Predictors of physical activity in school attending adolescents in Lagos State, Nigeria.

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Abstract

Background

Physical activity has been shown to be a significant protective factor for different health outcomes. The World Health Organization (WHO) recommends that children and adolescents should accumulate at least 60 minutes of moderate-to-vigorous-intensity physical activity (MVPA) daily. Africa is rapidly undergoing an unprecedented phase of urbanisation and how to ensure healthy lives for its residents is increasingly becoming an important question. Some of the immediate effects of urbanisation are pressures on existing built environment. Previous reviews have synthesised associations between the built environments and physical activity in children and adolescents, but they have focused on non-African settings. Therefore, the first objective of this PhD study was to present evidence on the built environment constructs that were associated with physical activity among children and adolescents in Africa.

Lagos occupies a unique position in West Africa subregion, as the city with the highest rate of urbanisation. As with most cities that are going through urbanisation, inequitable distribution of resources in different areas of the city affect physical activity. The second objective was to determine the proportion of school attending adolescents that reached the recommended MVPA level in Lagos State, Nigeria and to identify the predictors that were associated

with reaching the recommended level. And finally, the third objective was to explore the barriers and facilitators of physical activity among school attending adolescents in Lagos State, Nigeria.

Methods

To achieve the above-mentioned objectives, three inter-related studies were conducted. First, a systematic review, adhering to the JBI methodology, was conducted to synthesise the existing evidence on the association of built environment constructs with physical activity among children and adolescents in Africa. Comprehensive electronic searches of ten databases from inception to 22 October 2021 were conducted to identify relevant published and unpublished studies. Two reviewers independently screened the papers, assessed the quality of the included studies using the JBI standard critical appraisal tool, and extracted data using a pre-piloted form. Where possible, data were synthesised using random effects meta-analyses, with effect sizes reported as mean differences (MD) with 95% confidence intervals (CI). The Grading of Recommendations Assessment, Development and Evaluations (GRADE) was used to assess the certainty of the findings.

Second, a cross-sectional study was conducted among a representative sample of 720 adolescents aged 12-19 years from 20 schools in Lagos State, Nigeria in 2020. A validated physical activity questionnaire (Activity Questionnaire for Adults and Adolescents,

AQUAA) was administered to assess MVPA and the predictors assessed were socio-demographic variables, anthropometric measurements, sedentary behaviour, self-efficacy, perceived benefits, and perceived barriers. Third, a qualitative study, using semi-structured interviews, was conducted to explore the views and experiences of 21 decision-makers, who were responsible for planning the physical and health education curriculum in secondary schools in Lagos State, Nigeria, on the barriers and facilitators of physical activity in school attending adolescents.

Results

In the systematic review, of the 10,706 identified records, six cross-sectional studies were included which comprised 4628 children and adolescents. Three of the studies had a high-quality score of ≥ 7 out of 8. Seven built environment constructs were reported within the included studies namely, residential density, street connectivity, crime safety, availability of physical activity facilities and infrastructure, walkability, aesthetics, and traffic safety. Three of the constructs were assessed with objective measures. Results from individual studies found significant associations between physical activity and objective measure of traffic safety (Mean difference (MD) 2.63 minutes; 95% Confidence interval (CI) 0.16 to 5.1; one study) and an objective measure of crime safety (MD 2.72 minutes; 95% CI 0.07 to 5.37; one study). No significant associations were found between active transportation and any of the built

environment constructs. The GRADE evidence for all the assessed constructs was either low (the built environment constructs may lead to little or no difference in physical activity or active transportation) or very low (it was uncertain whether the built environment constructs affect physical activity).

In the cross-sectional study, complete data was provided by 528 adolescents for the study (73% response rate). The recommended MVPA level was reached by 82.8% (95% CI 79.3–85.7) of the participants. Participants spent a median time of 44 (Inter quartile range (IQR) 12.9, 110) minutes of MVPA per day on household-based activities, followed by school-based activities (median 21.4; IQR 4.3, 50.4), active transportation (median 14.3; IQR 0, 35), sport-based activities (median 8.6; IQR 0, 58.9) and leisure-based activities (median 8.6; IQR 1.1, 34.3). Participants in public schools were four times more likely to meet the recommended MVPA level compared to those in private schools (Odds ratio (OR) 3.97, 95% CI 2.46–6.42).

In the qualitative study, eight themes were identified and explored. The barriers to physical activity were (i)students' characteristics (ii) parental objections (iii) no prioritisation of physical activity (iv) insufficient resources and (v) challenges with schools' initiatives. The facilitators to physical activity were (vi) students' interests (vii) students' awareness of benefits and (viii) schools' initiatives.

Conclusion

The evidence base for the association between built environment constructs and physical activity in African settings is limited, with no consistent evidence of an association. Therefore, further high-quality studies should be conducted before firm conclusions can be drawn. Findings from the cross-sectional study suggest that a high proportion of school adolescents met the recommended MVPA level in Lagos State, Nigeria. Additionally, our study suggests that interventions for promoting MVPA should be targeted to private schools. Our study's finding from the qualitative study can help design interventions to increase physical activity among school attending adolescents in Lagos State, Nigeria.

Published Papers

Adebusoye, B., Phalkey, R., Leonardi-Bee, J. & Chattopadhyay, K. Association of the built environment with physical activity in children and adolescents in Africa: a systematic review protocol. *JBI Evid Synth* **18**, 553-563, doi:10.11124/JBISRIR-D-19-00162 (2020).

Adebusoye, B., Chattopadhyay, K., Ekezie, W., Phalkey, R. & Leonardi-Bee, J. Association of built environment constructs and physical activity among children and adolescents in Africa: a systematic review and meta-analysis. *JBI Evid Synth*, doi:10.11124/jbies-21-00295 (2022).

Adebusoye, B., Leonardi-Bee, J., Phalkey, R. & Chattopadhyay, K. Proportion of school attending adolescents meeting the recommended moderate-to-vigorous physical activity level and its predictors in Lagos, Nigeria. *Int J Environ Res Public Health* 2021;**18**:10744. doi:10.3390/ijerph182010744.

Adebusoye B, Leonardi-Bee J, Phalkey R *et al.* Barriers and facilitators of physical activity among school attending adolescents in Lagos State, Nigeria: A qualitative study exploring views and experiences of decision-makers in secondary schools. *Health Science Reports* 2023;**6**:e997.

Conference Presentations

1. The 10th International Festival of Public Health Programme, virtual meeting, July 22, 2021. Oral presentation. Association between built environment and physical activity among children and adolescents in Africa: a systematic review and meta-analysis.

2. The 1st African and 2nd Nigerian conference on Adolescent and Youth Health and Development, August 18, 2021. Oral presentation. Moderate-to-vigorous physical activity level and its predictors in school attending adolescents in Lagos, Nigeria: a cross-sectional study.

3. University of Nottingham Sue Watson Postgraduate Presentation, April 2021. Oral presentation. Levels of moderate-to-vigorous physical activity and its predictors in school attending adolescents in Lagos, Nigeria.
4. University of Nottingham Faculty of Medicine Postgraduate Research Forum, June 2019. Oral and E-poster. An investigation of the factors that influence physical activity patterns of adolescents in Nigeria.

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Authors' contribution

This research was designed and conducted by the author under the supervision of three supervisors: Dr Kaushik Chattopadhyay, Dr Revati Phalkey, and Prof Jo Leonardi-Bee. The author was responsible for developing the protocols of the study, acquiring ethical approval, conducting the studies, analysing the data, interpretation of the findings and the overall write up of the thesis and the published articles. The author was supported by Dr Winifred Ekezie and Caius Ikejezie on screening, critical appraisal and the data extraction of the articles included in the systematic review. Two research assistants, Ayomide Tijani and Emmanuel Usen, supported the conduct of the survey.

List of abbreviations

Abbreviation	Meaning
AHKGA	Active Healthy Kids Global Alliance
AQUAA	Activity Questionnaire for Adults and Adolescents
BMI	Body mass index
CI	Confidence interval
DALYs	Disability adjusted life years
EE	Energy expenditure
GDP	Gross domestic product
(GoPA!)	Global Observatory for Physical Activity
GRADE	The Grading of Recommendations Assessment, Development and Evaluation
HDL	High-density lipoprotein
HICs	High-income countries
LGA	Local government area
LMICs	Low-and middle-income countries
LTPA	Leisure time physical activities

MAS	Material Affluence Scale
MD	Mean difference
MVPA	Moderate-to vigorous intensity physical activity
NCDs	Non-communicable diseases
OR	Odds ratios
PA	Physical activity
PPS	Probability proportional to their enrolment size
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
PROSPERO	International Prospective Register of Systematic Reviews
SES	Socio-economic status
UN	United Nations
UNESCO	United Nations Educational, Scientific and Cultural Organisation
WHO	World Health Organization
WHR	Waist to hip ratio

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Chapter One

Introduction

1.1 Physical activity

The World Health Organization (WHO) defines physical activity as any bodily movement produced by skeletal muscles that requires energy expenditure including activities undertaken while working, playing, carrying out household chores, travelling, and engaging in recreational pursuits.[1] Physical activity is a complex multidimensional behaviour whose health effects are determined by its intensity, duration, type (e.g., aerobic vs strength training) and domain.[2] Ancient physicians believed in the value of physical activity for health, but by the 20th century, an opposite view emerged that underestimated the benefits of physical activity;[3] for example, complete bed rest was prescribed for patients with acute myocardial infarction.[3] People pointed out the alleged dangers of physical activities;[4] investigations to disprove this belief were inconclusive as there were no differences seen between those who engaged in physical activities and those that didn't.[4,5] For example, in 1954, the Senior Health Officer of Cambridge University investigated the longevity of local sportsmen using a case control study, compared to a random group of men from the University, showing there was no evidence that involvement in sports prolonged life.[3,4] However, with increasing evidence from epidemiological studies, such as the association between increased involvement in physical activity at work and a reduction in coronary heart disease, the benefits of physical activity began to get established.[6] The development of new

technologies has enabled people to reduce the amount of physical labour needed to accomplish many tasks in their daily lives.[7] Although the technological revolution has been of great benefit to many populations throughout the world, it has come at a major cost in terms of the contribution of physical inactivity to the worldwide epidemic of non-communicable diseases (NCDs).[7-9] Physical activity is therefore considered a cornerstone for combating NCDs.[10,11] People benefit from even modest activity and when compared with inactive individuals, people who were active even at levels lower than the recommended (about 1.5h per week), lived three years longer.[11,12]

1.2 Global burden of physical inactivity

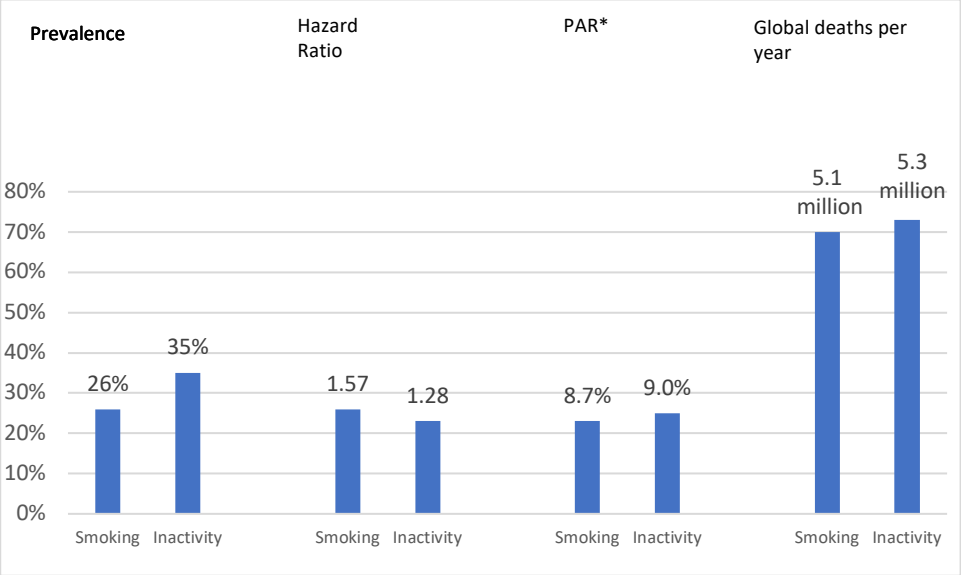
Physical inactivity is estimated to cause 6-10% of the major NCDs such as coronary heart disease, type 2 diabetes, breast cancer and colon cancer.[3] The failure to spend 15-30 minutes a day in brisk walking increases these diseases by 20-30%.[3,13] In the recent Global Burden of Diseases study 2019, Disability adjusted life years (DALYs) increased by 13.1% in adolescents for NCDs between 1990 and 2019. Headache disorders, depression, anxiety and low back pain were some of the top ten causes of global DALYs for adolescents.[14] Children and adolescents are heavily impacted by NCDs. For example, globally, 1.2 million people under the age of 20 years died of NCDs in 2002. Also, worldwide, more than 25% of

obese adolescents have signs of type 2 diabetes by the age of 15 years.[15]

Worldwide, physical inactivity is the fourth leading cause of death; it is responsible for approximately 5 million deaths per year.[16,17] It shortens lifespan by 3-5 years,[12,13] and it is associated with 9% of premature mortality.[18]

Economically, physical inactivity burdens society through the hidden and growing cost of medical care and loss of productivity.[13] In 2013, physical inactivity cost health care systems 53.8 billion dollars worldwide.[18] Physical inactivity related deaths contribute to $13.7 billion in productivity losses, and was responsible for 13.4 million disability adjusted life years (DALYs) worldwide. Low- and middle-income countries (LMICs) have a larger proportion of the disease burden (75% of DALYs).[18] LMICs are undergoing substantial social and physical transitions.[11] 80% of the world's population live in LMICs and more than 80% of the global burden of NCDs lies here and only a small fraction of research on physical activity has been focused in these countries.[11] With the elimination of physical inactivity, life expectancy of the world's population might be expected to increase by 0.68 years.[3] These findings make physical inactivity similar to other established risk factors such as obesity and smoking. For direct comparison, research shows that inactive people in the US will gain 1.3 – 3.7 years from age 50 years by becoming active, while for obesity, if all people in the US were to attain normal

weight, life expectancy in the population is expected to increase by 0.5-0.7 years at age 50 years.[3] In comparison to smoking, physical inactivity and smoking are the two major risk factors for NCDs around the globe. Of the 36 million deaths each year from NCDs, physical inactivity and smoking each contribute about 5 million deaths.[13] Figure 1 shows the comparison of global burden between smoking and physical inactivity.



*; Population attributable risk

Figure 1: Comparison of global burden between smoking and physical inactivity

1.3 Benefits of physical activity in children and adolescents

Regular physical activity helps children and adolescents to develop healthy musculoskeletal tissues (i.e., bones, muscles, and joints). There is evidence of the association of increased participation in physical activities and increased bone mineral density in adolescents. Systematic reviews and randomized controlled trials show that pre-pubescent and pubescent children who had extra

physical activities in schools showed significant increases in their bone mass densities compared to those who only had the regular physical education classes.[19-21]

Physical activity helps to develop a healthy cardiovascular system, studies have shown significant reductions in systolic and diastolic blood pressure in adolescents with blood pressure above the 67th percentile that participate in physical activity, particularly aerobic exercises.[21,22]

Regular physical activity improves body composition and levels of metabolic health biomarkers.[23] Physical activity (aerobic exercise) led to significant reductions in triglycerides and improvements in high-density lipoproteins (HDL) cholesterol in at least one lipid/lipoprotein variable.[21] There are indications of dose-response relationship between physical activity and metabolic disorder as low volumes of moderate-to-vigorous physical activity (MVPA) have been shown to be beneficial for adolescents at the greatest risk.[21,24]

Physical activity develops neuromuscular awareness (i.e., coordination and movement control). It enhances recovery from disease, accident and disability; it increases strength, endurance and helps maintain a healthy body weight.[25] There are reported associations between physical activity and being overweight, where longitudinal studies have shown that adolescents who were more active were less likely to be overweight and had less body fat when compared to those who were less active.[26]

Physical activity is also associated with psychological benefits in adolescents by improving their control over stress, symptoms of anxiety and depression; and greater participation in physical activity is associated with lower risk of planning suicide.[21,27]

Participation in physical activity also assists in social development in adolescents by providing opportunities for self-expression, building self-confidence, social interaction and integration,[1] and improves their academic achievements and quality of life.[28] Evidence from longitudinal studies and systematic reviews have shown that objectively measured MVPA has a long-term positive impact on academic attainment and cognition.[29-31]

It has also been suggested that physically active young people more readily adopt other healthy behaviours e.g., avoidance of tobacco, alcohol, and drug use. Physical activity has been shown to track into adulthood from childhood and adolescence.[32] Immediate and future health benefits are established for children and adolescents who are physically active.[11]

1.4 Physical activity levels in children and adolescents

The WHO recommends that children and adolescents should accumulate at least 60 minutes of MVPA daily,[1] however MVPA levels among children and adolescents globally are typically lower than recommended.[33] Data from 1.6 million students aged 11-17 years, which is equivalent to 81.3% of the global population of adolescents of this age, shows that 80 to 81% of school–going

adolescents were insufficiently physically active in 2016.[33,34] Physical inactivity levels significantly decreased by 2.5% points for boys between 2001 and 2016, from 80.1% to 77.6%, whereas there was no significant decrease for girls (85.1% to 84.7%); leading to a significant global difference of 7.1% points in insufficient activity between sexes in 2016.[33] It appears that the global target of a 15% relative reduction in insufficient physical activity, which if met would reduce physical inactivity to less than 70%, will not be achieved by 2030. Adolescent boys have however shown some progress.[33] No clear pattern is observed across the different income group: insufficient physical activity was 84.9% in low-income countries, 79.3% in lower-middle income countries, 83.9% in upper-middle income countries and 79.4% in high-income countries.[33] Overall, there are no improvement in global levels of participation over the last two decades but there are substantial sex differences with girls less active than boys.[2,33] Figure 2 shows the levels and trend of physical inactivity in adolescents across by sex and region in 2001 and 2016.

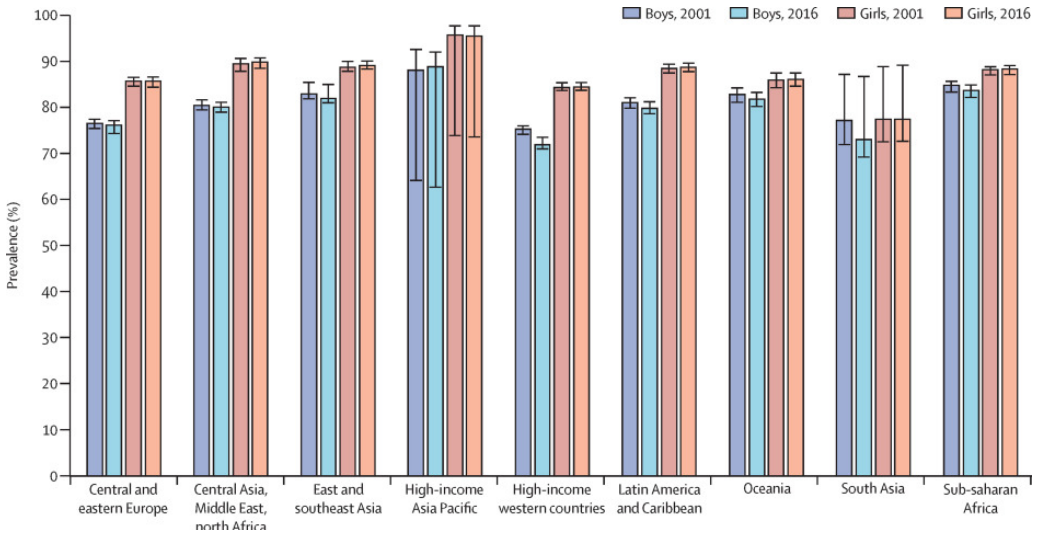


Figure 2: Prevalence of insufficient physical activity among school-going adolescents aged 11-17 years, by sex and region, 2001 and 2016.[33]

1.5 Measurement of physical activity

With the promotion of regular physical activity, it is essential that they are measured appropriately. Valid and reliable measures of physical activity are a necessity in studies designed to document the frequency and distribution of physical activity in defined population groups.[35] Physical activity is a complex behavior characterised by multiple dimensions and domains. The dimensions of physical activity include frequency, duration, intensity, and type, whereas the domains of physical activity traditionally include leisure- time physical activity, occupational physical activity, transportation activity, and activities associated with tasks performed in the house, yard, or garden. In children and adolescents, in-school physical activity (including recess and physical education), out-of- school physical activity, and physical activity in specific behavioral settings (e.g, after-school programs) may also be considered important domains. Ideally, a physical activity measurement tool should

provide valid and reliable assessments of all 4 dimensions of activity behavior in all the domains.

