|
| (X. Wang et al., 2022) | China (Beijing) | Cross-sectional study | N=1758 | In average 9 years | Streetscape characteristics based on Street View and machine learning: 1. walkability, 2. enclosure, 3. street safety facilities (traffic lights, streetlights, cameras, etc.). Additionally: population density, intersection density, subway density, proximity to school | Walking to school (yes/no) as the dependent variable derived from travel data | ▪ Walking to school accounted for 51.6% of trips.<br>▪ Enclosure was positively associated with walking (OR = 2.04; 95% CI: 1.23–3.37).<br>▪ Walkability was negatively associated with walking (OR = 0.73; 95% CI: 0.51–1.05).<br>▪ Street safety facilities were negatively associated with walking (non-linear; overall negative; p = 0.002).<br>▪ Intersection density was positively associated with walking (OR = 1.27; 95% CI: 1.05–1.53).<br>▪ Population density was positively associated with walking (OR = 1.24; 95% CI: 0.98–1.56).<br>▪ Metro station density was negatively associated with walking (OR = 0.89; 95% CI: 0.79–1.01).<br>▪ Negative effects of walkability and street safety were stronger in high-income, high-education, car-owning households. | 1 |
| (Wayas et al., 2023) | South Africa (Cape Town) | Cross-sectional study | N=143 | 13-18 years | Perceived neighborhood characteristics assessed using NEWS-Africa: residential density, land use (diversity and access), street connectivity, infrastructure and safety for walking, aesthetics, traffic and crime safety, personal safety; creation of a general walkability index | Self-reported questionnaire on MVPA across various domains: physical education, informal activities, school and club sports, active transport, household chores; additionally, BMI and WC measurement | ▪ Adolescents from low-income areas had lower perceived walkability, lower PA, and higher BMI percentile.<br>▪ Only 51.7% met the MVPA guideline (≥420 min/week).<br>▪ Girls had lower PA, higher BMI, and more household chores than boys.<br>▪ Land-use diversity was positively associated with club sport participation (β = 2.15; 95% CI: 0.66–3.64; p = 0.05).<br>▪ Street connectivity was positively associated with school sport participation (β = 1.29; 95% CI: 0.03–2.56; p = 0.04).<br>▪ Personal safety was negatively associated with club sport participation (β = –1.69; 95% CI: –3.18 to –0.19; p = 0.03). | 2 |

# 4 Discussion

## 4.1 Summary of Key Findings

This systematic review analyzed 20 studies that examined the influence of physical activity-friendly environments on the PA behavior of schoolchildren in LMICs. The majority of the included studies were cross-sectional (n = 16), supplemented by three qualitative studies and one longitudinal study. The studies are geographically diverse, covering countries such as Brazil, South Africa, Nigeria, Vietnam, Malaysia, and Turkey. Regarding the age of the target population, most studies focused on children and adolescents between 6 and 18 years. Overall, the studies can be categorized into two thematic clusters: 13 studies were assigned to Cluster 1 (physical-infrastructural environmental factors), and five to Cluster 2 (social and educational influences). Two studies addressed factors from both clusters (Uys et al., 2016; Chinkonda et al., 2024).

A key finding of this review is the repeatedly demonstrated importance of the physical environment for schoolchildren's PA behavior. This was particularly evident in several studies through the impact of lacking infrastructure, such as missing sidewalks, poor traffic safety, or unclear school routes. Chinkonda et al. (2024) and Parobii et al. (2018) report that the absence of safe and child-friendly traffic conditions is perceived as a major barrier to daily PA, by children, parents, and teachers alike.

Another recurring pattern emerged regarding gender differences in PA: seven of the analyzed studies observed that girls are significantly less physically active than boys. This applies to both school-related mobility and leisure-time activities. The studies by Lavin & Berra (2020), Oyeyemi et al. (2014), Pintos-Toledo et al. (2024), Trang et al. (2012), Wachira et al. (2022), Wayas et al. (2023), and Wang et al. (2018) attribute this finding to various factors, including gender roles, lower parental support, and a greater sense of embarrassment among girls when engaging in physical activities.