Different methods are used to estimate physical activity levels, objective measures include; doubly labelled water which estimate precise measures of energy expenditure (EE), direct observation, heart rate monitoring, use of accelerometers and pedometers, to more subjective measures of physical activity, such as self-reports, which are usually validated with accelerometers.[36] More recently global navigation satellite systems (GNSS) such as the Global Positioning System (GPS) are also used. They provide a measurement of position in three dimensions, i.e., latitude, longitude, and altitude. Time-series data of position yields speed, ascent/descent rates, and acceleration. GNSS data are most useful when combined with other behavioural exposure data in order to determine the spatial context of the behaviour.[37] Different methods have their own advantages and disadvantages in terms of validity, cost and feasibility.[36]

1.5.1 Self-report questionnaires

Self-report questionnaires are an affordable and convenient way of assessing physical activity that can provide information on the context and type of the activity.[38] They also have the ability to characterise activity historically.[35] They are convenient for the respondents and they do not alter the behaviour under study.[39]

Although convenient, self-report methods are subject to considerable recall bias.[35]

1.6 Correlates of physical activity in children and adolescents

Enhancing physical activity requires the consideration of a range of behavioural influences both internal (e.g., beliefs, cognitions) and external (e.g., social needs, contextual factors).[40] As a consequence, the application of theoretical frameworks marked a critical transitional point for the study of physical activity in the late 1980s and early 1990s. Theoretical frameworks create a context for understanding, explaining, and ultimately intervening upon physical activity. Thus, the use of theoretical frameworks are generally considered an essential feature in physical activity science.[40]

There are four main theoretical frameworks that have been applied to understand and change physical activity over the last three decades. They are the social cognitive approaches, humanistic/organismic approaches, socio ecological approaches, and dual process approaches. The social cognitive framework is based on the premise that people form, and subsequently act upon, expectancies of behavioural events and outcomes. For this framework, individuals will intend to be physically active if they believe that physical activity is important, and they are truly capable of enacting physical activity.

The humanistic/organismic approach is thought to be motivated by an innate drive to grow, develop, and realize one's potential—a concept often referred to as self-actualization.[40] The dual process approach is the mapping of individual level behavioural determinants onto one of two different types of influence – reflective processes which are deliberative, effortful, and intentional effects, and non-conscious or automatic processes, which are spontaneous, harder to notice and harder to control.[40] The reflective processes include the conventional social-cognitive approach variables (e.g., intentions, values, expectations), and non-conscious processes include the comparatively less understood and less tested determinants of physical activity such as habits and automatic motivation.[40,41]

Theoretical frameworks such as socio-ecological theory take a broad view of health behaviour causation.[42] This framework recognises that individual behaviours such as physical activity are likely dependent on the dynamic relationships between multiple determinants (i.e., biology, motivation, self-efficacy, socio-cultural, policy, built and natural environments).[42,43] A key principle is that knowledge about all types of influence can inform development of multilevel interventions to offer the best chance of success.[42,44] The socioecological framework offers not only multiple levels of influence on behaviour but also for a

broad understanding of physical activity which often occurs within a single individual across several contexts such as occupation/work, transport and leisure.[40] In addition, the focus on policy and environmental levels of behaviour change provide targets for government to focus on attempting to improve health outcomes. Settings-based interventions such as schools, urban design, parks, and recreation facilities are targets where governments can take action.[40,45] These approaches can align with public health policies for a more environmentally friendly urbanisation and thus avoid blaming individuals for their roles in unhealthy behaviour. The socioecological framework advocates a shared responsibility for health among all sectors.[40] Figure 3 shows a socioecological model showing multiple influences on physical activity behaviour.

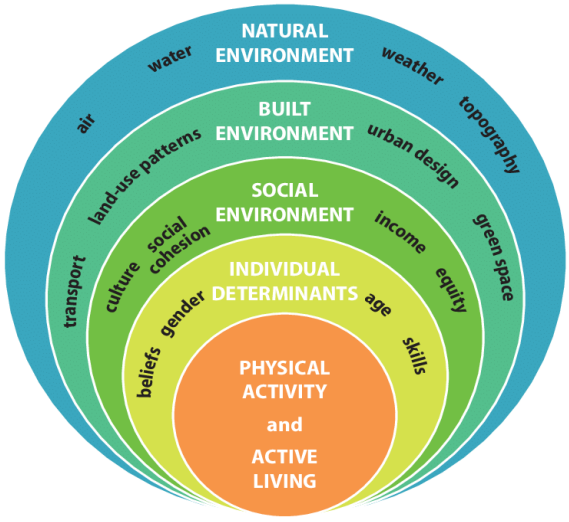


Figure 3: A socio-ecological model showing multiple influences on physical activity.[46]

1.6.1 Individual correlates

Individual correlates of physical activity can be categorised into demographic, biological, psychosocial factors. These factors include age, gender, anthropometric measures, attitude, perceived behavioural control, perceived competence, self-efficacy, perceived benefits and perceived barriers. A recent systematic umbrella review which summarises present knowledge about the correlates of physical activity reported male sex, self-efficacy, perceived behavioural control, valuing physical activity for health status (appearance or achievement) and barriers to physical activity were significantly correlated with physical activity in adolescents.[42]

1.6.1.1 Age

Studies indicate that physical activity declines with ageing in children and adolescents.[47,48] From a systematic review that looked at physical activity change during adolescence, it is extrapolated that physical activity declines, on average by 5.9% per year.[49] Also, from the International Children's Accelerometry Database, a study that assessed objectively measured physical activity in children across 10 countries; it was found that total physical activity levels and percentage MVPA were progressively lower after age 5-6 years.[50]

1.5.1.2 Sex

Boys appear to be more physically active than girls are. In a multi-country analysis it was found that activity levels were higher among boys than girls.[50] This pattern is observed in both high-income countries (HICs) and LMICs.[42,51-54]

1.5.1.3 Psychosocial factors

Self-efficacy (confidence in the ability to be physically active in specific situations) has been shown to be a consistent positive correlate and determinant of physical activity in children and adolescents.[42,54] Also, perception of barriers and benefits to physical activity have been associated with decrease and increase in physical activity levels of adolescents respectively.[55] While perceived benefits of physical activity such as feeling less anxious, less depressed and to lose weight were most likely reasons for adolescents to be physically active, perceived self-consciousness about body or physical appearance, lack of proper equipment or access to exercise facilities were barriers to physical activity.[56]

1.5.1.4 Sedentary behaviours

Sedentary behaviour is defined as a distinct class of behaviours (e.g. sitting, watching TV and computer use) characterised by little physical movement and low energy expenditure.[57] The fundamental characteristic of these behaviours is that sitting predominates.[58] Among the most profound changes in the

recent decades are the remarkable growth in the availability of electronic forms of entertainment, including television, the internet, mobile telephones and video games.[58] Evidence for the association between sedentary behaviours and biomedical health indicators (body mass index, blood pressure, blood lipids and bone mass) in children and adolescents are still inconclusive,[57] there however seems to be a moderate evidence for an inverse longitudinal relationship between screen time and aerobic fitness in children and adolescents.[57] Sedentary behaviours in children and adolescents have often being studied in HICs; higher levels of sedentary behaviours have been found in children and adolescents from lower socio-economic backgrounds, and those from households with more access to televisions and computers. Lower sedentary behaviours on the other hand, have been found in children and adolescents whose parents have rules on screen time.[58]

1.5.2 Social environment

1.5.2.1 Social support

Parental and familial support for physical activity has consistently shown a strong influence on children's and adolescents' physical activity participation.[42,54,59,60] Parental support is often operationalised as encouragement, involvement, or facilitation. Parental encouragement seems to have the greatest effect.[59] Similarly, peers do have a strong

influence on adolescent decision-making. Peer support during physical activity is associated with increased physical activity in adolescents. This association may even be greater for overweight adolescents.[61]

1.5.2.2 Socioeconomic status

In LMICs, most studies have found children and adolescents of lower socio-economic status (SES) usually characterised by attending public schools and living in rural areas to have higher physical activity levels accumulated through active transportation to schools when compared to those with higher SES.[47,52,62,63] In HICs on the other hand, children and adolescents of lower SES have lower levels of physical activity.[64]

1.5.3 Built environment

The built environment refers to the surroundings created by humans and used for human activity.[65] Evidence from HICs shows that built environment interventions have the potential to provide population-wide effects and the means for a sustained effect on behaviour change.[66] This is because behaviour modification is a product of individual choices and the surrounding environment.[67] Thus, the built environment is identified as an important driver of children's and adolescents' physical activity levels.[68,69] The built environment constructs, such as availability of and access to parks, higher street connectivity, sidewalks, bicycle lanes, green space, public and

private recreation facilities, lower levels of crime and the aesthetic qualities of neighbourhoods have been positively associated with physical activity levels in children and adolescents.[42,70] Timperio et al. found a lower likelihood of walking or cycling was associated with parents' perception that their children needed to cross several roads to reach play areas, their perception of limited public transport in their area, and child's belief that there were no parks or sports grounds near home.[71] In adolescents, there is evidence that built environment association with physical activity differs by gender and socioeconomic status.[67] Also, parks have consistently shown significant positive associations with adolescents' engagement in physical activities. When in close proximity to the home, parks are destinations that can be actively travelled to.[72] Manipulating the built environment to be more health promoting will most likely have sustainable and far-reaching impacts on population health behaviours and outcomes.[66] Neighbourhoods present the opportunity to understand the environmental correlates of physical activity among children and adolescents, since they have less autonomy in their behaviours and are more likely than adults to be influenced by their neighbourhood environment.[73]

1.6 Schools as settings of physical activity

Schools represent a unique behaviour setting for the promotion of lifelong physical activity during critical development stages of life.[74] Opportunities for in-school physical activity are largely dependent upon school-level policies and practices and administrative support.[75] International organisations such as the WHO recognise schools as avenues to promote health. The WHO recommends that schools should provide quality physical and health education that supports children and adolescents to develop healthy behaviour patterns that will keep them physically active throughout their lives.[1] This has led to WHO's launch of several school based initiatives designed to improve the health of students, school personnel, families and other members of the community through schools.[76] The WHO developed a Framework for Action, which offers schools and other stakeholders the key principles and simple tools to help them create a healthier environment. Countries have developed various projects to suit their needs. For example, in Canada, 'Passport For Life' is a formative assessment that supports the development and advancement of physical literacy among students and teachers achieved significant improvements in participation and interest of children across a range of activities. Students reported higher feelings of confidence, importance, autonomy, and enjoyment along with less anxiety in physical

activity.[77] Similarly, in the US, some schools have transformed the focus of physical education from traditional sports to other activities that children and adolescents enjoy. This curriculum focuses on games they want to keep playing and couples this with technology that will get them moving. The impact reported young people enjoyed physical activity more, felt better about themselves, became more inclusive and worked together more.[77] In Kenya, in an area which is home to some of the world's poorest and most disadvantaged girls, early and unwanted pregnancies, and vulnerability to HIV/AIDS, leads to low retention in school, increasing their likelihood of being in a cycle of poverty. A project named 'Moving the Goal Posts' (MTG), uses the power of sport to tackle these issues. The project challenges stereotypes, and supports girls to stay in or return to education, enabling them to access the many benefits of attending school including participation in curriculum physical education.[77] Also, existing evidence from systematic reviews demonstrate that school-based physical activity interventions account for significant improvement across several health outcomes for school going children and adolescents,[78] increase students' in school and out of school physical activity levels.[79,80]

1.7 Physical activity in Nigeria

Global Observatory for Physical Activity (GoPA!) was established to measure global progress in the areas of physical

activity surveillance, policy, and research.[17] GoPA! reported that Nigeria currently has neither a physical activity surveillance system nor a national plan.[17,81] Economically, physical inactivity was responsible for approximately $31 million of health-care costs in Nigeria was responsible for 123 thousand DALYs in 2013.[18] Physical inactivity related deaths cost $143 million in productivity losses.[18] In Nigeria, the barriers to being physically active appear to be mediated by a couple of contextual factors. Rapid urbanisation and widespread industrial activities in the country have created several environmental challenges that affect healthy behaviours across many Nigerian cities. High density traffic, poor road designs and unsafe terrains characterise many cities, with recreational walking and cycling unappealing to many.[82] The prevailing low levels of health literacy and sociocultural barriers are additional contextual issues. Many regard cycling or walking as a sign of a low socioeconomic status, hence would rather prefer to own or be in a car for better societal recognition and respect.[82]

In children and adolescents, comparing the results from Nigeria's report card on physical activity for children and youth between 2013 and 2018; overall physical activity level which reduced by about 20% from 2013 to 2016, improved from 2016 to 2018.[83-85] Sex disparities were also noted with boys more physically active than girls.[83] However, they reported that

Nigerian children and adolescents engage in active transportation, especially in the context of transport to and from school.[83,85]

Nigeria is the seventh largest country in the world and most populated in Africa.[86] Thus, tracking the physical activity profile of Nigeria is relevant to national, regional and international public health actions.[87] The paucity of physical activity data in Nigeria makes it difficult to accurately characterise the physical activity patterns of the population, formulate policies or design interventions to improve physical activity since interventions to promote physical activity should be informed by knowledge of the factors that influence physical activity behaviour.[88]

1.8 Research Rationale

Africa is rapidly undergoing an unprecedented phase of urbanisation and how to ensure healthy lives for its residents is an important question.[89] A systematic review which assessed temporal trends and correlates of physical activity among children and adolescents in Africa revealed that urbanisation was associated with a trend towards decreased physical activity and aerobic fitness over time.[52] Some of the immediate effect of the urbanisation are pressures on existing built environment which can have negative impacts on the wellbeing and health of the people.[90] Previous reviews have synthesised associations between the built environment constructs and physical activity

in children and adolescents but they have focused on non-African settings. Therefore, the first objective of this PhD study was to present evidence on the built environment constructs that were associated with physical activity in children and adolescents in Africa.

In a recent pooled analysis of cross-sectional survey data on physical activity in adolescents from 146 countries there were no data from Nigeria, because the available studies from Nigeria did not use samples which were representative of a national or defined subnational population.[33,91] In terms of health promotion and combating NCDs globally, adolescents in Nigeria are important targets because over 43 million Nigerians are between the ages of 10 and 19 years.[92] The adolescent stage is a life phase in which the opportunities for health are great and future patterns of adult health that can either support or undermine future health status are established.[93]

Hence, the second and third objectives of this PhD study seeks to investigate the levels and predictors of physical activity, and to identify and explore the barriers and facilitators of physical activity among school attending adolescents in Lagos State, Nigeria.

1.8.1 Rationale for conducting the study in Lagos State, Nigeria

Lagos is located in the south western region of Nigeria and the region is reported to be region with the lowest prevalence of physical activity in Nigeria.[82] Lagos State in Nigeria ranks seventeenth out of the world's 31 megacities (cities with 10 million inhabitants or more) and has an estimated population of 14 million.[94] It occupies a land area of 3,577 km^2 representing 0.4% of Nigeria total land area.[95] It is the most densely populated state in Nigeria as it is estimated to have 1,308 persons per square kilometre.[96] With the present annual growth rate of 3.9 percent, Lagos is projected to have a population of over 24 million in 2030.[94] Lagos occupies a unique position in Nigeria and in West Africa sub region, as the city with the highest rate of urbanisation.[97] As with most cities that are going through urbanisation, inequitable distribution of resources in different areas of the city affect physical activity.[98] Physical activity in urban environments has health benefits but comes with attending risks of harm from injury, violence and/or exposure to pollution.[99] In many HICs and more affluent parts of LMICs, the benefits of physical activity tend to outweigh these risks with access to safe spaces for physical activity.[100] However, for the lower socio-economic groups that comprise the majority of urban residents in megacities like Lagos,

physical activity is undertaken in unsupportive and potentially harmful environments while navigating dangers such as air pollution and road traffic injury.[99] Where you live to a large extent determines how much physical activity you can lawfully engage in.[100] Affluent-gated communities are able to access spaces for physical activity especially in the communal playgrounds and along paved streets, but this is not the case for residents of low income communities.[99] Lagos state has been characterised to have a high number of barriers to physical activity related to traffic, personal safety and a lack of safe places for outdoor play.[101] Lagos has over a thousand secondary schools[102] and given the limiting environment of the state to facilitate physical activity; the schools provide an avenue to encourage and foster physical activity among students.

Figure 4: Map of Nigeria showing Lagos State.[103]

Figure 5: Map of Lagos State[104]

1.10 Aim and Objectives

The overall aim of this thesis was to understand the factors that were associated with physical activity among school-attending adolescents in Lagos State, Nigeria.

The specific objectives of this thesis were to:

1. Synthesise the association between built environment constructs and physical activity in children and adolescents in Africa (chapter two).
2. Quantify the prevalence of MVPA among school attending adolescents in Lagos State, Nigeria and identify which predictors are associated with achieving MVPA (chapter three).
3. Identify and explore the views and experiences of decision makers in secondary schools on the barriers and facilitators of physical activity among school attending adolescents in Lagos State, Nigeria (chapter four).

The subsequent sections of the thesis describe the rationales and methodology used in addressing the objectives of the research.

Chapter two

Association of built environment constructs and physical activity in children and adolescents in Africa: a systematic review and meta-analysis

2.1 Introduction

The built environment refers to the surroundings created by humans and used for human activity.[65] Examples of built environment attributes include residential density, walkability, pleasant neighbourhoods, as well as crime and traffic safety.[100,105] These components of the built environment play a vital role in determining individuals' physical activity behaviours across domestic, occupational, transportation, and leisure time physical activity domains.[100] The built environment has the potential to affect the long-term health of children and adolescents by increasing the daily physical activity they experience through independent mobility and play.[69,106] Proximate recreational facilities appear to predict older children's and adolescents' physical activity levels;[106] there is evidence that the presence of physical activity facilities close to home is positively associated with active transportation and MVPA in adolescents.[107] Perceived neighbourhood safety has also been associated with physical activity and leisure-time walking in adolescents.[108] There is also an evidence of a safe neighborhood significantly predicting walking activities among girls.[108] Conflicting reports have been reported for residential density: a study reported no significant association with children's physical activity[109]; another study has reported negative association with physical activity in adolescents[110];

while another study reported significant associations with weekend day MVPA in adolescents.[111] Regarding street connectivity, a study reported an inverse association between adolescents' out-of-school physical activity and higher street connectivity.[112] Neighbourhoods with higher walkability, density, and accessibility are reported to be associated with active transportation (human-powered travel e.g walking) for children and adolescents. Also, installation of traffic calming features and improvements of sidewalks are associated with active transportation in children and adolescents.[113,114] For younger children, the impact of the built environment is influenced by the decision-making of parents as gatekeepers of their behaviour.[106] As children develop and are given more independent mobility, the design of neighbourhoods becomes a determinant of whether children are able, and are permitted by their parents, to walk and use destinations locally, particularly in terms of proximity and connectivity to local destinations, including schools and shopping centres, and the presence of footpaths.[106] It is indicated that more time playing outdoors is significantly associated with increased physical activity in children and adolescents.[115,116] Conversely, inaccessible or non-existent sidewalks or bicycle paths contribute to sedentary habits.[117]

Regular physical activity improves body composition, cardiorespiratory and muscular fitness, bone health, and levels of metabolic health biomarkers among children and adolescents.[23] It is also associated with psychological benefits in adolescents by improving their control over anxiety and depression symptoms. Regular physical activity assists in social development by providing opportunities for self-expression, and building self-confidence, social interaction, and integration.[118] It also improves cognitive outcomes (academic performance, executive function).[1] Furthermore, physical activity in children and adolescents has been shown to track into adulthood and thus influences individual and public health in the adult population.[119] Given the immediate and future health benefits of regular physical activity, the World Health Organization (WHO) recommends at least 60 minutes of MVPA in children and adolescents daily.[11,120]

Countries in Africa are currently undergoing rapid socioeconomic developments and urbanisation, which have resulted in shifts in habitual and occupational physical activity from high-energy expenditure activities (e.g., active transport, manual labour) to low-energy expenditure activities (e.g., motorized transport).[9,52] While urbanisation and the shaping of the built environment have provided a number of socioeconomic benefits,[65] the transition to lower levels of physical activity have

brought about a more sedentary life with negative health consequences, particularly non-communicable diseases (NCDs).[9,52] In 2017, 2.1 billion children were affected with NCDs.[121] Current evidence show that only 13.8% - 14.5% of adolescents reached the recommended level of physical activity in sub-Saharan Africa,[33,91] this is lower than the proportion of adolescents that reached the recommended level globally (19%). A rapidly urbanising world creates challenges, and there is a need to maintain, upgrade, and develop urban areas to support and promote public health.[122] In present-day society, a sedentary lifestyle has become the norm, hence the need to actively encourage more physical activity, especially play, incidental physical activity, and transport-related walking or cycling at an early age for it to be sustained through adulthood.[106]

2.1.1 Rationale for this systematic review

Given the reported associations between the built environment and physical activity or active transportation in children and adolescents, and the specific built environment features in Africa that are different from other countries,[123] it is imperative to synthesise the findings across Africa. Previous systematic reviews have synthesised associations between the built environment and physical activity in children and adolescents, but these studies have focused mostly on countries outside of

Africa.[69,73,124-133] Understanding the potential influence that the built environment can have on children's and adolescents' physical activity and active transportation can be pivotal. This will present evidence to key stakeholders, such as urban planners and transportation officials, on what built environment construct to invest in to support and promote habitual physical activity among children and adolescents in Africa.

2.1.2 Review objective

The objective of this systematic review was to synthesise the association between built environment constructs and physical activity in children and adolescents in Africa.

2.1.3 Inclusion criteria

2.1.3.1 Participants

Children and adolescents between five and 19 years of age in Africa were eligible for inclusion. The lower age limit of five was chosen because evidence suggests that MVPA begins to decline from approximately five years of age in children,[134] and 19 years of age is the upper limit because it is consistent with the WHO's cut-off for adolescence.[135]

2.1.3.2 Exposure

Any built environment construct, including but not limited to walkability, availability of playgrounds, traffic safety, residential density, land-use mix, green spaces, and crime-related safety, was considered for inclusion. Both objective and perceived

measures of the built environment constructs were considered. All settings (neighbourhood and school-based) were eligible for inclusion. Neighbourhoods and school-based settings are of particular importance, because neighbourhoods in which children live are important settings for health promoting actions and policy,[131] and schools represent a unique setting for the promotion of lifelong physical activity during critical development stages of life.[74]

2.1.3.3 Outcome

We included all domains of physical activity, including leisure-time, active transportation, domestic, and occupational. Any measure of physical activity levels was considered, including, but not limited to, the total time spent undertaking physical activity per week or per day, and length of time undertaking MVPA per week or per day. Outcomes could be measured either subjectively using self-reported (or parent/teacher/guardian reported) questionnaires, or objectively using accelerometers or pedometers.

2.1.3.4 Types of studies

Eligible study designs included experimental designs (including randomized controlled trials), quasi-experimental designs (including non-randomized controlled trials), and comparative analytical observational designs (including prospective and

retrospective cohort studies, case-control studies, and cross-sectional studies).

2.2 Methods

This systematic review was conducted in accordance with an a priori published protocol[136] and was prospectively registered in PROSPERO (CRD42019133324). The authors followed the JBI systematic review of etiology and risk guideline[137] and the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guideline.[138]

2.2.1 Search strategy

The search strategy was developed in two steps. An initial limited search was carried out in MEDLINE (Ovid) to identify relevant articles. The text words contained in the titles and abstracts of the relevant articles and the index terms used to describe the articles were used to develop a full search strategy for MEDLINE in consultation with a librarian. This search strategy was adapted for each included database. The following databases were searched for published studies: MEDLINE (Ovid; 1946–22 October 2021), Embase (Ovid; 1974–22 October 2021), CINAHL (EBSCO; 1958–22 October 2021), Web of Science (1900–22 October 2021), PsycINFO (Ovid; 1806–22 October 2021), Scopus (1788–22 October 2021), and SPORTDiscus (EBSCO; 1974–22 October 2021). EThOS (2009–

22 October 2021) and ProQuest Dissertations and Theses (1975–22 October 2021) were searched for unpublished studies. No language restrictions were applied and the search strategy for each database is listed in Appendix 1. The reference lists of all the included studies and relevant systematic reviews were also screened for additional studies.

2.2.2 Study selection

All identified citations were collated and uploaded into EndNote v.X8.2 (Clarivate Analytics, PA, USA) and the duplicates were removed. Two reviewers (BA and CI) independently screened the titles and abstracts for eligibility against the inclusion criteria. Studies identified as potentially eligible were retrieved in full. Two reviewers (BA and WE) independently screened the full text of the studies in detail against the inclusion criteria. Full-text studies that did not meet the inclusion criteria were excluded and reasons for their exclusion are provided in Appendix 2. Any disagreements that arose between the reviewers were resolved through discussion or with a third reviewer (JLB) if consensus was not reached.

2.2.3 Assessment of methodological quality

Two reviewers (BA and WE) independently appraised the included studies using the standardized critical appraisal tool for experimental,[139] quasi-experimental,[139] and comparative analytical observational studies.[140] Any disagreements that

arose between the reviewers were resolved through discussion or with a third reviewer (JLB) if consensus was not reached. The methodological quality scores of the included studies were computed as a percentage of those being assigned a "Yes" rating for each domain and overall. All studies meeting the inclusion criteria were included in the review, irrespective of their methodological quality score.

2.2.4 Data extraction

An Excel (Redmond, Washington, USA) template was developed, piloted, and used for data extraction by two reviewers (BA and WE), independently. Any disagreements that arose between the reviewers were resolved through discussion or with a third reviewer (JLB) if consensus was not reached. The following information was extracted: title, author, study period, study design, country, population characteristics, inclusion and exclusion criteria, sample size, recruitment method, data collection procedure and tool, built environment construct and definition, mode of measurement for both built environment construct and physical activity or active transportation, data analysis technique, results, and authors' conclusions (Appendix 3). The association between physical activity or active transportation and built environment constructs was extracted as adjusted effect estimates or, where not reported, as the crude estimate or raw data. Effect estimates were extracted as

either mean differences (MDs) or odds ratios (ORs) together with their 95% confidence intervals (CIs). Where raw data were extracted, crude effect estimates (MD or OR) with 95% CIs were estimated. For outcome measures expressed as categories, the OR was estimated from raw data, and the highest quantile was compared to the combination of the other quantiles.

2.2.5 Data synthesis

A narrative synthesis was initially used in this review to systematically examine the data. First, a general description of the characteristics of the included studies was performed, and second, random effects meta-analyses[141] were conducted for each built environment construct using RevMan V5.4 (Copenhagen: The Nordic Cochrane Centre, Cochrane). Results are expressed as pooled MD or pooled OR, with 95% CIs. Where outcomes were only reported for different time points, the timings related to after school were used in preference for the meta-analysis to aid consistency in the pooled data. Where studies reported both objective and perceived measures of built environment constructs, both measures were presented in the meta-analyses, however, they were not pooled. Heterogeneity was quantified using I^2. Where studies could not be included in the meta-analysis due to insufficient reporting of results, the findings from these studies were reported narratively using *p*-

values as reported by the studies. We were unable to formally explore reasons for heterogeneity between studies using subgroup analysis and sensitivity analysis due to an insufficient number of studies; however, where possible, we reported whether there was evidence of an interaction by socioeconomic status (SES) using *p* values from tests of interaction as reported in the paper. We were also unable to conduct formal investigations of publication bias due to the insufficient number of studies in the meta-analyses.

2.2.6 Assessing certainty in the findings

The Grading of Recommendations Assessment, Development and Evaluation (GRADE) approach[142] was used to determine the certainty of the evidence for each finding related to the built environment constructs, using synthesised findings from meta-analyses or findings from the narrative syntheses where pooled results were not available. A Summary of Findings (Appendix 4) was created using GRADEPro GDT (McMaster University, ON, Canada). This was undertaken by two independent reviewers (BA and JLB). Findings were initially ranked as low and were downgraded to very low if there was evidence of any of the following: risk of bias, imprecision, inconsistency of evidence, and indirectness. Findings were upgraded based on the magnitude of association, evidence of a dose-response association, and where all plausible residual confounders or

biases would reduce the demonstrated effect or suggest a spurious effect when the results show no effect.

2.3 Results

2.3.1 Study inclusion

We identified 10,706 records from the database search. After removing duplicates, 8787 papers were screened based on their titles and abstracts, and 49 studies were screened at the full-text stage. Six studies were included in the review[123,143-147] (Figure 6). The reasons for the exclusion of the 43 studies evaluated at the full-text screening stage were either ineligible participants (n=7), ineligible exposure (n=31), ineligible outcome (n=1), duplicate cohort (n=1), or full-texts were not available (n=3). See Appendix 2 for a list of excluded studies.

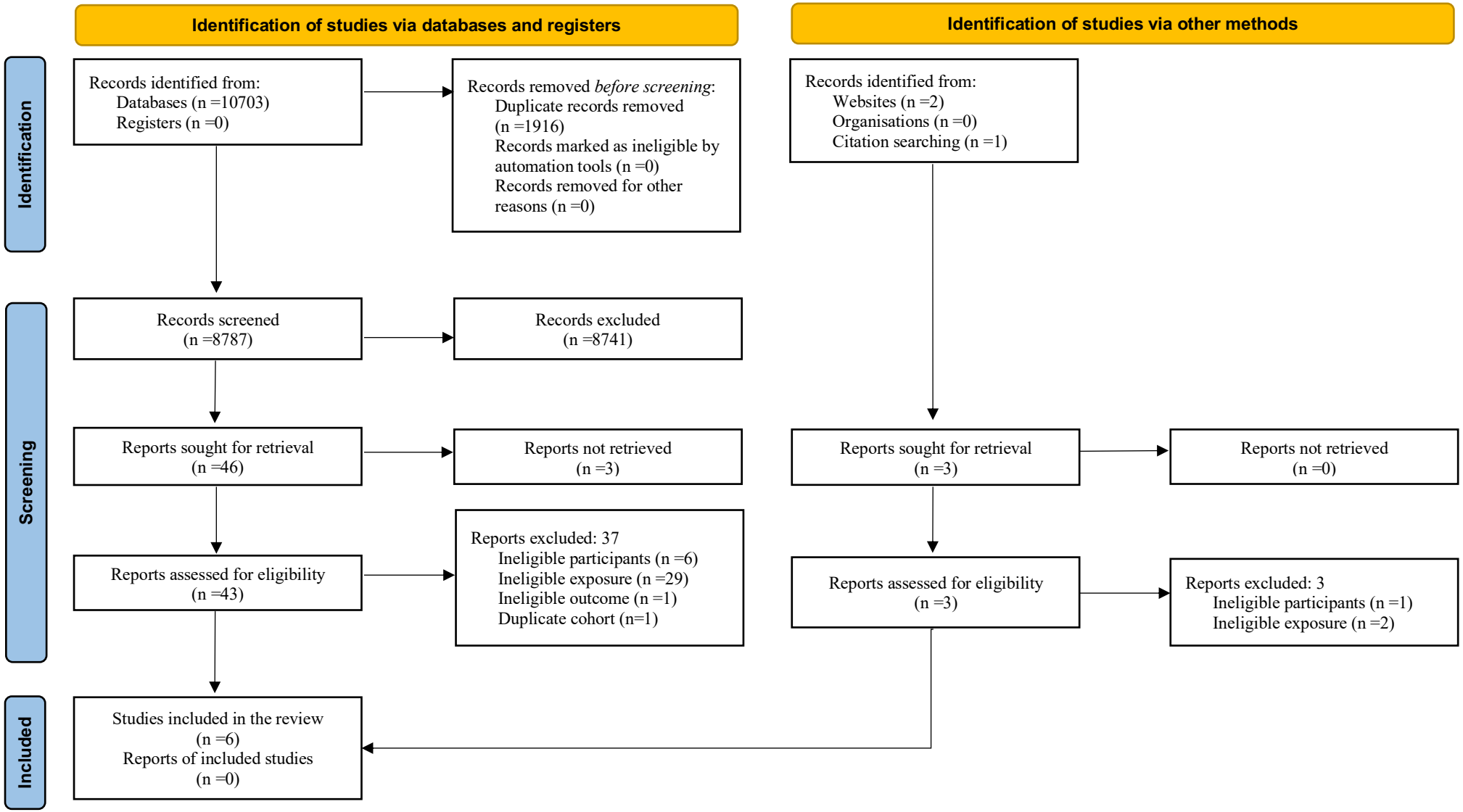


Figure 6: Search results and study selection and inclusion process[138]

2.3.2 Methodological quality

Overall, half of the included studies had scores over 70%,[123,143,146] with the remaining studies having lower scores of either 50%[144] or 62.5%[145,147] (Table 1). Studies that had lower scores either did not measure exposure in a valid and reliable way,[147] not use objective standard criteria for the measurement of the condition,[123,144,146] not identify confounders,[144,145] not state strategies to deal with confounding,[144,145] or not use appropriate statistical methods.[144,145]

Table 1: Critical appraisal of included studies

Author (year)	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Total %
Manyanga et al.(2019)[143]	Y	Y	Y	Y	Y	Y	Y	Y	100
Moges et al.(2018)[144]	Y	Y	Y	N	N	N	Y	N	50
Muthuri et al.(2016)[145]	Y	Y	Y	Y	N	N	Y	N	63
Oyeyemi et al.(2014)[123]	Y	Y	Y	N	Y	Y	Y	Y	88
Siiba (2021)[147]	Y	Y	N	N	Y	Y	N	Y	63
Uys et al.(2016)[146]	Y	Y	Y	Y	Y	Y	Y	Y	100
Total (%) Yes	100	100	83	50	67	67	83	67	

Y, yes; U, unclear; N, no. Critical appraisal questions Q1- Were the criteria for inclusion in the sample clearly defined? Q2- Were the study subjects and the setting described in detail? Q3-Was the exposure measured in a valid and reliable way? Q4- Were objective, standard criteria used for measurement of the condition? Q5- Were confounding factors identified? Q6- Were strategies to deal with confounding factors stated? Q7- Were the outcomes measured in a valid and reliable way? Q8- Was appropriate statistical analysis used?

2.3.3 Characteristics of included studies

The six included studies were conducted in Ghana,[147] Ethiopia,[144] Kenya,[145] Mozambique,[143] Nigeria,[123] and South Africa[146] (Table 2). All the included studies used an analytical cross-sectional study design and were published between 2014 and 2021. The sample sizes ranged from 258 to 1276 participants, and ages ranged from six to 19 years. All studies included boys and girls as participants. An objective measure of physical activity levels was used in three studies,[143,145,146] whereas the remaining three used self-reported measures based on questionnaires.[123,144,147] Two studies reported the proportion of participants meeting the guidelines of ≥60 minutes per day of MVPA.[143,145] One study reported the length of time undertaking MVPA as minutes per day based on specific time points of before school, after school, and at the weekend.[146] One study reported the length of time undertaking MVPA as minutes per week based only on leisure (sports participation) time and the minutes per week of active transportation to school.[123] Another study categorised the length of time conducting any physical activity as low (<30 minutes/day), moderate (30 to 59 minutes/day), or high (≥60 minutes/day).[144] The sixth study reported the usual travel modes of their participants and how frequently they used it in a typical school week.[147]

Five studies reported on perceived measures of built environment constructs within neighborhoods,[123,143,145-147] focusing on the following: residential density,[123] street connectivity,[123,145] traffic safety,[146,147] crime safety,[123,143,145-147] walkability,[123,145-147] availability of physical activity facilities and infrastructure,[123,144,146,147] and aesthetics.[123,145] Two studies reported on built environment constructs using objective measures.[144,146] One of these reported three objectively assessed built environment constructs: availability of physical activity facilities, neighbourhood safety, and traffic safety,[146] while the other study focused on an objective measure of the availability of physical activity facilities and infrastructure using the size of the playground at schools.[144]

Table 2: Characteristics of included studies

Authors Publication year	Country	Setting	Sample size	Characteristics (age range, % female)	Categorized built environment construct	Definition of the built environment construct	Mode of measurement of built environment construct	Measurement of physical activity	Mode of measurement of physical activity
Manyanga et al. 2019[143]	Mozambique	Neighbourhood	683	9-11 years, 52.9% female	A. Crime safety	A. Crime rate in the neighbourhood (ref: crime not a problem)	Perceived (by parents) using ISCOLE questionnaire	≥60 minutes/ day of total MVPA	Objectively using an accelerometer
Moges et al. 2018[144]	Ethiopia	School	1276	10-19 years, 50% female	Facilities and infrastructure	Size of playground ≥1092 m^2 (ref: < 1092 m^2)	Objectively (based on national requirement)	Low < 30 minutes of any physical activity Medium 30 to 59 minutes of any physical activity High ≥60 minutes/ day of any physical activity	Self-reported using a questionnaire (GPAQ)
Muthuri et al. 2019[145]	Kenya	Neighbourhood	563	9-11 years, 53.5% female	A. Social cohesion B. Street connectivity	A. (i) People around my neighbourhood are willing to help their neighbours, (ii) People in my neighbourhood can be trusted.	Perceived (by parents) using ISCOLE questionnaire – exposure categorized as	≥60 minutes/ day of total MVPA	Objectively using an accelerometer and perceived

					C. Crime safety D. Traffic safety E. Aesthetics F. Walkability	B. (i) There are not many dead-end streets, (ii) There are many different routes for getting from place to place. C. (i) I am afraid of my child being taken or hurt by a stranger on local streets, (ii) I'm afraid of my child being taken or hurt by a stranger in a local park, (iii) I am afraid of my child being taken or hurt by a stranger in my yard, driveway, or common area, (iv) I am afraid of my child being taken or hurt by a known "bad" person (adult or child) in my neighbourhood, (v) There is a high crime rate. D. (i) The speed of traffic on most streets is usually slow (30 mph or less), (ii) Most drivers go faster than the posted speed limits, (iii) The traffic makes it difficult or unpleasant for my child to walk. E. (i) There are many interesting things to look at while walking in my neighbourhood, (ii) Streets have good lighting at night. F. (i) There is a bus, transit/stage, or train stop within walking distance from my home, (ii) There are crosswalks and signals on busy streets, (iii) There are shops, stores, markets, and places to buy things I need within easy walking distance of my home/house, (iv) There are sidewalks on most streets, (v) There are many places to go within easy walking distance of the home.	present if responders reported agree or strongly agree with the statements		(child self-report)
Oyeyemi et al. 2014[123]	Nigeria	Neighbourhood	1006	12-19 years, 50.4% female	A. Residential density	A. Types of housing in the neighbourhood, options ranged from: (i) Detached single bungalows and duplexes, (ii) Mix of bungalows, duplexes, and apartments with shared facilities, (iii) Apartments with shared facilities, or flats of 1-2 stories, (iv)	Perceived using PANES-N questionnaire	Minutes per week of leisure (sports participation) time	Self-reported using AQuAA questionnaire

	B. Walkability C. Street connectivity. D. Facilities and Infrastructure. E. Aesthetics, F. Crime safety	Blocked apartment with multiple households per plot or flats of 3 or more stories. B. (i) Many places such as shops, stores, and markets to buy things I need are within easy walking distance of my home, (ii) It is within easy walking distance from my home to access public buses, and taxis in my neighbourhood, (iii) There are many non-residential places such as schools, hospitals, workplaces etc to go within easy walking distance of my home. C. There are many cross junctions in my neighbourhood. D. (i) My neighbourhood has several places such as open field, school playground, parks, public space and gymnasium to exercise and play sports (ii) There are separated pedestrian pathways on most of the streets in my neighbourhood, (iii) It could be safe to bicycle in or near my neighbourhood because there is little traffic, (iv) The walk and foot pathways in my neighbourhood are unobstructed and good for walking. E. (i) There are many beautiful things such as architectural design, shade trees, building varieties and attractive landscaping to look at while walking in my neighborhood, (ii) My neighbourhood is generally free from unattended domestic animals like goats, cattles, dogs etc (iii) My neighbourhood is generally free from garbage, stagnant water and offensive odours. F. (i) Walking is dangerous in my neighbourhood during the day because of	MVPA (transformed using square root) Minutes per week of active transportation (transformed using square root)

						inadequate security from molestation, crime and harassment from hooligans, rascals and drug addicts, (ii) Walking is dangerous in my neighbourhood during the night because of inadequate security from molestation, crime and harassment from hooligans, rascals and drug addicts, (iii) Walking is dangerous in my neighbourhood because of the speed of traffic and aggressive driving.			
Siiba 2021[147]	Ghana	Neighbourhood	842	6-16 years, 53% female	A. Facilities and infrastructure B. Crime safety C. Traffic safety D. Walkability	A. There are limited dedicated walking and cycling paths in my neighbourhood B. (i) I think that my neighbourhood is not safe for my child to walk/cycle to school, (ii) Stranger danger is a concern to me. C. (i) I am concerned about dangerous traffic en route to school, (ii) I think drivers are too fast on the streets of this neighbourhood, (iii) I am concerned my child might be injured in a road accident while walking to school, (iv) There is too much traffic in my neighbourhood, (v) Bicycling/walking to school would mean my child has to negotiate dangerous road junctions. D. There is no direct route for my child to walk/cycle to school.	Perceived using a questionnaire	Active travellers were defined as those who made more than half of their total weekly school trips via walking or cycling.	Self-reported using a questionnaire
Uys et al.2016 [146]	South Africa	Neighbourhood	258	9-11 years, 56.2% female	A. Facilities and infrastructure B. Crime safety C. Traffic safety	A. Parents estimated the length of time it took to walk from home to the nearest sporting venues, recreational facilities and parks by selecting one of the six options: 1-5 minutes, 6-10 minutes, 11-20 minutes, 21-30 minutes, > 30 minutes and don't know. B. (i) There is a high crime rate, (ii) Streets have good lighting at night, (iii) I am afraid of my child being taken or hurt by a	Objectively and perceived (by parents) using ISCOLE questionnaire	Minutes/ day of MVPA reported at three time points: before school, after school	Objectively using an accelerometer

	D. Walkability	stranger on local streets, (iv) I am afraid of my child being taken or hurt by a stranger in my yard, driveway or common area, (v) I am afraid of my child being taken or hurt by a stranger in a local park, (vi) I am afraid of my child being taken or hurt by a known bad person in my neighbourhood. C. (i) The speed of traffic on most streets is usually slow (50 kph or less), (ii) Most drivers go faster than the posted speed limits, (iii) The traffic makes it difficult or unpleasant for my child to walk, (iv) There are crosswalks and robots (traffic lights) on busy streets D. (i) There are shops, stores, markets and places to buy things I need within easy walking distance of my home/house, (ii) There is a bus, taxi, or train stop within walking distance from my home, (iii) There are sidewalks on most streets, (iv) There are many different routes for getting from place to place, (v) There are many interesting things to look at while walking in my neighbourhood, (vi) There are many places to go within easy walking distance from my home	and weekend MVPA.