Another notable finding is the repeated emphasis on objectively measured environmental factors, such as street connectivity or walkability, which were identified as strong predictors of active commuting to school and PA. Studies by Ozbil et al. (2021), Puttaswamy et al. (2023), Uys et al. (2016), Wayas et al. (2023), and Oyeyemi et al. (2014) demonstrate that a higher intersection density, good access to destinations, and a perceived safe infrastructure are directly associated with higher activity levels among children. Moreover, the so-called walkability index showed a positive correlation with PA in several of these studies.

However, some surprising or counterintuitive findings also emerged. Wang et al. (2022), for example, found that a higher walkability index in their sample was associated with a lower proportion of children walking to school. The authors argue that in a highly dense urban environment like Beijing, many sidewalks are blocked by illegally parked cars and street vendors. This leads to an unsafe and uncomfortable pedestrian environment, which parents may perceive as dangerous for their children. As a result, despite high walkability values, walking to school is chosen less frequently. This finding contradicts common assumptions and suggests that social or cultural contextual factors may moderate the effects of physical characteristics.

Another striking finding comes from Rossi et al. (2018), who observed that a shorter distance to soccer fields was associated with a higher BMI among children from low-income families.

The authors suggest a possible reverse causality, meaning that already overweight children may be more likely to visit certain places than children of normal weight.

An examination of the thematic focuses also reveals clear differences between the two clusters. While Cluster 1 centers on physical-infrastructural environmental factors, such as street connectivity, residential density, or proximity to parks and schools, Cluster 2 emphasizes social and school-institutional influences. Notably, studies in the first cluster primarily rely on directly measurable environmental data, such as GIS-based distances, walkability indices, or structural characteristics of the built environment. These environmental factors show a consistent association with PA behavior and BMI in numerous studies, particularly when infrastructure is safe, accessible, and diverse.

In contrast, the studies in Cluster 2 focus more on interactional and perception-based conditions within the school context, such as PA programs, teacher engagement, parental support, or health-related school policies. Especially striking is the range of possible influences within the school setting: for example, studies like Wafa & Ghazalli (2020) and Muthuri et al. (2014) demonstrated that even simple measures, such as daily movement sessions before class or banning high-calorie snacks from the school canteen, can have positive effects on children's PA behavior and weight development. Similarly, the study by Parobii et al. (2018) highlights that emotional, social, and cultural aspects, such as feelings of safety or social support, are crucial for enabling health-promoting behaviors.

While Cluster 1 primarily reveals the structural conditions that facilitate or hinder PA, Cluster 2 provides valuable insights into how social practices and institutional frameworks influence actual behavior. Both perspectives complement each other, making it clear that effective PA promotion in LMICs can only succeed if both physical and social conditions are considered together.

### 4.2 Comparison with Other Reviews

The systematic review by Kodali et al. (2023), which examined the relationship between built environment factors and children's quality of life, also provides insights that align with the findings of the present study. This is particularly evident regarding the role of green spaces, which both reviews repeatedly describe as beneficial - whether in terms of PA (e.g., Bozkurt 2021; Rossi 2018) or subjective well-being. While the findings of Kodali et al. (2023) are primarily situated in the context of high-income countries, the present study emphasizes the importance of physical activity-friendly environments specifically in the context of LMICs.

Similarly, the results of Christian et al. (2017), who reviewed the impact of the built environment on early childhood development in Australia, show patterns that partly parallel those identified in this review of schoolchildren in LMICs. Christian et al. (2017) also found positive effects of greater residential garden space and lower traffic exposure on social and emotional development. In parallel, several studies included in this review, such as Puttaswamy et al. (2023) or Ozbil et al. (2021), show that objective factors like street connectivity or low traffic density are associated with higher PA or active mobility.