ISCOLE; International Study of Childhood Obesity Lifestyle and the Environment, PANES-N; Physical Activity Neighbourhood Environment Scale in Nigeria, MVPA; Moderate–to-vigorous physical activity, GPAQ; Global Physical Activity Questionnaire, AQuAA; Activity Questionnaire for Adults and Adolescents.

2.3.3 Review findings

2.3.3.1 Physical activity

Residential density

One study assessed perceived residential density, which was operationalised by the main type of housing in the neighbourhoods, with options ranging from detached single houses to blocked apartments with multiple households.[123] This study found that perceived residential density may lead to little or no difference in physical activity (MD 0.01 minutes, 95% CI -0.11 to 0.12; I^2 = 0%; Figure 7; low certainty). The study investigated whether there was evidence of an interaction with SES but found no significant SES interaction (girls: p=0.86, boys: p=0.43).

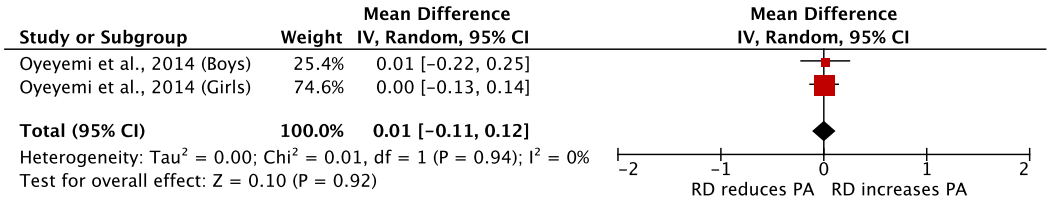


Figure 7: Forest plot for the association of residential density (RD) with physical activity (PA)

Street connectivity

Two studies assessed perceived street connectivity, which was operationalised as the availability of many cross-junctions in neighbourhoods, few dead-end streets, and the availability of different routes for getting from place to place.[123,145] One study showed that perceived street connectivity may lead to little or no difference in physical activity (MD -0.01 minutes, 95% CI -

0.11 to 0.10; I^2 = 0%; Figure 8; low certainty).[123] Similarly, the other study, which could not be included in the meta-analyses as it only reported *p* values, found no significant association between physical activity and having many different routes from place to place (p=0.25); however, this latter study did find a significant association between physical activity and not having many dead-end streets (p=0.004).[145] One of the studies investigated whether there was evidence of an interaction by SES, but found no significant SES interaction (girls: p=0.15, boys: p=0.30).[123]

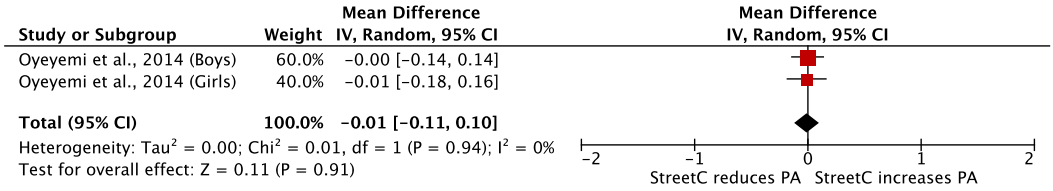


Figure 8: Forest plot for the association of perceived street connectivity (StreetC) with physical activity (PA)

Crime safety

Four studies assessed perceived safety, which was generally operationalised as feeling safe in the neighbourhoods.[123,143,145,146] A pooled analysis of two studies found that perceived crime safety may lead to little or no difference in physical activity (pooled MD 0.03 minutes, 95% CI - 0.18 to 0.24; I^2 = 0%; Figure 9; low certainty).[123,146] Similarly, two further studies, which were not included in the meta-analysis due to either reporting the effects using an OR[143] or only presenting p values,[145] found perceived crime safety was

not significantly associated with physical activity (crime safety: OR 1.54, 95% CI 0.85 to 2.78;[143] crime rate: p=0.40[145]). Muthuri et al. found no significant association with other measures of crime safety, such as being afraid of one's child being taken or hurt by a stranger either on a local street (p=0.77); in a local park (p=0.55); in a yard, driveway or common area (p=0.06); or by a known bad person in the neighborhood (p=0.43).[145] Conversely, when crime safety was assessed as an objective measure using crime rates,[146] a significant association was seen with physical activity (MD 2.72 minutes, 95% CI 0.07 to 5.37; Figure 9; very low certainty). Out of the four studies, two studies investigated whether there was evidence of an interaction by SES.[123,146] The first study found a stronger association between perceived crime safety and physical activity in boys in those living in high-income neighbourhoods compared with those living in low-income neighborhoods (p=0.01), however, no interaction was seen in girls (p=0.43).[123] Also, the second study found a significant interaction between those in lower SES groups, who were less active in unsafe neighbourhoods, compared with those in higher SES groups for an objective measure of crime safety (p=0.02), but no significant interaction was seen when a perceived measure of crime safety was used (p=0.65).[146]

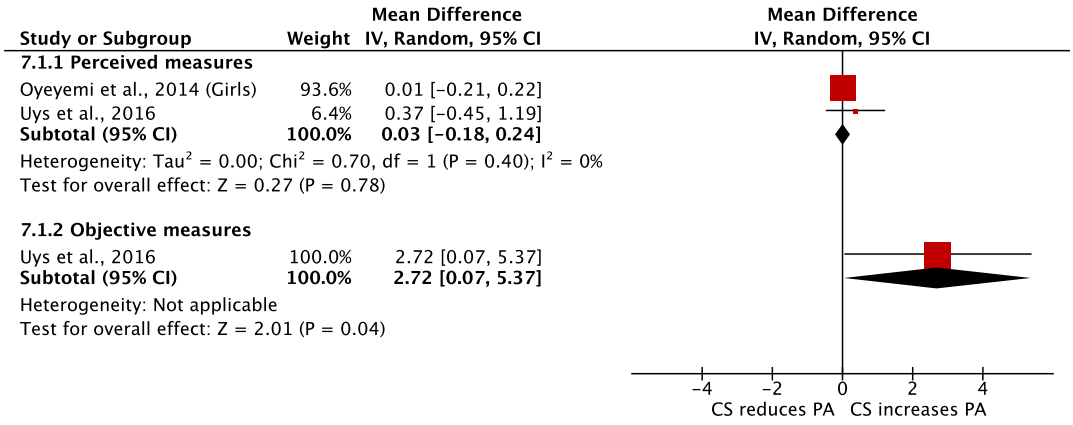


Figure 9: Forest plot for the association of perceived crime safety (CS) with physical activity (PA)

Availability of physical activity facilities and infrastructure

Three studies assessed this construct, which was described as the availability of physical activity facilities and infrastructure, and included the presence of facilities, proximity to facilities, presence of separated pedestrian and bicycle pathways, and adequate size of the playground.[123,144,146] A pooled analysis of two studies found that perceived availability of physical activity facilities and infrastructure may lead to little or no difference in physical activity (pooled MD 0.13 minutes, 95% CI -0.04 to 0.31; I^2 = 30%; Figure 10; low certainty).[123,146] Two studies reported objective measures of the construct.[144,146] The first study,[144] which could not be included in the meta-analyses due to reporting the effect as an OR, found a significant association between the construct (larger playgrounds at school) and increased physical activity (OR 1.68, 95% CI 1.35 to 2.10); however, the other study found no significant association with physical activity (MD -0.03 minutes, 95% CI -0.44 to 0.38;

Figure 10; very low certainty).[146] Out of the three studies, two studies investigated whether there was evidence of an interaction by SES, with none finding a significant interaction (Oyeyemi et al. 2014[123]: girls: p=0.24, boys: p=0.31; Uys et al. 2016[146]: perceived measure: p=0.93, objective measure: p=0.29).

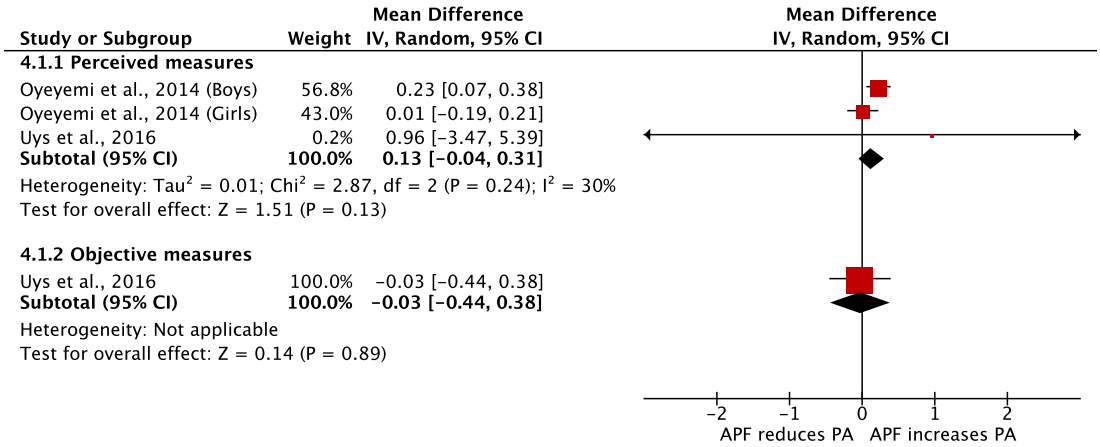


Figure 10: Forest plot for the association of perceived availability of physical activity facilities (APF) with physical activity (PA)

Walkability

Walkability was assessed in three studies and was operationalised as the accessibility to different services, such as stores, buses, and non-residential places, including schools and hospitals; the presence of sidewalks on streets.[123,145,146] A pooled analysis of two studies found that perceived walkability may lead to little or no difference in physical activity (pooled MD 0.04, 95%CI -0.15 to 0.23; I^2= 21% Figure 11; low certainty).[123,146] Similarly, the remaining study, which was not included in the meta-analysis due to only reporting p values,

found physical activity was not significantly associated with three measures of walkability (having services within easy walking distance of home, p=0.63; having sidewalks on most streets, p=0.62; or having many places to go within walking distance of homes, p=0.14). However, significant associations were seen with whether public transport was within easy walking distance of the home (p<0.001) and having crosswalks and signals on busy streets (p=0.05).[145] Two studies investigated whether there was evidence of an interaction by SES, with none finding a significant interaction (Oyeyemi et al. 2014:[123] girls: p=0.09, boys: p=0.24; Uys et al. 2016:[146] p=0.14).

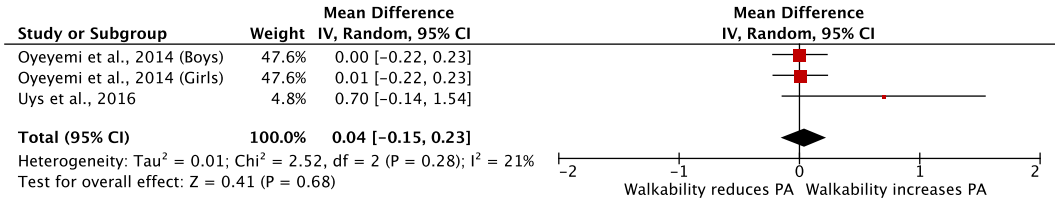


Figure 11: Forest plot for the association of walkability with physical activity (PA)

Aesthetics

Two studies assessed perceived aesthetics (defined as the many interesting/beautiful things to look at within the neighborhood or the neighborhoods being free from unattended animals, garbage, stagnant water, and offensive odors).[123,145] One study found that perceived aesthetics may lead to little or no difference in physical activity (MD 0.00, 95% CI -0.13 to 0.13; I^2 = 0%; Figure 12; low certainty).[123] Similarly, another

study, which could not be included in the meta-analysis due to only reporting p values, did not find a significant association with two measures of aesthetics (having many interesting things to look at, p=0.46; streets having good lighting at night, p=0.44).[145] One study investigated whether there was evidence of an interaction by SES, but found no evidence of an interaction (girls: p=0.78, boys: p=0.98).[123]

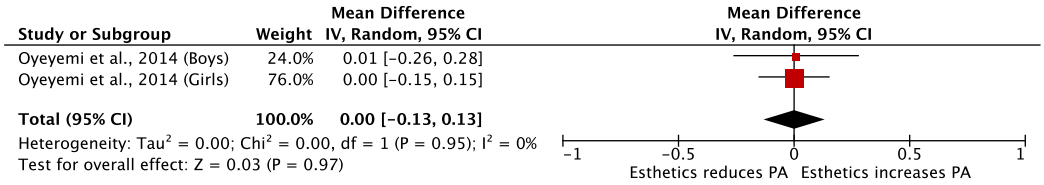


Figure 12: Forest plot for the association of aesthetics with physical activity (PA)

Traffic safety

Two studies assessed perceived traffic safety, which was defined as the adherence to speed limits and availability of crosswalks and traffic lights on busy streets.[145,146] One study found that it is uncertain whether perceived traffic safety decreases physical activity (MD -0.32 minutes, 95% CI -1.69 to 1.05; Figure 13; very low certainty).[146] Similarly, the other study which could not be included in the meta-analysis due to only reporting p values, found no significant association when assessed against three measures of perceived traffic safety (speed of traffic is usually low, p=0.67; most drivers go faster than the speed limit, p=0.52; traffic makes it difficult for my child to walk, p=0.54).[145] Conversely, when traffic safety was

assessed as an objective measure using motor vehicle accidents, a significant association with physical activity was seen (MD 2.63 minutes, 95% CI 0.16 to 5.10; Figure 13; very low certainty).[146] One study investigated whether there was evidence of an interaction by SES: a significant interaction was noted for the objective measure of traffic safety (p=0.05), where children in lower SES groups were less active in areas with high traffic safety compared to children in higher SES groups, but no significant interaction was seen when a perceived measure of traffic safety was used (p=0.60).[146]

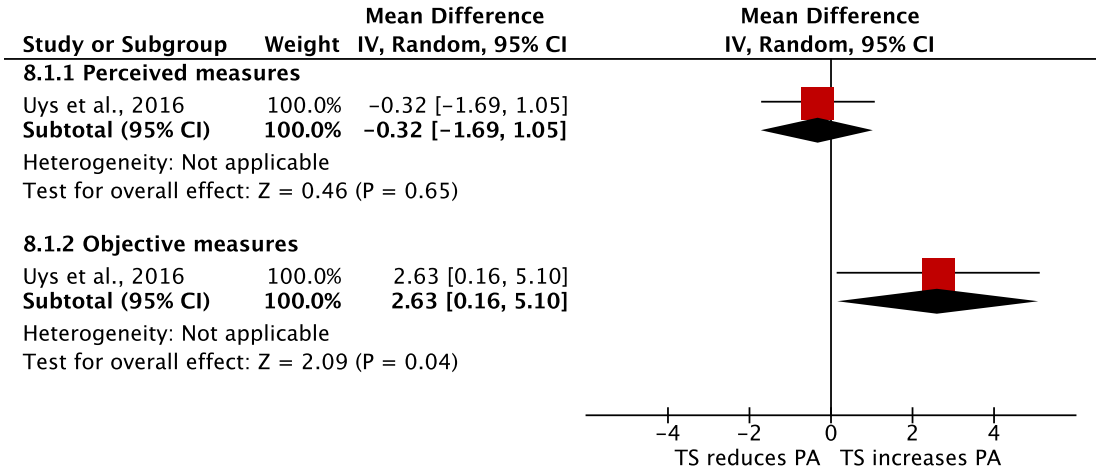


Figure 13: Forest plot for the association of traffic safety (TS) with physical activity (PA)

2.3.3.2 Active transportation

Residential density

One study assessed the association of perceived residential density with active transportation and found that perceived residential density may lead to little or no difference in active transportation (MD 0.00 minute, 95% CI -0.06 to 0.07; I^2 =

0%; Figure 14; low certainty).[123] The study investigated whether there was evidence of an interaction with SES, but found no significant SES interaction (girls: p=0.56, boys: p=0.23).

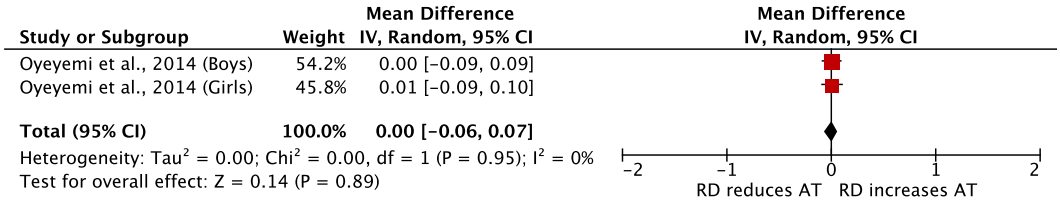


Figure 14: Forest plot for the association of residential density (RD) with active transportation (AT)

Street connectivity

One study assessed the association of perceived street connectivity with active transportation and found that perceived street connectivity may lead to little or no difference in active transportation (MD 0.00 minute, 95% CI -0.05 to 0.06; I^2 = 0%; Figure 15; low certainty).[123] This study investigated whether there was evidence of an interaction by SES but found no significant SES interaction (girls: p=0.55, boys: p=0.15).[123]

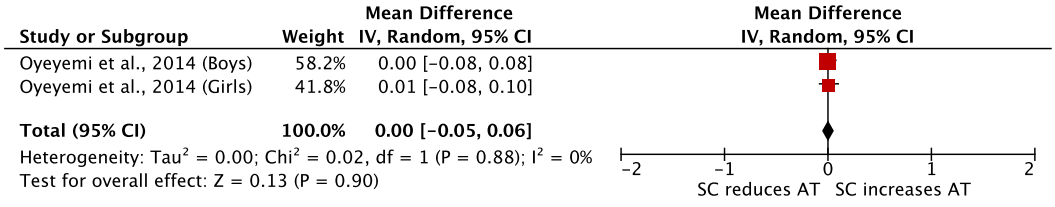


Figure 15: Forest plot for the association of street connectivity (SC) with active transportation (AT)

Crime safety

Two studies assessed the association of perceived safety with active transportatation.[123,147] One of the studies found that perceived crime safety may lead to little or no difference in active transportation (MD 0.00 minute, 95% CI -0.10 to 0.10; I^2 = 0%; Figure 16; low certainty).[123] The other study, which could not be included in the meta-analysis due to reporting ORs, found no significant association with two measures of safety (I think that my neighbourhood is not safe for my child to walk/cycle to school, OR 1.06, 95%CI 0.99 to1.14; and stranger danger is a concern to me, OR 1.13, 95%CI 0.93 to 1.36). One of the two studies investigated whether there was evidence of an interaction by SES and found no significant interaction (girls: p=0.90, boys: p=0.81).[123]

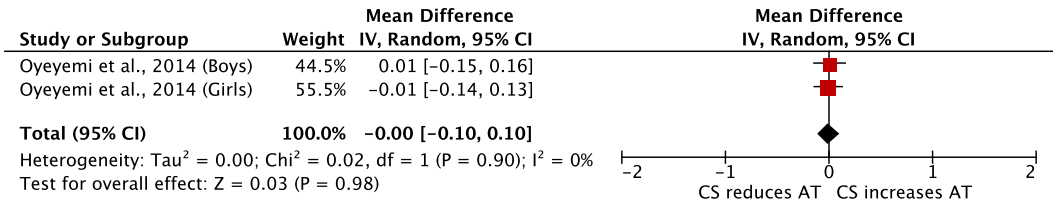


Figure 16: Forest plot for the association of crime safety (CS) with active transportation (AT)

Availability of physical activity facilities and infrastructure

Two studies assessed the association of perceived availability of physical activity facilities and infrastructure with active transportatation.[123,147] One of the studies found that perceived availability of physical activity facilities and infrastructure may

lead to little or no difference in active transportation (MD -0.00 minute, 95% CI -0.08 to 0.07; I^2 = 0%; Figure 17; low certainty).[123] The other study which could not be included in the meta-analysis due to reporting OR found no significant association with one measure: there are limited dedicated walking and cycling paths in my neighbourhood (OR 0.85, 95%CI 0.75 to 1.03). One of the two studies investigated whether there was evidence of an interaction by SES and found no significant interaction (girls: p=0.09, boys: p=0.26).[123]