Fernandes et al. (2023) likewise emphasize the relevance of green spaces and safe infrastructure for promoting PA. A notable difference, however, lies in the methodological quality of the

included studies: Fernandes et al. (2023) criticize the generally low study quality, lack of control groups, and short follow-up periods. By contrast, while many of the studies in the present review are also cross-sectional and share methodological limitations, their sheer number reveals clear patterns, such as gender differences or socioeconomic disparities, that were less of a focus in Fernandes et al.'s review.

### 4.3 Patterns, Mechanisms of Action, and Best Practice Examples

The analysis of the included studies reveals a series of recurring patterns and particularly effective combinations of environmental factors that consistently influence the PA behavior of schoolchildren in LMICs. The most frequently studied physical environmental characteristics were proximity to parks and playgrounds, street connectivity, the walkability index, and traffic safety. These factors showed a significant association with increased PA or lower BMI in numerous studies (e.g., Bozkurt, 2021; Rossi et al., 2018; Puttaswamy et al., 2023; Ozbil et al., 2021; Uys et al., 2016).

However, combinations of objective and subjective environmental characteristics appear to be especially effective. Studies such as those by Oyeyemi et al. (2014), Trang et al. (2012), and Uys et al. (2016) demonstrate that a positive perception of the environment, regarding safety, accessibility, or support, can significantly enhance the impact of objectively available infrastructure. A well-connected neighborhood alone is often not sufficient to promote active behavior if feelings of insecurity or cultural barriers are present at the same time.

It has also been shown that children from wealthier families and more affluent neighborhoods are often less physically active. Although children in wealthier neighborhoods tend to live in safer environments, have better access to PA opportunities, and attend schools with more structured PA programs, this does not necessarily translate into higher activity levels. On the contrary, some studies paradoxically found lower activity levels, possibly due to increased use of motorized transportation or lower parental motivation to encourage active commuting to school (Trang et al., 2012; Oyeyemi et al., 2014; Muthuri et al., 2014).

Children from poorer neighborhoods, on the other hand, often face greater environmental barriers, including lack of infrastructure, unsafe routes to school, crime, and absence of public spaces. Nevertheless, several studies show that children in these contexts are more likely to walk to school despite adverse conditions, possibly due to a lack of alternatives (Uys et al., 2016; Trang et al., 2012; Oyeyemi et al., 2014). However, these findings are not consistent. The study by Wayas et al. (2023) found that young adults from poorer neighborhoods in Cape Town reported lower perceived walkability, less PA, and a higher BMI.

An outstanding example of the combined consideration of physical and social environmental factors is the study by Ozbil et al. (2021). It shows that both objective street connectivity and parents' subjective perceptions of sidewalks and shade-providing trees are significantly associated with active commuting to school in an urban context. In addition to Ozbil et al. (2021), which exemplifies how objective features of the built environment (street connectivity) together with perceived qualities (e.g., shade-providing trees, sidewalk conditions) influence school commuting behavior, several other studies also highlight the added value of combining physical and social environmental factors.

For instance, Oyeyemi et al. (2014) demonstrate that objectively available opportunities for PA, such as access to destinations or infrastructure, are associated with increased activity only in

certain groups (e.g., boys from low-income neighborhoods), mediated by perceived safety and cultural norms. For girls in particular, perceived safety and the feeling of being exposed or observed during PA play a crucial role in determining whether public sports facilities are used. Similarly, Trang et al. (2012) and Uys et al. (2016) examine both spatial and traffic-related conditions as well as parents' perceptions of safety and social cohesion, revealing that subjective risk assessments strongly modulate behavior.

Overall, it can be concluded that an exclusively objective view of the environment is insufficient if the subjective meaning of these conditions, especially in challenging social contexts, is not taken into account.

### 4.4 Strengths and Limitations of This Review

This systematic review has methodological limitations that must be considered when interpreting the results. One of the main challenges lies in the methodological heterogeneity of the included studies. The studies differ significantly in study design (e.g., cross-sectional, qualitative approaches, longitudinal), methods of measuring physical activity (objective vs. subjective), and outcome measures (BMI, MVPA, AST, etc.). The outcome measures themselves (BMI, MVPA, AST) also have conceptual and methodological limitations. While BMI is a simple metric for assessing weight status, it does not directly reflect activity levels or body composition and is influenced by many other factors (e.g., diet, genetics, sociocultural influences).