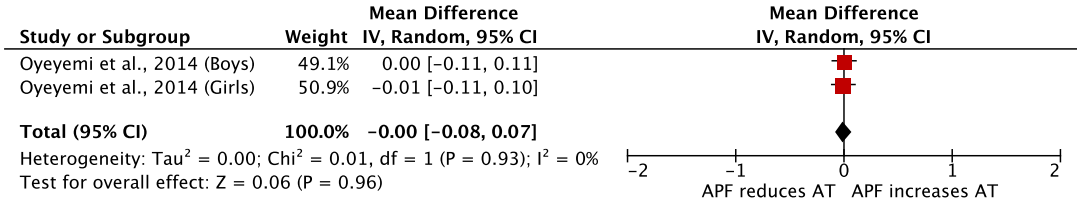


Figure 17: Forest plot for the association of perceived availability of physical activity facilities (APF) with active transportation (AT)

Walkability

Two studies assessed the association of perceived walkability with active transportation.[123,147] One study found that perceived walkability may lead to little or no difference in active transportation (MD 0.10 minutes, 95% CI -0.11 to 0.31; I^2 = 84%; Figure 18; low certainty).[123] While the other study which reported OR found no significant association with "there is no direct route for my child to walk/cycle to school", (OR 0.89, 95% CI 0.76 to 1.03). One study investigated whether there

was evidence of an interaction by SES but found no significant SES interaction (girls: p=0.62, boys: p=0.66).[123]

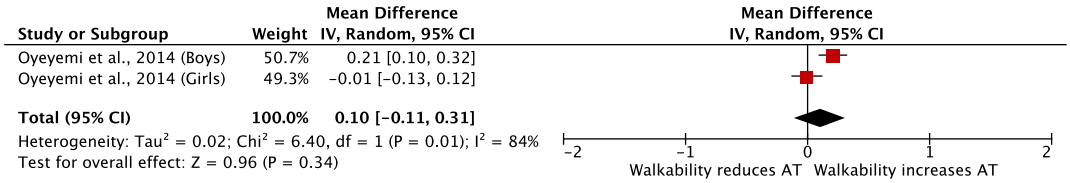


Figure 18: Forest plot for the association of perceived walkability with active transportation. (AT, active transportation)

Aesthetics

One study assessed the association of perceived aesthetics with active transportation and found that that perceived aesthetics may lead to little or no difference in active transportation (MD -0.00 minute, 95% CI -0.08 to 0.08; I^2 = 0%; Figure 19; low certainty).[123] This study investigated whether there was evidence of an interaction by SES but found no significant SES interaction (girls: p=0.36, boys: p=0.42).[123]

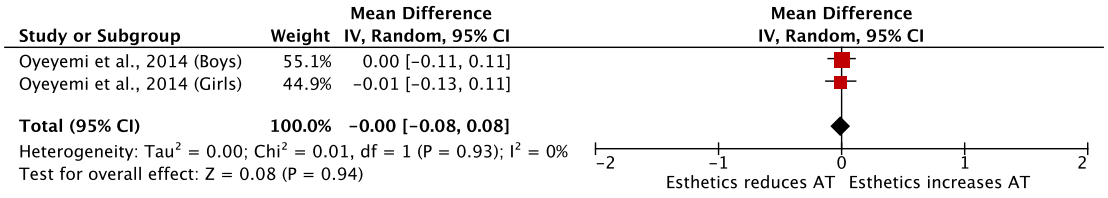


Figure 19: Forest plot for the association of perceived aesthetics with active transportation (AT)

Traffic safety

One study assessed the association of perceived traffic safety with active transportation.[147] This study reported no significant associations with five measure of traffic safety: I think drivers drive too fast on the streets of this neighbourhood (OR 0.75,

95%CI 0.57 to 1.02); I am concerned about dangerous traffic en route to school (OR 0.99, 95%CI 0.96 to 1.03); I'm concerned my child might be injured in a road accident while walking to school (OR 0.78, 95%CI 0.57 to 1.06); there is too much traffic in my neighborhood (OR 0.86, 95%CI 0.69 to 1.07); bicycling/walking to school would mean my child has to negotiate dangerous road junctions (OR 0.97, 95%CI 0.93 to 1.01).

2.4 Discussion

This is the first systematic review assessing the association between built environment and physical activity among children and adolescents in Africa. The certainty of the evidence from the findings of six cross-sectional studies was either low or very low. Three of the studies were deemed of high quality, however, meta-analyses were limited due to the different methodological approaches employed by the studies.

Residential density

The GRADE evidence for perceived residential density in this review was low, with no significant association between residential density and physical activity or active transportation. Our finding is similar to a recent systematic review of five studies from non-African populations that found no consistent significant association between residential density and physical activity or active transportation in children and adolescents.[131]

However, another systematic review found consistent significant associations between residential density and physical activity in both children and adolescents, but only when residential density was measured objectively.[73] Two other systematic reviews reported inverse associations between higher residential density and physical activity in children and adolescents.[124,128] High residential density (measured as either high-density living or urban sprawl) has the potential to precipitate increased opportunities for social interaction between neighbours, which could translate to subsequent health benefits,[122] and potentially greater density of proximate amenities and services. However, high residential density may also constrain opportunities for physical activity due to the lack of private and public indoor and outdoor space, which could limit the ability to play.[148] There is still little understanding about the optimum density to promote social contact while mitigating other urban exposure, particularly in more vulnerable and low-income populations.[122]

Street connectivity

The GRADE evidence for perceived street connectivity in this review was low, with no evidence of a significant association between street connectivity and physical activity or active transportation. Two previous systematic reviews reported inconsistent associations between street connectivity and

physical activity in children and adolescents,[73,149] while another one suggested a positive association between street connectivity and physical activity.[126] The inconsistent associations reported for street connectivity might be attributed to traffic safety concerns,[149,150] where some areas with low street connectivity may also be areas with low traffic, thus providing safer locations for children's outdoor play.[73] Street connectivity might be more related to active transportation than leisure time physical activity, because better street connectivity provides a more walkable environment, especially for children and adolescents.[126] However, this was not clear in our review. Adjusting for the presence of certain built environment features, such as traffic calming barriers, speed limits, and segregated pedestrian lanes, may make possible associations between street connectivity and physical activity or active transportation more substantial.

Crime safety

The GRADE evidence for crime safety in this review was low and very low for perceived and objectively measured crime safety, respectively. However, we found a significant association for objective measures of crime safety and physical activity in our review. A similar association was seen in a systematic review of studies from countries with established market economies, where an objective measure of crime safety (low crime

incidence) was associated with physical activity.[133] Additionally, further systematic reviews reported different findings, with one systematic review finding higher crime safety was associated with outdoor physical activity in children but not in adolescents. This study, however, reported associations between higher safety and active travel.[131]

A systematic review of studies across three continents found no evidence of association between crime safety and active transportation to school or during leisure.[113] Another systematic review found no significant association between features of neighbourhood safety and physical activity in children.[148] Current evidence suggests that there is a consistent association in the hypothesised direction between perceived crime and physical activity in children from high-income countries, but such associations are less consistent and not in the hypothesised direction in lower-income countries, where most African countries fall.[151] This difference is said to be due to physical activity being largely optional in high-income countries but obligatory in countries of lower levels of economic development; children in the latter countries may therefore accumulate high levels of physical activity despite high perception of crime rates.[152]

Walkability

The GRADE evidence for perceived walkability in this review was low, with no significant association between walkability and physical activity or active transportation to school. Research has found that walkability and taking part in organised sports were the most frequently investigated construct;[131] however, no consistent association with physical activity appears evident. However, this review reported more significant positive associations with active transportation. One systematic review found objective measures of walkability was associated with physical activity in children,[73] but another systematic review reported only a trivial to moderate positive effect of an objective measure of walkability on physical activity in children and adolescents.[69] Another review also reported a convincing association between walkability and active transportation to school.[113] We, however, found a significant association with active transportation to school but only in boys in one of the included studies.[123] This association could be due to the different parameters that were used to assess walkability, which included access to different destinations, whereas closeness to bus stops may be more suited to foster active transportation more than physical activity.

Availability of physical activity facilities and infrastructure

The GRADE evidence for availability of physical activity facilities and infrastructure in this review was low for perceived measures and very low for an objective measure of the construct. Similarly, a systematic review found no significant association in 17 out of the 20 studies reporting the association.[133] Conversely, two systematic reviews found children's participation in physical activity was associated with objectively measured and perceived measures of the construct.[73,149] However, one systematic review found inconsistent evidence between the availability of facilities and parks and physical activity in adolescents.[73] Regarding active transportation to school, a review reported evidence of a possible positive association.[113] Another review found consistent significant associations that reflected that shorter distances to facilities increased active transportation, but longer distances reduced active travel behavior.[131]

One of the studies included in our review reported a positive significant association with physical activity for boys but not for girls, and this might be because of the differences between adolescent boys and girls, in which boys are more likely to participate in leisure time physical activity than girls.[153,154] The lack of association seen in the other study could be because of the ages of the participants involved (nine to 11 years), and it

is possible that their participation in physical activity in parks is dependent on the availability of their parents or guardians to take them to the parks. The significant association observed in one of the included studies[144] in this review, which found that adolescents in schools with larger playgrounds were at increased odds of reaching the recommended level of physical activity compared to those with smaller playgrounds, is similar to the findings from a study where school playgrounds were renovated and led to children being more physically active.[155]

Aesthetics

The GRADE evidence for aesthetics in this review was low, with no significant association between aesthetics and physical activity or active transportation. Similar findings were also seen in a systematic review of non-African populations, where the majority of studies reported no significant association with either physical activity or active transportation.[131] However, an umbrella review found that increased access to aesthetically pleasing recreational space was associated with active transportation among adolescents.[125]

Traffic safety

The GRADE evidence for both objective and perceived traffic safety in this review was very low, where a significant association was only seen for an objective measure of traffic safety and physical activity, but no consistent significant

association with active transportation. Two further systematic reviews found heavy traffic was consistently unrelated to physical activity in children,[133] or found no association.[148] Regarding active transportation, results from a systematic review of non-African countries found that the majority of studies reported a significant association between transport-related physical activity and an objective measure of traffic speed/safety in children,[73] but no consistent association was seen in adolescents. Similarly, another systematic review found that increased traffic exposure reduced active transportation and even the presence of traffic-calming barriers in places of high traffic did not improve active transportation[131]; while another reported some evidence of a possible positive association between traffic safety and active transportation to school.[113] Although we found a significant result with physical activity in our review, this is representative of only one study (n=258), therefore, our interpretation of this significant association is with caution as it cannot be generalised to the whole African population.

2.5 Strengths and weaknesses

This systematic review has notable strengths due to the comprehensive search strategy employed, which provides reassurance that all eligible studies were identified; the use of double screening, data extraction, and critical appraisal to

minimise errors; the utilisation of meta-analysis to provide pooled estimates of the association between the built environmental construct and physical activity; and the use of GRADE to assess the certainty of the findings rather than solely relying on whether associations were significant. Additionally, we considered both perceived and objective measures of built environment constructs and objective and subjective measures of physical activity, since it was anticipated that differences in associations may be seen. Objective measures of built-environment settings and physical activity have fewer biases and, therefore, may enhance the precision and credibility of findings.[69,156] Also, as there is evidence of a poor agreement between perceptions of the built environment and the objectively measured environment in adolescents,[157,158] it is important that both are considered in the analyses. There is some evidence that environmental perceptions are stronger correlates of activity among adolescents than objective measures[72,157]; this is said to be due to a higher familiarity of the neighbourhood among residents, but objective measures may not accurately capture the relationship that exists between residents' physical activity and the environment.[72]

However, there are some limitations to the systematic review. We were unable to explore heterogeneity based on clinical (age, ascertainment of physical activity) and methodological

(adjustment for confounders) factors due to the small number of studies included in the systematic review. There were differences in the operationalisation of the constructs, which made it difficult to compare similar constructs from different studies, which could have affected the findings of this review. Additionally, we were unable to fully explore the different domains of physical activity due to the studies predominantly focusing on combined measures of MVPA. We included studies from northern and sub-Saharan Africa due to shared similarities, such as comparable gross domestic products (GDPs)[151]; however, we were unable to assess whether there were differences due to no studies being identified from northern Africa. Also, only two studies provided sufficient data to be included in the meta-analyses, which limited the synthesis, including the ability to estimate between study heterogeneity.

2.6 Conclusions and recommendations

The evidence for the association between built environment constructs and physical activity in children and adolescents in Africa is either low or very low, which limits the ability to draw firm conclusions. This suggests the need to conduct further high-quality studies in Africa, where both perceived and objective measures of built environment constructs are assessed. Furthermore, current evidence from the Active

Healthy Kids Global Alliance (AHKGA) suggests that countries with the most active children and adolescents have their physical activity driven by pervasive cultural norms. For such countries, being active is not just a choice but a way of life.[159] This supports the need for African countries to use the evidence to build cities that promote habitual physical activity in children and adolescents.

2.6.1 Recommendations for practice

The certainty of the evidence for the association between the built environment and physical activity in children and adolescents in Africa was low and very low, respectively, thereby making it difficult to make recommendations for practice. This systematic review, however, urges city planners, transportation officials, local government officers, and other stakeholders across Africa to consider how their decisions and actions could influence public health.

2.6.2 Recommendations for research

It was noted that the included studies analysed their data using different approaches, which did not permit the inclusion of some studies in meta-analyses. This underscores the need for consistency in the protocols used in Africa, which will aid the comparability of the studies and improve the quality of evidence generated. There appeared to be some differences in the associations based on whether objective or perceived measures

of built environment constructs were used; therefore, it is recommended that both measures should be included in future studies. Also, future studies in Africa should consider investigating associations between built environment and other domains of physical activity, and to consider using natural experiments or longitudinal studies to assess the associations.

Chapter three

Proportion of school attending adolescents meeting the recommended moderate-to-vigorous physical activity level and its predictors in Lagos State, Nigeria.

3.1 Introduction

The World Health Organization (WHO) recommends that adolescents should undertake at least 60 minutes of moderate-to-vigorous intensity physical activity (MVPA) per day.[1] MVPA helps adolescents to develop and maintain healthy musculoskeletal tissues, cardiovascular system and body weight.[1] It improves their mental health by reducing depression, anxiety and stress.[1] It also improves their academic achievements and overall quality of life.[28,160] It assists in their social development by providing opportunities for self-expression, improving self-confidence, social interactions and integration.[118] Providing the opportunities for adolescents to engage in sufficient physical activity will prevent poor health outcomes such as increased adiposity, poorer fitness and reduced sleep duration.[1]

In spite of the benefits of MVPA, data from 1.6 million students aged 11-17 years, which is equivalent to 81.3% of the global population of adolescents of this age, shows that only 19% of the world's adolescents reach the recommended level.[33] This is even lower in Sub-Saharan Africa as only 13.8% of them reached the recommended level in 2016.[33] A recent study on adolescents meeting the recommended MVPA level reported data from only 16 out of 53 Sub-Saharan Africa countries, and no data were available on Nigerian adolescents.[33] Another study

reported that 37% of adolescents in Nigeria reached the recommended MVPA level, however, this study was representative of only one state in the country.[161] Also, the study did not assess the psychosocial correlates of physical activity among adolescents such as self-efficacy, perceived benefits and perceived barriers that are known to be associated with physical activity among adolescents.[42,161] Furthermore, it did not consider whether the type of schools had an impact on the levels of physical activity among school attending adolescents. Schools represent a unique setting for the promotion of lifelong physical activity during critical development stages of life.[74] Opportunities for in-school physical activity are largely dependent upon school-level policies, practices and administrative support.[75] Existing evidence from systematic reviews demonstrates that school-based physical activity interventions account for significant improvement across several health outcomes for school going adolescents; and these interventions also increase students' in school and out of school physical activity levels.[78,80] Very little is known on the predictors that could be important to formulate policies or design, evaluate and implement interventions to improve physical activity levels among Nigerian school attending adolescents.[88] Therefore, this study aimed to assess

MVPA level among school attending adolescents in Lagos State and identify the predictors associated with it.

3.2 Methods

3.2.1 Study Design, Participants, Area and Period

A cross-sectional study was conducted among school attending adolescents aged 12–19 years in Lagos State, Nigeria. A cross-sectional study is used for this study because cross-sectional studies are primarily used to determine prevalence and also to infer association with risk factors.[162] Students with learning disabilities (based on school records) and students aged < 12 years were excluded. Data were collected between February and March 2020.

3.2.2 Sampling scheme

Given that the target population for this study are school attending adolescents, the district of education was used as a sampling reference. Lagos has six districts of education. Each district is an agglomeration of three to four local governments in the state. District IV was selected because it is a mix of three local governments (Apapa, Lagos Mainland and Surulere) that are distinctly characterized into different socio-economic strata.[163,164] There are 138 (58 public and 80 private) schools in the district. The private schools are owned by individuals and the management determines the welfare of the students and

teachers. In the public schools, the administration is entirely by government. However, as much as possible, both groups of schools operate a similar curriculum.[165] Schools in the district were selected using stratified random sampling. In the first stage, schools were stratified by local government area (LGA) and then by school type using the master list accessed from the official internet portal of all schools in Lagos State.[166] Next, a random selection was done by probability proportional to their enrolment size (PPS) by generating a random start number in Microsoft Excel. PPS is a sampling procedure under which the probability of a unit being selected is proportional to the size of the ultimate unit, giving larger clusters a greater probability of selection and smaller clusters a lower probability.[167] Subsequent schools were selected based on the sampling interval which was computed by dividing the total number of students in each LGA and schools by the number of schools needed. Selected schools were approached to participate in the study. If any school declined to participate, the next school on the list was approached. Consent forms were given to head of schools to sign.

A class was randomly selected based on the project plan and all students in the class were invited to participate. Number of students who declined to participate was recorded. Assent forms were given to the students who decided to participate.

Sample Size calculation

Using the proportion formula, previous research indicates that 37% of school attending adolescents in Nigeria meet the recommended MVPA level.[161]

Using the formula,

$$n = \frac{z^2(p)(1-p)}{d^2}$$

Where n= required sample size

Z= value corresponding to desired confidence interval 1.96

P=proportion 0.37

D= margin of error 0.05

Thus n=358.2

Accounting for a 1.5 design effect based on a value used in a similar setting.[168]

358.2*1.5=537.3

Additional sample size from estimated 20% non-response rate= 0.2*358.2 =71.6

Sample size= 537.3+71.6=608.9

To achieve a balanced distribution between private and public secondary schools, 305 students were to be taken from both private and public secondary schools. In Lagos Mainland there are a total of 24,384 students; 7127 attend private schools while 17257 attend public schools. In Surulere Local government, the total number of students are (47,955); 10646 are from private schools while 37309 are from public schools.

The number of students to be taken from the different type of schools was calculated thus:

$$\frac{no\ of\ (private) school\ students\ in\ a\ LGA}{total\ no\ of\ (private)\ school\ students\ in\ the\ 2\ LGAs} * 305$$

This yields the following number of students to be sampled from schools in each local government. (Table 3)

Table 3: Number of students to be sampled from schools

Type of schools	Number of students
Public junior school in Lagos Mainland	56
Public senior school in Lagos Mainland	39
Public junior school in Surulere	97
Public senior school in Surulere	114
Private school in Lagos Mainland	122
Private school in Surulere LGA	182
Total	610

3.2.3 Data Collection procedure and tool

Data collection tool

A self-reported quantitative questionnaire was developed and piloted among ten local students from a school who were not included in the final study. Self-report questionnaires are an affordable and convenient way of assessing physical activity that can provide information on the context and type of the activity.[38] They also have the ability to characterise activity

historically.[35] They are convenient for the respondents and they do not alter the behaviour under study.[39] The students found it easy to complete the questionnaire and no changes were made to the questionnaire.