Similarly, MVPA and AST capture only partial aspects of PA behavior and are often subject to measurement error, especially when self-reported. These limitations should be taken into account when interpreting the study findings. Consequently, the synthesis of results was narrative, which limits the quantitative power of the review. At the same time, the heterogeneity of study designs and outcomes can also be viewed as a strength, as consistent findings emerged despite this diversity.

The operationalization of environmental factors also varied greatly across studies. While some studies used objective GIS data or standardized walkability indices, others measured similar constructs through parental perceptions or simple proximity indicators. These conceptual differences complicate the identification of clear mechanisms of action and reduce comparability. However, the methodological diversity also offers an opportunity to capture environmental factors from different perspectives and to develop a broader understanding.

In terms of content, the generalizability of the results remains limited: although the included studies cover a broad range of regions across four continents (Europe, Asia, South America, Africa), most were conducted in urban settings, meaning that rural areas, cultural specificities, and the diversity within LMICs are only partially represented. The age range of the target groups is also heterogeneous, with younger children in preschool age particularly underrepresented.

Another limitation concerns the review process itself. Both the screening of titles and abstracts and the data extraction were conducted by a single reviewer. This single coding increases the risk of selective inclusion decisions or interpretation bias and reduces reliability. No independent second coding was conducted because this review was prepared as part of a master's thesis (individual project).

Despite these limitations, this review provides a systematic and structured synthesis of the current evidence on the relationship between physical activity-friendly environments and the PA behavior of schoolchildren in LMICs. The detailed table structure, the thematic clustering, and the integration of objective and subjective environmental factors offer differentiated insights into a research field that has so far received little systematic attention. Another strength of this review lies in the systematic assessment of study quality and risk of bias. By using the robvis tool, the risk of potential bias in the included studies was transparently and systematically evaluated. This visual representation not only provides a quick overview of the methodological quality of the studies but also enhances the transparency and objectivity of the synthesis of findings. In this way, the review's validity is strengthened.

## 4.5 Implications for Practice, Policy, and Research

This review highlights the relevance of environmental design for promoting PA among schoolchildren in LMICs. For practice, this implies that school and community stakeholders should specifically work to improve physical activity-friendly infrastructure. Particularly important are safe routes to school (e.g., sidewalks, traffic calming measures), accessible spaces for PA (such as parks or sports fields), and multisectoral collaboration that links school-based and urban planning processes.

While structural changes in residential environments, such as expanding sidewalks or improving traffic safety, are often associated with high costs and long-term planning, school-based interventions can be implemented more easily and quickly, as fewer stakeholders need to be involved in decision-making. An illustrative example is the KaziKidz intervention program in South Africa, which demonstrated that structured PA and health promotion programs during school hours can increase PA levels, particularly among previously inactive children and girls (Arnaiz et al., 2023). Additionally, a study included in this review, such as Wafa & Ghazalli (2020), shows that concrete school-based measures, such as visits from health professionals, simple movement exercises before lessons, eliminating the sale of high-calorie foods, and offering healthy snacks at the school kiosk, are significantly associated with lower BMI. The presence of a school-based PA policy was also linked to positive effects in this context. However, it also became evident that these positive effects are not sustainable without structural and long-term integration into everyday school life. Therefore, it is essential for policymakers to establish evidence-based intervention programs not only temporarily but as permanent components, ideally embedded within national education and health strategies.

Future research should increasingly adopt mixed-methods designs and longitudinal studies to better understand causal mechanisms and long-term effects. Since previous research has identified both objective and subjective influencing factors, an integrative approach considering both aspects is necessary for a comprehensive analysis. Therefore, socioeconomic contexts, gender aspects, and subjective perceptions of the environment (e.g., feelings of safety, social support) must be taken into account in order to develop targeted interventions tailored to specific groups.

# 5 Conclusion

This master's thesis provides an evidence-based overview of the relationship between physical activity-friendly environmental factors and the PA behavior of schoolchildren in LMICs, based on a systematic review of 20 studies. The findings highlight that physical-infrastructural conditions, such as safe routes to school, street connectivity, residential density, and proximity to parks and sports facilities, play a central role in promoting PA. However, school-based factors and social influences, such as PA programs, role models, or peer groups, also significantly contribute to children's and adolescents' activity levels.

Recurring patterns were particularly evident regarding gender differences: girls were less physically active than boys in almost all studies, pointing to structural and social barriers. Another notable finding is the relationship with socioeconomic background: while children from wealthier neighborhoods often live in safer environments and attend schools with better opportunities for PA, this does not necessarily translate into higher activity levels. On the contrary, several studies showed lower PA among this group, possibly due to more frequent use of motorized transport or lower parental motivation to encourage active commuting. Conversely, children from poorer neighborhoods, despite facing significant environmental barriers, were more likely to actively commute to school, partly due to a lack of alternatives.

Despite the diversity of studies, many questions remain. The predominance of cross-sectional designs and methodological heterogeneity limit the generalizability of the findings. At the same time, some studies demonstrate that innovative and integrative approaches, such as combining objective and subjective environmental measurements or implementing school-based intervention programs, can have promising effects.

From a practical perspective, this points to a clear mandate for action: promoting PA must be systematic, context-sensitive, and sustainable. Only through participatory and multisectoral approaches can lasting improvements in PA behavior among children in LMICs be achieved.

## 6 List of Abbreviations

| Abbreviation | Meaning |
|---|---|
| AQuAA | Activity Questionnaire for Adolescents and Young Adults |
| AST | Active School Travel |
| AT | Active Transportation |
| FFQ | Food Frequency Questionnaire |
| GIS | Geographic Information System |
| ISCOLE | International Study of Childhood Obesity, Lifestyle and the Environment |
| LIC | Low-Income Country |
| LMIC | Low- and Middle-Income Country |
| MVPA | Moderate to Vigorous Physical Activity |
| NCD | Non-Communicable Disease |
| NEWS-Africa | Neighborhood Environment Walkability Survey – Africa |
| NEWS-Y | Neighborhood Environment Walkability Scale – Youth version |
| PA | Physical Activity |
| PAAL | Physical Activity and Active Leisure |
| PANES-N | Physical Activity Neighborhood Environment Scale – Nigeria adaptation |
| PAQ | Physical Activity Questionnaire |
| PAQ-C | Physical Activity Questionnaire for Children |
| SES | Socioeconomic Status |
| SOPARC | System for Observing Play and Recreation in Communities |
| WC | Waist Circumference |
| WHtR | Waist-to-Height Ratio |

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## 10 Poster

See page 55.

Department of Sport, Exercise and Health

# How Does a Physical Activity-Friendly Environment Affect Schoolchildren's Physical Activity Behavior? A Systematic Review of Low- and Middle-Income Countries

**Valentin Ammann**
First Supervisor: Dr. Ivan Müller

## 1 | Background

Physical inactivity among schoolchildren is a growing public health concern, especially in low- and middle-income countries (LMICs), where socioeconomic and infrastructural challenges limit opportunities for movement. Despite global guidelines recommending at least 60 minutes of daily moderate-to-vigorous physical activity, 81% of adolescents worldwide do not meet these recommendations (Guthold et al., 2020). The built environment, factors like walkability, access to parks, and traffic safety, can play a key role in promoting or hindering physical activity (Saelens & Handy, 2008; Diez Roux et al., 2007).