The data were collected from the students with the use of a self-reported questionnaire. The questionnaire was administered to the participants in the class. It was available in English, the official language of the country. The questionnaire contained three sections. Section I included questions on socio-demographic variables: date of birth (age in years was calculated using the date of birth recorded by the participants and the date the questionnaires were administered). Sex (male, female or prefer not to say), ethnicity (Hausa, Igbo, Yoruba or others), class (junior, first three years of the secondary school or senior, last three years of the secondary school) and type of school (public or private). Socioeconomic status (SES) was assessed using the Material Affluence Scale (MAS) developed for adolescents in developing countries.[169] It contained questions on what property the family had, such as cars, fridge, television, computer, radio and home ownership, the number of people with whom the participants shared their rooms (dichotomised into ≤ 3 or more to indicate crowding) and the type of house they lived in (mud, bamboo, block, cemented and painted). Dichotomous response variable (0,1) were created for

each of the responses. For variables with more than one response such as car ownership, and type of house they were coded as: (0=no car, 1 =one or more cars), (0=non-block house, 1=block house cemented and painted). Scores were assigned to each participant based on the materials they had and divided into quintiles. The participants were categorised into low, middle and high income based on the MAS.[169]

Section II contained questions on physical activity and sedentary behaviour which was assessed by using the Activity Questionnaire for Adults and Adolescents (AQuAA).[170] Current recommendations on global physical activity surveillance suggest the use of questionnaires that assess specific domains of physical activity, especially active transportation and sedentary behaviours.[7] The AQUAA assesses seven-day recall, this was preferred for this study because with short time frames the estimates are less vulnerable to recall bias.[170] It assesses the different domains in which physical activity takes place; it included commuting activities (to and from school), habitual physical activity done in schools, household activities, leisure time activities and active sports. AQuAA shows acceptable evidence of test-retest reliability (ranged from 0.38 to 0.71) among adolescents in Nigeria.[161] MVPA level was computed by summing the time (minutes/week) spent on moderate and vigorous physical activities across the different domains. The

proportion of participants that met the recommended MVPA level (i.e., 60 min of MVPA per day) was estimated. Sedentary behaviour was assessed by the time spent on watching TV, reading/doing homework and surfing the internet per week. It was computed from the amount of time participants spent watching TV, and surfing the internet per week. Those who had >14 h per week screen time (i.e., >2 h per day) were categorised as high sedentary behaviour.[171]

Section III contained questions on self-efficacy, perceived benefits, and perceived barriers. Self-efficacy was assessed using a self-efficacy questionnaire.[172] The questionnaire asked participants to rate their agreement on their ability to be physically active in different situations on an eight-item scale. The items include: a) I can be physically active on most days of the week, b) I can ask my parent or other adult to do physically active things with me, c) I can be physically active during my free time on most days even if I could watch TV or play (sedentary) video games instead, d) I can be physically active on most days even if it is very hot or cold outside, e) I can ask my best friend to be physically active with me on most days, f) I can be physically active even at home, g) I can do active things because I know how to do them and h) I can be physically active during my free time on most days no matter how busy

my day is. Each item used a 5-point Likert scale that ranged from strongly disagree to strongly agree.

Perceived benefits and perceived barriers were assessed through questions used in similar studies.[56,173,174] Participants were asked to rate their agreement on a scale of strongly disagree to strongly agree on the effects (benefits) of physical activity. The items include Physical activity helps me with: a) My weight and physical appearance, b) My health and fitness - helps me feel healthier and stronger, c) Social interaction-helps me meet new people, d) Pleasure-gives me enjoyment, e) Competition- helps me compete better, f) Relief from stress and depression- helps me feel less stressed and depressed, g) Admiration of others- helps others to admire me, h) Relaxation from (school) work- helps me relax from school work. For perceived barriers, participants were asked to rate how some barriers prevented them from being physically active. The items include Could you please rate the frequency with which the following barriers prevented you from exercising: a) Lack of time, b) Lack of discipline, c) Lack of interest, d) Health problems, e) Personal problems, f) Not skilled enough, g) Too expensive, h) No transportation, i) Not liking to sweat, j) Fear of being laughed at, k) Cultural factors, l) The climate is not suitable and m) Lack of facilities). Each response was graded on a one (strongly disagree) to five (strongly agree) scale. Mean

scores were computed for each participant for each of these scales.[175] The questionnaire is found in Appendix 5.

Training of field workers

Two research assistants were trained by BA to support the data collection of the study. The research assistants had previous experience with data collection and had a Bachelor of Science qualification. They were informed about the objectives of the study and to go through the questionnaire and get familiar with the content. They were also told to check the filled questionnaires if the students had filled them properly. If they were not properly filled, we (the research assistants and I) directed the students to fill in the missing items. They were also trained on how to take accurate anthropometric measurements based on a standard protocol.[176,177] Inter-rater agreements of anthropometric measurements were done to ensure that they had learnt how to take the measurements accurately.

Anthropometric measures

Anthropometric measurements were measured because they are used to define overweight and obesity.[178] Being overweight or obese is associated with physical inactivity.[179]

Body mass index (BMI)

Weights

Body weights were measured twice to the nearest 0.1kg on an electronic scale DETECTO slimPRO (Cardinal/DETECTO, MO,

USA). Participants were politely asked to take off their shoes; remove external clothing such as jackets and sweaters and also to empty their pockets. They were told to position their feet as indicated on the scales and stand still. The weight measurements were taken after the value remains fixed in the display panel. The weight values were read, recorded and assessed for accuracy and legibility.[176]

Standing heights

Standing heights were measured twice using a portable stadiometer Seca 213 (Seca, Hamburg, Germany) to the nearest 0.1cm. Participants were kindly asked to remove shoes, socks and hair ornaments that may interfere with the height measurement. It was ensured that the stadiometer was on a flat level ground vertically against wall. The subjects were asked to stand in the centre of the measuring board with their feet flat on the ground and their backs against the board. The subjects were asked to look straight ahead. It was ensured that their arms hung down at their sides and their shoulders were level. The measuring board's moveable headpiece was gently and firmly slid down until it touched the crown of the participants' heads (compresses the hair). The written measurements were rechecked for accuracy and legibility.[176]

Body Mass Index (BMI) was computed as mean body weight (kg) divided by mean height (m) squared (kg/m2).[180] Age and

sex specific prevalence of grade I-III thinness, normal, overweight and obesity was determined using the WHO criteria and with the zanthro package in STATA V.14.2 (Stata Corp LLC, College Station, TX, USA).[181] Participants aged 18 to 19 years were classified according to the adult WHO BMI classification.[182]

Waist to hip ratio

Assessment of waist circumference

Waist circumferences were measured twice using an anthropometric tape (Seca 203) in standing position to the nearest 0.1cm. The measurements were made at the approximate midpoint between the lower margin of the last palpable rib and the top of the subjects' hip bone. The tape was placed horizontally around the subjects, making sure that the tape was in the same spot on the opposite side. The participants were asked to stand erect with their feet positioned close together and the weight evenly distributed on both feet. The participants were told to relax their arms gently at both sides, breathe out gently and relax while being measured. We ensured that the measuring tape was snug but not tight enough to compress the skin. Measurements were made to the nearest 0.1cm (1mm) and recorded. The recorded measurements were checked for accuracy and legibility.[176,177] They were measured twice and the mean of the two readings were used in the computation of the waist to hip ratio (WHr).

Assessment of hip circumference

Hip circumferences were measured twice with Seca 203 (Seca, Hamburg, Germany) around the widest portion of the buttocks to the nearest 0.1cm.

The waist-to-hip ratio was computed by dividing the mean waist circumference by the mean hip circumference.[183] Anthropometric measurements were carried out by researchers of the same sex.

3.2.4 Data entry and management

The coded data were entered into a Microsoft Excel sheet and then exported into STATA V.14.2. The exported data were cross-checked by BA against each of the completed questionnaires to ensure accuracy and all discrepancies found were corrected.

3.2.5 Statistical analysis

Frequencies and proportions were reported for categorical variables. Means and standard deviations were reported for normally distributed continuous variables, and medians and interquartile range for non-normally distributed continuous variables. To assess the representativeness of the respondents included in the analyses, the characteristics of participants with and without missing outcome data (MVPA level) were compared using the chi-squared test for categorical variables and *t*-tests for continuous variables. Where predictors could be added to

the model as either a continuous or categorical variable, we fitted the predictor as a continuous variable where there was a significant linear trend across categories. To deal with missing predictor values, we included a separate category for missing data for each categorical predictor and for each continuous predictor, we assigned the mean value of each continuous variable to the missing value and included a dummy variable in the model indicating the presence or absence of missing data. Univariate logistic regression was conducted to investigate the crude association between the proportion of participants that met the recommended MVPA level and predictor variables. To identify any independent association, multivariable logistic regression was performed, where predictors with a p-value < 0.10 in the univariate logistic regression were initially included. Next, all non-statistically significant predictors in the model were removed and added independently to a model that consisted of only the significant predictors. The final model consisted of the predictor variables that were statistically significant, (p < 0.05). The crude and adjusted odds ratios (ORs) together with the 95% confidence intervals (CIs) and p-values are presented. Data were analysed using STATA V.14.2 (Stata Corp LLC, College Station, TX, USA).[184]

3.3 Result

A total of 33 schools (10 public and 23 private) were approached to participate in the study, and 11 private schools declined the request. Two private schools that initially expressed an interest to participate did not take part due to the COVID-19 pandemic. The remaining 20 schools (10 public and 10 private) participated. A total of 752 students were sampled. Figure 20 shows the flowchart of the study participants. Participants without outcome data (MVPA level) tended to be older ($p = 0.005$), were more likely to have a higher socioeconomic status ($p = 0.025$) and be in the senior class ($p < 0.001$). (Appendix 6).

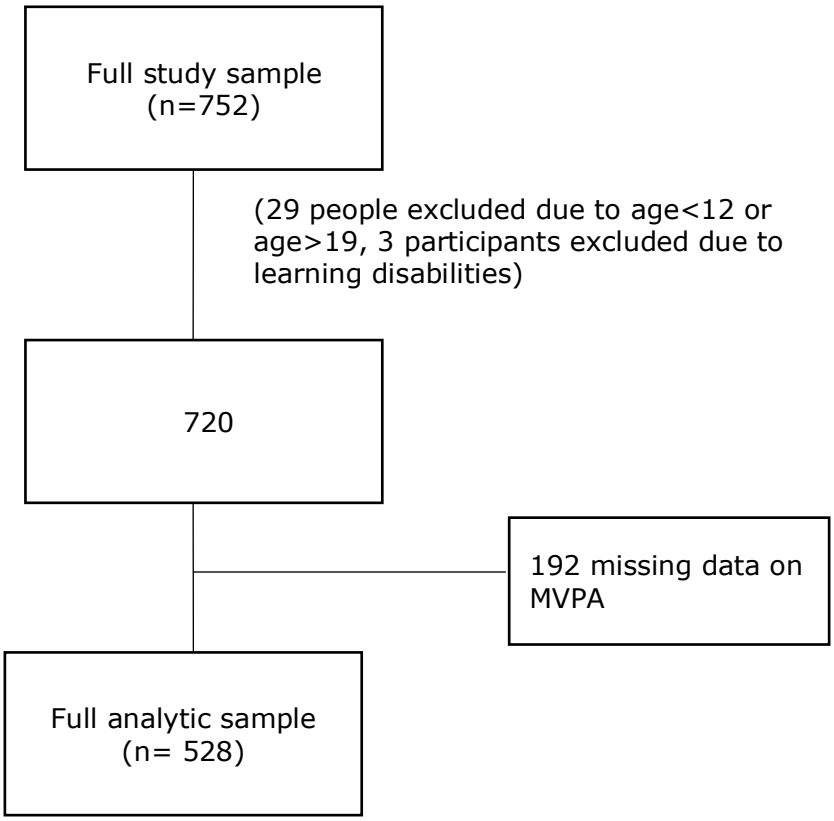


Figure 20: Flowchart of the study participants

Participants' characteristics are reported in Table 4. The mean age of the participants was 14.9 ± 1.6 years, and 55.3% of them were female. Of the participants, 82.8% (95% CI 79.3 to 85.7) met the recommended MVPA level. Participants spent a median time of 44 (IQR 12.9, 110) minutes of MVPA per day on household-based activities, followed by school-based activities (21.4; 4.3, 50.4), active transportation (14.3; 0, 35), sport-based activities (8.6; 0, 58.9) and leisure-based activities (8.6; 1.1, 34.3).

Table 4: Characteristics of participants

		Meeting the recommended MVPA level	
Characteristics	**Total n=528 n (%) or otherwise indicated**	**Yes n=437 n (%) or otherwise indicated**	**No n=91 n (%) or otherwise indicated**
Age (years)[a]	14.9 (1.6)[b]	14.9 (1.6)[b]	14.5 (1.5)[b]
Gender			
Male	234 (44.3)	194 (44.4)	40 (44.0)
Female	292 (55.3)	241 (55.2)	51 (56.0)
Prefer not to say	2 (0.4)	2 (0.5)	0 (0)
Ethnicity			
Hausa	6 (1.1)	5 (1.1)	1 (1.1)
Ibo	172 (32.6)	133 (30.4)	39 (42.9)
Yoruba	291 (55.1)	247 (56.5)	44 (48.4)
Others	58 (11.0)	51 (11.7)	7 (7.7)
Missing	1 (0.2)	1 (0.2)	0 (0)
Socioeconomic status			
Low	229 (43.4)	204 (46.7)	25 (27.5)
Middle	213 (40.3)	167 (38.2)	46 (50.6)
High	75 (14.2)	57 (13.0)	18 (19.8)
Missing	11 (2.1)	9 (2.1)	2 (2.2)
School			
Public	319 (60.4)	289 (66.1)	30 (33.0)
Private	209 (39.6)	148 (33.9)	61 (67.0)
Class			
Junior	231 (43.8)	197 (45.1)	34 (37.4)
Senior	297 (56.3)	240 (54.9)	57 (62.6)
BMI			

Grade III-I thinness	111 (21.0)	98 (22.4)	13 (14.3)
Normal	356 (67.4)	296 (67.7)	60 (65.9)
Overweight	51 (9.7)	37 (8.5)	14 (15.4)
Obese	8 (1.5)	5 (1.1)	3 (3.3)
Missing	2 (0.4)	1 (0.2)	1 (1.1)
Waist-to-hip ratio	0.8 (0.04)[b]	0.80 (0.04)[b]	0.80 (0.05)[b]
Missing	19		
Sedentary behaviour			
Low	214 (40.5)	179 (41.0)	35 (38.5)
High	290 (54.9)	237 (54.2)	53 (58.2)
Missing	24 (4.6)	21 (4.8)	3 (3.3)
Self-efficacy	3.5 (0.6)[b]	3.6 (0.6)[b]	3.4 (0.6)[b]
Missing	2		
Perceived benefits	3.8 (0.6)[b]	3.8 (0.6)[b]	3.7 (0.6)[b]
Missing	2		
Perceived barriers	2.6 (0.6)[b]	2.6 (0.6)[b]	2.7 (0.7)[b]
Missing	2		
Time spent on MVPA across the different domains			
Household	44 (12.9, 110)[c]	60(25, 128.6)[c]	7.1 (2, 15)[c]
School	21.4 (4.3, 50.4)[c]	25(7.14, 64.3)[c]	4.3 (0, 10.7)[c]
Active transportation	14.3 (0, 35)[c]	17.9(0.7,42.8)[c]	1.4 (0,10.7)[c]
Sport	8.6 (0, 58.9)[c]	17.1 (0, 70)[c]	0 (0, 4.57)[c]
Leisure	8.6 (1.1, 34.3)[c]	13.6(2.9, 45)[c]	1 (0, 5)[c]

a Age was included as a continuous predictor; BMI, Body Mass Index; MVPA, Moderate-to-vigorous physical activity; b Mean (SD); c Median (IQR).

Table 5 reports the unadjusted association between meeting the recommended MVPA level and predictors. Participants who were older, had a higher BMI, had a higher waist- to-hip ratio, had a lower socioeconomic status, attended a public school or had higher self-efficacy were significantly more likely to meet the recommended MVPA level.

Table 5: Unadjusted association between meeting the recommended MVPA level and predictors

	Unadjusted OR	**95% CI**	**p-value**
Age (years)	1.21	1.04-1.42	0.016
Gender			
Male	1.00		
Female	0.97	0.62-1.54	0.911
Prefer not to say	Not estimable		
Missing	Not estimable		
Ethnicity			0.142
Yoruba	1.00		
Hausa	0.89	0.10-7.81	
Ibo	0.61	0.38-0.98	
Others	1.30	0.55-3.04	
Missing	Not estimable		
Socioeconomic status			0.007
Low	1.00		
Middle	0.45	0.26-0.76	
High	0.39	0.20-0.76	
Missing	0.55	0.11-2.70	
School			<0.001
Private	1.00		
Public	3.97	2.46-6.42	
Class			0.175
Junior	1.00		
Senior	0.73	0.46-1.16	
BMI			0.063
Normal	1.00		
Grade III-I thinness	1.53	0.80-2.90	
Overweight	0.54	0.27-1.05	
Obese	0.34	0.08-1.45	

Missing	0.20	0.01-3.29	
Waist-to-hip ratio	0.01	0.00-2.07	0.091
Missing	Not estimable		
Sedentary behaviour			0.689
Low	1.00		
High	0.87	0.55-1.40	
Missing	1.37	0.39-4.84	
Self-efficacy	1.44	1.02-2.03	0.039
Missing	Not estimable		
Perceived benefits	1.28	0.90-1.81	0.171
Missing	Not estimable		
Perceived barriers	0.90	0.63-1.30	0.583
Missing	0.62	0.06-6.05	0.683

BMI, Body Mass Index.

Table 6 reports the association between meeting the recommended MVPA level and predictors. Following the model building strategy, the only significant predictor was school type, where participants who attended a public school were 3.97 times more likely to meet the recommended MVPA level compared to those in private schools (OR 3.97, 95% CI 2.46 to 6.42).

Table 6: Independent association between meeting the recommended MVPA level and predictor

	Adjusted OR	**95% CI**	**p-value**
School			<0.001
Private	1.00		
Public	3.97	2.46-6.42	

3.4 Discussion

This study presents the proportion of school attending adolescents who reached the WHO recommended MVPA level in Lagos State, Nigeria. A total of 82.8% of our participants reached the recommended MVPA level, and this was higher than what was reported in the northern part of the country (i.e., 37%).[161] This wide disparity could be due to the ownership of cars as more than 73% of their participants reported household ownership of one or more cars compared to 54% in our study. This study additionally reported that adolescents with family ownership of cars reported significantly less active transportation. We found certain similarities between the two studies—boys participated in sports more than girls, while girls were more active than boys in household activities.[161] This finding of higher participation in sports among boys compared to girls is similar to what was reported in a study in South Africa, where boys spent more time on vigorous sports than girls,[153] and to a study that compared physical activity patterns between boys and girls across seven countries in Sub-Saharan Africa.[154] The proportion of school attending adolescents who reached the recommended MVPA level in our study is higher than what has been reported globally.[33] We used a questionnaire that assessed physical activity across all the domains and the time spent on each, and this could have led to higher MVPA level

reporting. Other studies assessed physical activity based on participation in sports by asking the question, 'over the last seven days, how many days were you physically active for a combined total of at least 60 min per day'.[154,185,186] For direct comparison, 35.7% of our study participants reported meeting the recommended MVPA level through sports.

Although we assessed the independent effect of various predictors on MVPA level, we found the type of school was the only significant predictor, where adolescents in public schools were more likely to reach the recommended MVPA level compared to those in private schools. This result is similar to what was reported among school-going children in Kampala, Uganda[187] and school-going adolescents in Jordan and Nigeira.[165,188] Similarly, in a study conducted in Saudi Arabia, girls in public secondary schools were more physically active than girls in private schools.[189] A plausible reason for this could be socioeconomic differences. In our study, students in private schools were of higher socioeconomic status than those in public schools (78% vs. 38%). Hence, the chances of private school students doing household activities or using active transportation were less, and this could have contributed to their lower MVPA level. Furthermore, being in a private school could be an indication of having parents who place more emphasis on education and higher academic achievements than

on sports and active recreation.[33] This has often been cited as a barrier to participation in physical activities among adolescents.[33] Also, having visited the schools for study data collection, public schools had a larger expanse of land compared to private schools.

Finally, our finding in relation to public school students being at increased odds of reaching the recommended level compared to private school students' conflict with findings from high income countries where private school students are more likely to have access to more physical activity opportunities than public school students due to access to more financial resources.[190] However, this is not the case in Lagos State, many of the private schools in Lagos State, just like in many other low- and middle-income countries (LMICs) often face substantial constraints.[191] Parents choose private schools because government schools are perceived to be failing or too far from home. Such private schools run on incredibly tight budgets and therefore cannot provide the adequate resources for physical activity.[192]

Strengths and Limitations

To the best of our knowledge, this was the first study to assess MVPA level among school attending adolescents in Lagos, Nigeria. We included participants from both high- and low-income groups. This, therefore, makes the findings

generalisable to the school attending adolescents in Lagos State. Similar studies should be conducted in other parts of the country to have a complete picture of the issue. Our study suggests the physical activity domains where physical activity interventions should be targeted.

The study is, however, not without its limitations. The assessment of MVPA level was based on self-reporting, and this could have introduced social desirability bias, recall bias and over-estimated MVPA level of participants. Although the questionnaire used to assess MVPA level showed an acceptable test-retest reliability among adolescents in Nigeria,[161] there was a lot of missing data in our study. The missing data could have led to a reduction in the power of the study. An investigation into the missingness by comparing participants with complete data and those with missing data across the domains of physical activity assessed in the questionnaire showed that there were statistically significant differences between them for household based and sport based physical activities. In addition, a comparison of the best and worst case scenario did not affect the implication and conclusion of the study. The type of school remained statistically significant in both scenarios but with a reduced magnitude of effect. (Appendix 6) The missing data is probably due to the nature of the questionnaire which required three pieces of information (the number of days on which the

activity was performed, the duration, and intensity with which the activity was performed) to determine an answer. The failure to provide one out of the three required pieces of information led to missing data. Therefore, future studies should consider using objective measurement tools to assess MVPA level and validated questionnaires requiring less information to assess MVPA level, if self-reported. Of utmost importance is for the researchers to verify that the students are filling the questionnaires appropriately while administering it rather than checking after the administration.