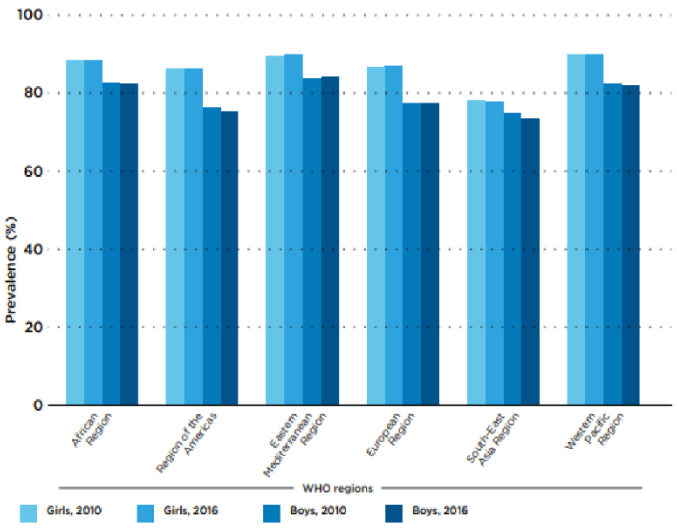


**Fig. 1:** *Prevalence of school children aged 11–17 years not meeting WHO physical activity guidelines, by WHO region, 2010 and 2016. Source: WHO (2022).*

## 2 | Method

A systematic review was conducted using five databases (PubMed, Scopus, VHL, BASE, EBSCO), following PRISMA guidelines (see Fig. 2). Out of 3,294 identified records, 20 studies met the inclusion criteria (16 cross-sectional, 3 qualitative, 1 longitudinal). Studies were grouped into two clusters: (1) physical-infrastructural factors and (2) social-educational influences. A risk of bias assessment was performed using an adapted AXIS tool and visualized with robvis.

## 3 | Results

Key findings across 20 studies:

**1.Physical environment:** Higher walkability, street connectivity, and access to parks/playgrounds were linked to higher physical activity and lower BMI. **2. Social-educational factors:** School-based interventions (e.g., exercise before class, healthy food policies) were associated with lower BMI. **3. Gender and SES differences:** Girls were consistently less active than boys; children from low-income areas were often more active out of necessity, despite facing infrastructural barriers. **4. Some unexpected findings**: higher perceived safety was linked to less leisure MVPA in boys from wealthy neighborhoods.

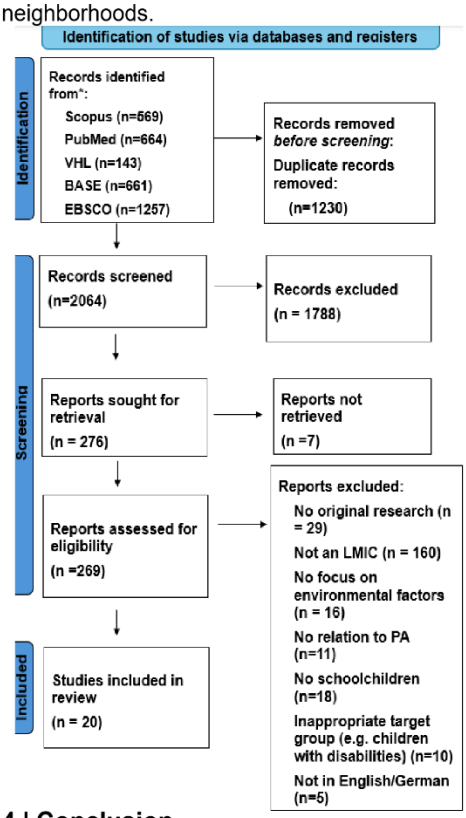


**Fig. 2:** *Prisma 2020 Flow Diagram for systematic reviews. Source: Page et al. (2021).*

## 4 | Conclusion

A physical activity-friendly environment positively influences schoolchildren's movement behavior in LMICs. Effective promotion requires addressing both structural (infrastructure) and social (school, cultural) factors. Policy and practice should combine improvements in the built environment with low-cost, school-based programs to sustainably increase physical activity among children.

## Literature

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**Valentin Ammann | DSBG | University of Basel | Galligässchen 6 | CH-4663 Aarburg | valentin.ammann@stud.unibas.ch**