3.5 Conclusions

In conclusion, there is a high proportion of school attending adolescents meeting the recommended MVPA level in Lagos, Nigeria. The lower MVPA level seen in private schools calls for a synergistic approach from all the stakeholders such as the government, school administrators, researchers, and parents to seek ways of promoting the importance of MVPA as well as the avenues for students to engage in it.

Chapter four

Barriers and facilitators of physical activity among school attending adolescents in Lagos State, Nigeria: a qualitative study exploring views and experiences of decision-makers in secondary schools

4.1 Introduction

Physical activity is known to offer immense benefits to adolescents such as helping them to develop and maintain healthy musculoskeletal tissues, cardiovascular systems and body weight.[1] Physical activity improves their mental health by reducing depression, anxiety and stress.[1] It has positive impacts on students' academic achievements and overall quality of life.[28,160] Physical activity also assists in their social development by providing opportunities for self-expression, improving self-confidence, social interactions and integration.[118]

In spite of the benefits accrued from being physically active; only approximately 19% of the global school-going adolescents reach the level recommended by the WHO. This is even lower in sub-Saharan Africa, where only 13.8% of school adolescents are reported to reach the recommended level.[33] The WHO recommends that secondary schools should provide quality physical and health education that supports adolescents to develop healthy behaviour patterns that will keep them physically active throughout their lives.[1] In keeping with this recommendation, Nigeria developed a National School Health Policy in 2006 which proposes the practice of physical activities for the health, academic and remediable problems (e.g., sleep problems, substance use) of school children and adolescents.[193]

However, very little is known on the implementation of this policy in schools.[194] Current evidence suggest that the overall physical activity levels in Nigerian school adolescents is low ranging from 5 to 37%.[83,161,195] These studies have reported that some socio-demographics factors such as religion, parents, socio-economic status (SES), number of children in the family, motivation, self-efficacy, age, weight status as factors associated with physical activity. Studies conducted in Lagos State have shown that the type of schools adolescents attend can impact their participation in physical activity.[196] There is also evidence of increased participation in physical activities of adolescents in schools following a professional development training programme for teachers to promote physical activity in adolescents in Lagos State.[197] Lagos State occupies a unique position in Nigeria as the country's most urbanised area and it has over a thousand secondary schools to accommodate its teeming adolescent population.[102] With urbanisation comes inequitable distribution of resources that impact physical activity.[98] Physical activity in Lagos, particularly for the lower socio-economic group which comprises the majority of its residents is undertaken in unsupportive and potentially harmful environments while navigating dangers such as air pollution and road traffic injury.[99] Schools, however, represent a unique setting for the promotion of lifelong physical activity during

critical development stages of life.[74] In addition, in-school adolescents spend a significant amount of time in schools.[198] Opportunities for in-school physical activity are largely dependent upon school-level policies, practices and administrative support.[75] A significant information gap exists on the factors which influence the participation of adolescents in school-based physical activity programmes in Nigeria.[194] No study has considered the experiences and views of key decision makers in schools who are responsible for the management of schools in Lagos State, Nigeria. Interventions to promote physical activity in adolescents should be informed by knowledge of the factors that influence it.[199] Therefore, this study identified and explored the views and experiences of schools' decision-makers on the barriers and facilitators of physical activity among school attending adolescents in Lagos State, Nigeria.

4.2. Materials and Methods

4.2.1. Study design

A qualitative study was conducted to address the aim of the study and the study was reported according to the COREQ guidelines of reporting qualitative studies.[200] A qualitative method was used because exploring perceptions and experiences is valuable in offering complementary insights and

understanding that may be difficult to access through reliance on a single data collection method.[201]

4.2.2. Study participants

The study participants were decision-makers, such as principals, vice-principals and district and state officials in the Lagos State Ministry of Education, who were responsible for planning the physical and health education curriculum of secondary schools.

4.2.3. Recruitment

Decision-makers in one of the six districts of Education in Lagos State were contacted through their offices. They were briefed about the research aims and their willingness to participate; they were given a participant information sheet that contained detailed information about the purpose of the study, why they were approached and the confidentiality of the data. The participant was given an informed consent form which was signed by both the lead researcher and the participant. Then, the place, date, and time to conduct the interview were scheduled.

4.2.4. Interview guide

The interview guide was developed using previous literature that has identified and explored the barriers and facilitators of physical activity in school adolescents among decision-makers in schools.[202,203] The interview guide had 10 questions which

included questions asking: Is physical and health education offered in your school as a subject? Could you please tell me about the physical activity participation of the students in your school? Can you please tell me about students' physical activity levels of in your school? Could you please share your thoughts on the kind of things that prevent students from getting more exercise in school? What kind of things do you think the school could do to make it easier for students to get more physical activity at school? If physical activity opportunities are improved, how do you think this might affect the current schools' curriculum? How inclusive will you describe the physical activities offered in your school? Could you please share your thoughts on how culturally sensitive issues (religion, culture) influence physical activity participation among the students? How will you describe teachers' motivation to be involved during physical activities in your school? The interview guide had questions that allowed probing of participants' responses. The interview guide was piloted with one school principal, and the transcript was included in the data as no changes were made to the interview guide.

4.2.5. Data collection

A trained qualitative researcher conducted the semi-structured interviews. Face-to-face interviews in the participants' place of work (schools/offices) were planned for all the interviews but

due to the COVID-19 pandemic, 12 interviews were conducted over the phone. The interviews were recorded with permission using a digital recorder. The interviews were conducted from March to September 2020 and in English since it is the official language of the country.

4.2.6. Data analysis

Three of the interviews were transcribed verbatim by the lead researcher and the remaining 18 were transcribed verbatim by a professional transcriber after signing a non-disclosure agreement. All identifiable information was removed. All the transcripts were compared against the recordings for accuracy and any discrepancies were corrected. Transcripts were read several times by the lead researcher to become familiar with the data. Data were analysed using the deductive thematic analysis framework of Braun and Clarke.[204] The first interview transcript was analysed by hand by the lead researcher to generate the initial codes. Subsequent transcripts were analysed using NVivo 12 (QSR International Ltd, Melbourne, Australia). Codes were organised into overarching categories, after which themes and sub-themes were assigned. Themes were reviewed by the lead researcher to ensure that they were distinct and not overlapping. The process was continuously discussed with senior study authors to refine the themes and sub-themes. The themes were further considered in relation to

the whole dataset to ensure they accurately reflected the dataset. Anonymised quotes annotated by role and type of school are presented to support the defined themes. During the analysis, the lead researcher referred to her reflexivity notes to examine how her beliefs and judgements could have influenced the findings.[205] For the reflexivity notes, the lead researcher was aware of her gender and her experience of the physical and health education classes she attended in secondary school, therefore, the interview guide prepared beforehand helped to mitigate the effects of the researcher's bias in the interviews.

4.2.7. Ethics

Ethics approval was obtained from the University of Nottingham's Faculty of Medicine and Health Sciences Research Ethics committee (429-1912) and the Lagos State Health Research and Ethics Committee (LREC/06/10/1319).

4.3. Results

Twenty-one school decision-makers were interviewed. Ten (six principals and four vice-principals) were from private schools and eight (two principals and six vice-principals) were from public schools. The remaining three participants were district and state officials in the Lagos State Ministry of Education. Fourteen participants were males. The semi-structured interviews ranged from eight to 50 minutes in length (mean duration of 20 minutes).

4.3.1 Themes

A total of eight themes were identified and explored which were categorised into student-, parent- and school-related barriers and facilitators. Five were barriers and three were facilitators. The barriers were (i) students' characteristics, (ii) parental objections, (iii) no prioritisation of physical activity, (iv) insufficient resources and (v) challenges with schools' initiatives. The facilitators were (vi) students' interest, (vii) students' awareness of benefits (viii) schools' initiatives. Table 7 shows the themes and sub-themes.

Table 7:Table showing the themes and sub-themes

Themes	**Sub-themes**
Barriers	
Student-related barriers	
1.Students' characteristics	1. Physical disabilities or health status
	2. Body image concerns
	3. Little or no interest in physical activities
	4. Belief that physical activities were more suited for boys
	5. Boys' monopoly of school playgrounds
	6. Girls' religious norms, such as not wearing shorts or trousers for physical activities
Parent-related barriers	
1. Parental objections	1. Physical activities will lead to less time for academic activities

	2. Physical activities will lead to pregnancy problems in daughters
	3. Physical activities will lead to injuries
School-related barriers	
1. No prioritisation of physical activity	1. Physical and health education was offered only in junior classes
	2. Emphasis on students' academic engagements
	3. Physical and health education is more theoretical than practical
2.Insufficient resources	1. Lack of physical and health education teachers
	2. Lack of financial resources for facilities and equipment
3. Challenges with schools' initiatives	1. Heavy traffic made it difficult to transport students to community facilities
	2. Students engaged in brawls during inter-house sports competitions
Facilitators	
Student-related facilitators	
1. Students' interests	1. Students enjoyed physical activities
	2. Students pursued individual physical activity interests outside of the school setting
2.Students' awareness of benefits	1. Students' awareness that physical activities make them fit
	2. Students' awareness of the financial incentives from professional sports
School-related facilitators	

1. Schools' initiatives	1. Organising weekly physical activity sessions by the schools during school hours
	2. Organising the annual sports competition by the school
	3. Schools' key decision-makers responding to students' concerns
	4. Sensitising students and parents on the benefits of physical activity in adolescents
	5. Enlisting third-party organizations to engage students in physical activity

4.3.1.2 Barriers

Student-related barriers

Students' characteristics

This theme describes how students' personal attributes such as physical disabilities or health status or sex differences prevent them from being physically active. This theme comprises six sub-themes.

> *"Although, there are some students that have challenges, like those with SS (Sickle cell anaemia),... we normally exempt them because of their health status."* [District Official 2, District]

It was also noted that such students were avoided by their peers during physical activities even if they showed interest.

"We have some students that are actually SS and because some students want to play safe, once those SS get to the field you will hear others shouting, "I'm not playing ball with you," they only just want to play safe and not get into any trouble." [Principal, Private School]

Two participants specifically mentioned that students who were overweight were usually not interested in physical activity.

"Yeah, of course, you know that some girls are lazy, so you force them to do that… and probably sometimes fat ones, they are not ready to lift their legs." [Principal, Private School]

One of the participants commented that girls perceived that physical activities were not meant for them.

"We notice with the girls, they are too self-conscious of themselves and they have this idea of whether it is cool or not... is it cool to run about like boys do?" [Principal, Private School]

There were also some comments as regards the poor participation of girls in physical activities, due to boys' monopolisation of the schools' playgrounds, particularly for football.

"But you know how boys do now? Boys play football every day and sometimes when the girls too are feeling like they want to play, they approach me sometimes or approach

somebody else that we should please chase the boys away, they want to play." [Principal, Private School]

Some of the participants commented on how some religious norms like the accepted mode of dressing affected girls' participation in physical activity.

"Some people out of religion say they don't want to wear short knickers or some don't want to expose their legs." [Vice-Principal, Public School]

Parent-related barriers

Parental objections

Many participants also commented that some parents felt that involvement in physical activities would affect their children's academic performance, hence, they discouraged their children from participating in physical activities.

"Then parents attitude sometimes because some parents believe that they should not do anything in school apart from the cognitive aspects. You see the children being willing sometimes, but because of what their parents say like "I have not sent you there to go and play football or run, you are supposed to go there and count all the As that you can in the academic sphere." [Principal, Private School]

Some participants also commented on the parents' views on what physical activity is permitted particularly for the girl child;

and how physical activity might delay their daughters' development, particularly concerning pregnancy.

> *"Because some of them will come with the fact that it affects girls' development, that girls may not be able to give birth, so with the parents, we just said we would pull it down and we have been able to do that over time."* [Principal, Private School]

There were also comments about the fears that parents have that their children might become injured if they participate in physical activities.

> *"Do you know where they can get to, I will be spending on this child and he will go and get a broken leg."* [Principal, Public School]

School-related barriers

No prioritisation of physical activity

This theme describes how students' engagement in physical activity was not taken as a priority in schools. It comprises three sub-themes. All our participants confirmed that physical and health education is offered as a compulsory subject in the junior class but optional or not available in the senior classes. Some reasons such as the subject not being a pre-requisite for most of the courses in the university, or students can only offer a limited number of subjects for qualifying exams or no scheduled

time for it on the schools' timetables, particularly for senior secondary students were cited.

> *"Yes, it is offered only in the junior class between grade 7 and grade 9."* [Principal, Private School]

Some of our participants also commented that there was more emphasis on the students' academic study than there was on physical activity. This is caused by the scheme of work in schools which many of our participants considered to be voluminous. They commented that the overloaded scheme of work made it difficult to allocate time for students' engagement in physical activity. Even sometimes teachers use some allocated time for physical activity to teach the students some parts of their subjects whenever they are unable to meet up with their expected teaching objectives.

> *"It is overloaded scheme of work, that is a major one, they're overloaded and the normal subjects they are offering to me, it's more than usual, 13 or 14, which will be reduced to about eight, maximum of eight when they are writing their exam."* [Vice-Principal, Private School]

Some of the participants said that the approach to the subject is more theoretical and involves little or no time for practice. The inclusion of practice if at all is left to the discretion of the teacher.

"Even... when you are looking at the syllabus in the junior secondary school, we don't have much of practical. We have much of theories in the scheme." [District Official 1, District]

Insufficient resources

This theme describes the limited resources that were barriers to physical activity. This theme was recurrent for most participants. Concerning human resources, some of our participants said that they had no teachers to teach the subject, or they had very few teachers to effectively cater to the student population.

"The lack of trainers, because we have over 1,000 students in this school and we have only one physical health education teacher. So for just one person to take over 1,000 students, it's too much. So, I would say we need more trainers." [Vice-Principal, Public School]

Concerning financial resources, some of the participants commented that due to lack of funds they did not have sufficient space or facilities or equipment which could engender a variety of activities.

"And you know this is an urban school and one of the major problems in an urban school is space. So, it's not a school with a lot of space where you can assign a lot of space for different games and different physical activities." [Principal, Private School]

Challenges with schools' initiatives

This theme describes how opportunities that the schools have made to encourage physical activity among the students have been undermined by different circumstances. One of our participants mentioned that their use of community facilities within the environs of the school has been mitigated by the traffic situation in Lagos State and this reduces the number of times they can go there.

> *"You may decide to spend this one hour to go to the stadium and before you know it you spend three hours going to stadium and coming back. So what we do is that once in a while we go outside the school to use community facilities." [Principal, Private School]*

Another participant mentioned how the inter-house sports they do are usually limited because students engaged in brawls, because of the different conflicting issues among the students.

> *"Probably yes, during the inter-house sports,… because you know at the adolescent age, the truancy tendency is there… so, some people use the sporting activities as a time to revenge, so those things deter us." [Vice-Principal, Public School]*

Facilitators

Student-related facilitators

Students' interests

Some of our participants commented that many of the students were enthusiastic about physical activities and embraced such opportunities presented to them.

> *"Being youths, they are always willing to use up their energy, so whenever the school gives them opportunity, they fully participate." [Vice-Principal, Public School]*

Two participants commented on students who explored their physical activity interests outside of school settings. They further reported that the schools supported them to partake in external competitions whenever there was a need.

> *"We have one particular girl... representing Lagos State in handball, so we do have one or two students like that who participate in physical activity, but they do it outside, then when there is a need for that competition they normally come and seek for permission to engage in it outside." [Vice-Principal, Public School]*

Students' awareness of benefits

Three participants reported that the students' awareness of the benefits (health and financial benefits) of being engaged in physical activity kept them engaged in physical activities. Benefits such as having a good shape, particularly for the girls

and the possibility of getting into professional sports which have immense financial rewards were motivations for boys and their parents.

> *"But I also notice that some of these parents who are poor so to say, encourage their children to participate, especially in football for financial reasons; with the hope that they will make great footballers and earn some income." [Principal, Private School]*

School-related facilitators

Schools' initiatives.

This theme describes the different actions that different schools have taken to encourage physical activity in their schools. These initiatives include organising weekly physical activities during school hours, organising annual inter-house sports competitions, school decision-makers responding to students' concerns, sensitisation of parents and schools enlisting external organisations to engage their students in physical activities. Five participants reported scheduled times for weekly opportunities for their students to engage in physical activities.

> *"Like I told you on Friday, it's a must for everybody. The other days we can just leave anybody that's just willing to play... But on Friday it is a must for everybody" [Principal, Private School]*

Other participants talked about having an annual sports competition where students participate in physical activities both during the time of the competition and in the build-up to the competition.

> *"then once every year or so we do what we call our inter-house sports… that gives room to all the students now to participate but that happens once every year." [Principal, Private School]*

Also, three participants shared their experiences of responding to the concerns and interests of the students. They responded to the needs of students who for religious reasons do not want to wear some types of clothes or for those who had interests in other activities.

> *"But what we do is those who don't want the knickers, we sew… with a flap in front and at the back to cover the gap in between the legs, so that's what we do." [Vice-Principal, Public School]*

Some participants commented on schools sensitising the students and the parents on the benefits of physical activity to students.

> *"I think it is very important to sensitise not just the students but the parents… and tell them how important physical activity is." [Principal, Private School]*

Finally, five participants recounted their experiences of enlisting organisations such as corporate organisations, Non-governmental organisations (NGOs) and old students' associations to provide resources (both human and facilities/equipment) that engaged the students in physical activity.

> *"We have somebody who comes, not a teacher but he is hired, he comes here, and they take both the students and of course teachers, especially the males, they go there (community field). They do some jogging; some do a kind of dancing." [Vice-Principal, Public School]*

4.4 Discussion

This study identified and explored five barriers and three facilitators to physical activity in school attending adolescents among decision-makers in secondary schools in Lagos State, Nigeria. These were categorised into student-, parent- and school-related barriers and facilitators.

Our study found students' poor participation in physical activities due to physical disabilities, body image concerns, health status or lack of interest. Our finding of the exclusion of adolescents with physical disabilities and health challenges by their peers is similar to the finding reported in a scoping review which explored the barriers and facilitators to participation in adolescents in low-and middle-income countries. They reported

that adolescents with physical disabilities were excluded by their peers and this made them feel embarrassed at appearing physically inept.[206] In addition, lack of interest in physical activity and laziness were also reported as barriers in a study that was conducted in Morocco, North Africa.[203]

Our study finding regarding overweight students not participating in physical activity is similar to a study which showed that overweight students were discriminated against for negative expectations about their physical ability by their peers or teachers. This was reported to affect their participation in physical activity.[207] Existing evidence from a narrative review which included data from 1983-2013 reported that about 1.0% to 8.6% of Nigerian adolescents were overweight.[208] Recent studies have shown a prevalence of about 5.8% to 9.7%.[196,209] A continuous increase in the prevalence of overweight could further compound this barrier to physical activity in the future, creating a vicious cycle of both increasing adolescence overweight and decreasing physical activity levels. This calls for targeted interventions of behavioural modifications such as diet, and physical activity, which have shown to have moderate quality evidence for the lowering of body weights in adolescents.[210]

Our study's finding of boys being more interested in physical activity than girls and girls being constrained by cultural norms

was supported by a study which was conducted in Canada and India. The study reported that girls were less likely than boys to be interested in physical activity, with girls' participation in India further limited by societal restrictions.[211] This was also found in other studies conducted in Nigeria and Morocco, where girls were prevented from participating in sporting activities due to cultural factors such as mode of dressing,[203] or misconceptions of the impact of physical activity.[194] A further study reported that female teenagers dropped out of sports they enjoyed because they felt that the sports were masculinising their bodies.[207]

Our finding of parents preventing their female children from participating in physical activity over concerns that they will not be able to get pregnant was also similar to a finding reported in another study in Nigeria.[194] Similarly, a further study in South Africa reported that parents prevented their female children from engaging in physical activities to keep them safe from sexual violence.[212] In addition, our finding of parental fears over their children getting injured during physical activities was supported by a study in Bangladesh, where such parental fears were said to lead to changes to the activities offered in the physical education curricula.[213]

Our finding that physical activity was not prioritised in schools is similar to the findings from studies conducted in Nigeria and

South Africa, where physical and health education classes were more theoretical than practical;[194,212] or schools had no classes allocated to physical and health education.[214] Also, our finding of physical activity conflicting with the academic study is similar to that reported in a South African study, where students in the senior classes of secondary school were told to use their time to study rather than get involved in physical activity.[215] This finding persisted in other studies conducted in Morocco and in Nigeria where it was reported that some teachers and principals see physical and health education as a waste of time and suggest the time should be devoted to other academic subjects.[194,203] Our finding of limited human resources inhibiting physical activity is similar to what was reported in another study conducted in Nigeria, where participants reported a declining number of trained physical and health education teachers which they argued might be due to limited opportunities for continuing education and professional development for physical and health education teachers compared to other subjects like Mathematics and English that were deemed to be of higher relevance. Also, the study reported the lack of financial resources for facilities or equipment.[194] Schools' facilities such as large playgrounds are associated with physical activity in adolescents.[136,144] Finally, for school-related barriers, our finding of students engaging in brawls after inter-house sports

competitions was also noted in another study in Nigeria in which it was reported that inter-house sports were more frequently practised in private schools compared to public schools due to the aftermath crisis associated with the failure of losing teams to accept defeat in public schools.[194]

Our finding of students participating in physical activity because of their interests and health benefits is similar to what was reported in studies conducted in South Africa and Morocco where adolescents were reported to be inclined to be physically active because of the health benefits associated with it and also for enjoyment.[203,212] In addition, we found a similar finding with students participating in physical activities for financial gains in Nigeria and South Africa. Adolescents were incentivised to take part in sporting competitions by the prospect of cash prizes.[194,212,216]

Schools' initiatives such as scheduling weekly physical activities and organising annual inter-house sports competitions which provided opportunities for students' participation in physical activities have been cited as reasons for physical activity participation in students.[194,203] Although about 15 participants said they have annual inter-house sports competitions which provided opportunities for students' participation in physical activities, it however appears that because of the competitive nature of the activities, only students with physical activity

prowess would benefit from such competitions. While this practice is good for the identification and nurturing of innate talents; it might mask the importance of schools' physical activity which should be promoted with a respectful and helpful attitude avoiding attitudes of superiority.[207]

Two of our participants reported to have responded to the concerns of their students which suggests social support from teachers. Social support from teachers has been shown to elicit positive responses from students encouraging them to be physically active [203,217,218]. One of our participants commented that girls responded positively to activities that involved dance, this finding is corroborated by other studies which showed that dance classes have been shown to provide valuable opportunities for adolescent girls to be physically active.[212,215,219]

The initiative of enlisting third party organisations to engage the students in physical activity is in line with the United Nations Educational, Scientific and Cultural Organisation's (UNESCO) quality physical education guidelines. The guidelines encourage the development of partnerships between schools and community-based sports organisations. There is evidence that students are more likely to be physically active in schools where there is a well-established school-community partnership.[77]

When comparing our findings to high-income countries, there are some similarities in the barriers like limited resources. For example, in a study that was conducted in the USA which compared the barriers and facilitators between urban and rural youths; the study reported limited finances as a barrier where the parents needed finances to either pay to use the facilities for urban youths or for transportation to use the facilities for the rural youths.[202] Another similar barrier was the conflict with academic studies where adolescents complained of having to spend much of their time on school homework and did not have time to be involved in physical activities in the UK and USA.[220-222]

Finally, our study shows that physical activity was not usually offered as a subject by the senior (last three years of the secondary schools) students. The Lagos State Government should consider scheduling physical activity for senior students, whom our study has identified to lack a structured time for physical education classes. Additionally, stakeholders should ensure that the scheduled classes, for all students, guarantees students' participation in physical activity as is done in other parts of the world and not just the theoretical aspect. [223,224]

4.4.1 Strengths and weaknesses

To our knowledge, this is the first qualitative study that identifies and explores the barriers and facilitators of physical

activity among school adolescents in Lagos State, Nigeria. One of the strengths of this study is the diversity of the decision-makers that were interviewed which made us explore different views and experiences. Interviewing participants from both private and public schools helped to generate insights that are transferrable to both schools in Lagos State, Nigeria. Also, the semi-structured interview allowed the lead researcher to delve deeply into the participants' responses, thereby generating more insights into the research aims. We reached data saturation of findings at the 14th interview; we however continued the interviews to ensure that we do not miss any unique information.

A limitation of this study is that the views and experiences of the students and their parents were not captured in this study. Exploring their views and experiences would have provided more credibility to the findings of the study. Another potential weakness is that the average length of the interviews (20 minutes) seemed insufficient to deeply explore views and experiences, however, this is unlikely to have affected the overall findings since the same interview guide was used. Also, the similarity of our findings to those from other similar studies shows the richness of the data generated by our interviews. We acknowledge that our population has its own demographics and cultural characteristics which do not allow generalisability to be

inferred, but we have addressed this through providing a comprehensive description of the context of the study.

4.5 Conclusion

Our study identified and explored student-related, school-related and parent-related barriers and facilitators of physical activity in students in Lagos State. Findings from our study can help in designing interventions to increase physical activity among school attending adolescents in Lagos, Nigeria.

Chapter five

General Discussion

5.1 Overview of the thesis

The chapter described the findings from this research and how they contribute to the existing knowledge on physical activity in children and adolescents in Nigeria and Africa. This chapter also provides directions for further research.

5.2 Implications of thesis findings

The current evidence from the systematic review assessing the impact of built environment constructs on MVPA levels in children and adolescents in Africa is limited. Africa is undergoing rapid growth which is characterised by urban sprawl; redesigning the street network, or building new services and destinations, may be difficult and costly to implement, particularly when it comes to retrofitting the structure of existing neighborhoods.[225] There are examples, in HICs, of changes that have made substantial impact on the built environment. For example, more effective place-based interventions may include temporary site changes such as pop-up parks and playgrounds, regeneration of land use or revitalisation of dead space into green space.[225] These changes have been shown to increase physical activity, particularly in densely populated areas.[225,226] Stakeholders such as urban planners and transportation officials in Africa should take a cue from HICs and plan facilities that encourage physical activity in their environment. These facilities can include parks with

amenities that appeal to the different sex and age groups; segregated lanes to encourage walking and cycling; and safety measures that make children, adolescents and their parents feel safe.

In the cross-sectional study, the type of schools that adolescents attend predicted if they reached the recommended MVPA level. This was largely contributed to by their habitual activities in the physical activity domain of household activities, rather than engagement in sporting activities. This finding suggests the need for schools to facilitate diverse sporting activities to encourage their students in physical activity. Physical activity in schools is likely to be more effective to get everyone active because students are motivated by both their peers' involvement and teachers' motivation in physical activities.[227] It is also possible that students might find other peers with similar physical activity interests that require at least two participants. The schools have a strong potential to provide diverse opportunities to students with different skills, interests and abilities. There is evidence that participating with friends and having choice over the activities provided in schools can confer greater enjoyment from physical activity in adolescents.[228] Furthermore, evidence from a systematic review showed that peer-led physical activity interventions in

schools may have similar effectiveness as the ones delivered by professionals.[229]

In the qualitative study, there were shared similarities of barriers between the private and the public schools. However, some schools, particularly the private schools, appeared to have devised ways to mitigate some of the barriers that were cited by some of the participants. This suggests feasible interventions that schools can employ to mitigate the barriers to physical activity participation of their students. Such interventions include scheduling of physical activities on the schools' timetable, provision of resources (human and financial) to accommodate for various sporting interests suitable to students' interests, particularly for adolescent girls and the use of community facilities. The categorised findings of the qualitative study suggest the stakeholders that our interventions should be targeted to. These findings call for concerted efforts from the government, the school management, parents, and students to play their various roles in fostering physical activity in school environments.

Worthy of note is that some of the private schools who had developed means of engaging their students in physical activities did not meet the recommended level of MVPA despite the efforts that they have put in. For example, some of the barriers that were cited by most private schools in our study

was limited spaces to engage in physical activity. To mitigate this, some of them paid to use facilities outside of their schools. This finding suggests endemic inequalities that exist in Lagos State, Nigeria as it pertains to physical activity for school attending adolescents.[230] There is evidence that secondary students choose to be indoors in school grounds that are limited in size, lacking a varied and multifunctional content or where the design is not integrating elements into various useful settings.[231] There is a need for stakeholders (the government, school management, teachers and students) to develop innovative ways of engaging students in physical activities in spite of the prevailing challenges. This could be the use of indoor spaces like classrooms. They could leverage the digital technologies as was used during the COVID-19 pandemic to promote physical activity when physical distancing was needed to curb the spread of the disease.[232]

On a broader note, the Lagos State Ministry of Education and Ministry of Sports for youths' development should engage in mass media campaigns on the benefits of physical activity in adolescents; targeting the parents and religious leaders whom our study has identified to be influential on adolescents' participation in physical activities. A systematic review has shown the effectiveness of mass media campaigns on

increasing awareness of physical activity and physical activity levels.[233]

5.3 Implications and reflection of the impact of COVID-19 on the PhD.

The COVID-19 induced lockdown started in March 2020 in Lagos State, Nigeria. The lockdown impacted the number of schools that we had planned to sample students for the cross-sectional study. However, this did not affect the cross-sectional study as we had already sampled students than the required sample size. Although, some schools who had registered their interests could not participate in the study. Also, there was a delay to data entry because of the COVID-19 induced physical distancing measures, the data entry was done by one person, the lead researcher. While entering the data alone could have led to fatigue and increased errors, this was mitigated by checking the data twice to ensure accuracy.

The lockdown however affected the qualitative study as it was quite challenging to reach the participants, consequently, the interviews were conducted over six months. This may have impacted the responses of the interviewees as their responses could have been subjected to recall bias as the schools were closed. Also, it was not possible to read their non-verbal expressions such as body language and facial expressions. There is also the possibility of the loss of contextual data like

the interviewees' physical characteristics and the interview setting, all of which could be meaningful in qualitative studies.[234]

5.4 Limitations

It is possible that the physical activity levels reported in this study are exaggerated as evidence suggest that physical activity may be grossly overestimated in adolescents' self-report compared to accelerometers.[235] Future studies can consider the use of other objective measures such as pedometer or accelerometers. Although, the use of objective measures may present logistic challenges in large epidemiological studies. Also, this study was conducted only in adolescents without disabilities. Engaging in physical activity can be more challenging for adolescents with disabilities. Children and adolescents with limitations in balance, strength, coordination, power and aerobic fitness can struggle, and a lack of success often leads to sedentary behaviour.[236] Schools should be trained on inclusive physical activity to encourage students with disabilities by making available equipment and facilities suitable for them. In the larger society, existing entities that cater to people with disabilities should be supported and trained to get people with disabilities become more physically active.

In addition, we had a higher decline rate from private schools than the public schools. This was possibly due to inability to see the owners of the schools. Private schools that consented were those that we had access to the management. Future studies should consider alternative approach of contacting the heads of schools, this could be going through the Ministry of Education or through the association of private schools in Nigeria. This will help to mitigate the bias that such lack of participation could have introduced.

5.5 Recommendation

The findings from this PhD suggest that adolescents in private schools are at a higher risk of not reaching the recommended level. The students should be made aware of the importance of physical activity and the different domains in which they can be active. Particularly, students in private schools should be made aware of physical activities in household and active transportation.

One of the differences we found between the schools were that the schools that scheduled time for physical activity reported that their students had regular times to engage in physical activities. The Ministry of Education should encourage schools to schedule physical activity on their timetables.

This study found girls to be marginalised with respect to participation in physical activities; schools should therefore

ensure that the interests of girls (e.g dance) are catered to as they appear to be more at risk of not reaching the recommended level when compared to boys.

Parents and religious leaders were identified to be influential over the students' involvement in physical activities; they (parents and religious leaders) should be sensitised on the importance of physical activity, so that they can encourage their children's participation in physical activities.

Finally, future research should consider the use of objective measures for the measurement of physical activity to ascertain the true proportion of adolescents that reach the recommended level.

5.6 Conclusion

This study contributes to existing knowledge on the built environment constructs that could facilitate physical activity among children and adolescents in Africa. It also estimated the proportion of school attending adolescents who reach the recommended level of MVPA, predictors associated with achieving MVPA levels, and the barriers and facilitators of physical activity in school settings, in Lagos State, Nigeria. Consequently, findings from our study can help in designing interventions to increase levels of physical activity among school attending adolescents in Lagos, Nigeria.

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Appendices

Appendix 1: Search strategy

MEDLINE (OVID) (1946 - 22 October 2021) - 2022 results

#	Searches	Results
1	exp Physical Fitness/	33417
2	exp Running/	21967
3	exp Walking/	60113
4	exp Exercise/	218722
5	exp Gardening/	1067
6	exp Sports/	197781
7	exp "Sports and Recreational Facilities"/	5738
8	exp Dancing/	3158
9	exp "Physical Education and Training"/	13828
10	exp Motor Activity/	316113
11	exp Yoga/	3224
12	exp Fitness Centers/	619
13	exp "play and playthings"/	15552
14	exp Recreation/	225121
15	exp Sedentary Behavior/	11617
16	(physical adj5 (fit* or train* or activit* or inactivit* or endur* or exercis*)).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]	217027
17	((leisure or fitness) adj5 (centre* or center* or facilit*)).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary	1868

	concept word, rare disease supplementary concept word, unique identifier, synonyms]	
18	(swim*1 or swimming).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]	46440
19	(exercis*3 adj5 aerobic).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]	14468
20	(active adj (travel*4 or transport* or commut*)).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]	21277
21	(exercise* or sport* or sedentariness).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]	505036
22	(sedentary adj (lifestyle or behavio$r)).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword	16994

	heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]	
23	("use" adj3 stair*).ti,ab.	250
24	or/1-23	845430
25	exp Child/	2014290
26	exp Adolescent/	2129235
27	exp Students/	144771
28	exp Pupil/	9859
29	exp Youth Sports/	535
30	exp Minors/	2682
31	(boy or boys or boyhood).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]	153563
32	girl*.mp.	158748
33	(child* or adolescen* or student* or minor* or kid* or teen* or preteen* or youth* or young* or juvenil*).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]	5825544
34	or/25-33	5861578
35	exp Environment/	1386740
36	exp Built Environment/	904

37	exp Environment Design/	7676
38	environment.mp.	657761
39	exp Residence Characteristics/	71535
40	residenc*.mp.	157676
41	exp Crime/	143071
42	street connectivity.mp.	259
43	exp Parks, Recreational/	1654
44	exp Public Facilities/	1289
45	exp Bicycling/	11996
46	exp Social Environment/	121750
47	exp "Conservation of Natural Resources"/	103334
48	exp City Planning/	2375
49	built.ti,ab.	84696
50	communit*.ti,ab.	635053
51	exp Urban Health/	18160
52	exp Cities/	135716
53	(neighbourhood* or neighborhood*).ti,ab.	34969
54	facilit*.ti,ab.	760737
55	amenit*.ti,ab.	1552
56	location*.ti,ab.	438214
57	planning.ti,ab.	227446
58	design*.ti,ab.	2007510
59	sprawl.ti,ab.	447
60	land us*.ti,ab.	17311
61	(aesthetic* or esthetic*).ti,ab.	51988
62	(pavement* or sidewalk*).ti,ab.	2950
63	path*.ti,ab.	3128443
64	trail*.ti,ab.	25442
65	green*.ti,ab.	223101
66	(city or cities).mp.	189512

67	(park or parks or parkland or parklands).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]	23226
68	playing field*.mp.	749
69	open space*.mp.	1399
70	outdoor*.mp.	27714
71	walkability.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]	1117
72	motor vehicle*.mp.	20716
73	railroads.mp.	3202
74	Automobile Driving/	20490
75	transport*.ti,ab.	560228
76	commut*.ti,ab.	4761
77	(motoring or motorist*1).ti,ab.	681
78	road us*.ti,ab.	1425
79	traffic.ti,ab.	51322
80	travel*4.ti,ab.	70063
81	pedestrian*.ti,ab.	6191
82	(speed hump*1 or speed bump*1).ti,ab.	127
83	or/35-82	8875897
84	Africa.hw,kf,ti,ab,cp.	174821
85	exp Africa/	291272
86	exp Africa, Central/	16759

87	exp Africa, Eastern/	70095
88	exp Africa, Northern/	38742
89	exp "Africa South of the Sahara"/	229473
90	exp Africa, Southern/	70735
91	exp Africa, Western/	70443
92	exp South Africa/	45390
93	sub-saharan africa.mp.	25707
94	(Algeria or Angola or Benin or Botswana or Burkina Faso or Burkina Fasso or Upper Volta or Burundi or Urundi or Cameroon or Cameroons or Cameron or Camerons or Cabo Verde or Central African Republic or Chad or Comoros or Comoro Islands or Comores or Mayotte or Congo or Zaire or Cote d'Ivoire or Ivory Coast or Djibouti or Egypt or United Arab Republic or Equatorial Guinea or Eritrea or Ethiopia or Gabon or Gabonese Republic or Gambia or Ghana or Guinea or Guinea-Bissau or Kenya or Liberia or Madagascar or Malawi or Nyasaland or Mali or Mauritania or Mauritius or Agalega Islands or Morocco or Ifni or Mozambique or Namibia or Niger or Nigeria or Rwanda or Ruanda or Sao Tome or Seychelles or Sierra Leone or Somalia or South Africa or Sudan or Swaziland or Tanzania or Togo or Togolese Republic or Tunisia or Uganda or Zambia or Zimbabwe or Rhodesia).hw,kf,ti,ab,cp.	610099
95	or/84-94	680047
96	24 and 34 and 83 and 95	2022

EMBASE (OVID) (1980 - 22 October 2021) –3949 results

#	Searches	Results
1	exp physical activity/	462229
2	exp fitness/	37485
3	exp sport/	180436

4	exp recreation/	81882
5	exp exercise/	364703
6	exp physical education/	11219
7	exp training/	90484
8	exp physical inactivity/	7020
9	exp sedentary lifestyle/	16513
10	(physical adj5 (fit* or train* or activit* or inactivit* or endur* or exercis*)).mp. [mp=title, abstract, heading word, drug trade name, original title, device manufacturer, drug manufacturer, device trade name, keyword heading word, floating subheading word, candidate term word]	300984
11	(exercise* or sport* or sedentariness).mp. [mp=title, abstract, heading word, drug trade name, original title, device manufacturer, drug manufacturer, device trade name, keyword heading word, floating subheading word, candidate term word]	668989
12	(active adj (travel*4 or transport* or commut*)).mp. [mp=title, abstract, heading word, drug trade name, original title, device manufacturer, drug manufacturer, device trade name, keyword heading word, floating subheading word, candidate term word]	16329
13	(sedentary adj (lifestyle or behavio$r)).mp. [mp=title, abstract, heading word, drug trade name, original title, device manufacturer, drug manufacturer, device trade name, keyword heading word, floating subheading word, candidate term word]	22489
14	(Physical Education and Training).mp. [mp=title, abstract, heading word, drug trade name, original title, device manufacturer, drug manufacturer, device trade name, keyword heading word, floating subheading word, candidate term word]	4428

15	1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14	1241856
16	exp child/	2640141
17	exp adolescent/	1571429
18	exp student/	275763
19	exp "minor (person)"/	749
20	exp juvenile/	3485752
21	(child* or adolescen* or student* or minor* or kid* or teen* or preteen* or youth* or young* or juvenil*).mp. [mp=title, abstract, heading word, drug trade name, original title, device manufacturer, drug manufacturer, device trade name, keyword heading word, floating subheading word, candidate term word]	6175426
22	or/16-21	6668427
23	exp environment/	7895765
24	exp environmental planning/	15644
25	exp neighborhood/	11723
26	exp recreational park/	3598
27	exp social environment/	546333
28	exp city planning/	2668
29	exp urban health/	1362
30	exp "traffic and transport"/	219666
31	exp traffic safety/	9328
32	public facilities.mp.	1061
33	(facilit* or design* or land us* or walkability or street connectivity).mp. [mp=title, abstract, heading word, drug trade name, original title, device manufacturer, drug manufacturer, device trade name, keyword heading word, floating subheading word, candidate term word]	3483650
34	or/23-33	10594370

35	exp Africa/	353501
36	exp "Africa south of the Sahara"/	266462
37	exp Central Africa/	1575
38	exp North Africa/	46628
39	exp South Africa/ or Africa/	108445
40	(Algeria or Angola or Benin or Botswana or Burkina Faso or Burkina Fasso or Upper Volta or Burundi or Urundi or Cameroon or Cameroons or Cameron or Camerons or Cabo Verde or Central African Republic or Chad or Comoros or Comoro Islands or Comores or Mayotte or Congo or Zaire or Cote d'Ivoire or Ivory Coast or Djibouti or Egypt or United Arab Republic or Equatorial Guinea or Eritrea or Ethiopia or Gabon or Gabonese Republic or Gambia or Ghana or Guinea or Guinea-Bissau or Kenya or Liberia or Madagascar or Malawi or Nyasaland or Mali or Mauritania or Mauritius or Agalega Islands or Morocco or Ifni or Mozambique or Namibia or Niger or Nigeria or Rwanda or Ruanda or Sao Tome or Seychelles or Sierra Leone or Somalia or South Africa or Sudan or Swaziland or Tanzania or Togo or Togolese Republic or Tunisia or Uganda or Zambia or Zimbabwe or Rhodesia).hw,ti,ab,cp.	559384
41	or/35-40	612590
42	15 and 22 and 34 and 41	3949

PsycINFO (OVID) (1806 - 22 October 2021) – 173 results

#	Searches	Results
1	exp Physical Fitness/	4549
2	exp Physical Activity/	46440
3	exp Running/	2167
4	exp Walking/	6114
5	exp Exercise/	28663

6	exp Aerobic Exercise/	2052
7	exp Leisure Time/	9599
8	exp Sports/	36554
9	exp Training/	81421
10	exp Athletic Training/	1829
11	exp Physical Education/	4830
12	exp Dance/	2531
13	exp Recreation/	71091
14	exp Sedentary Behavior/	1920
15	(physical adj5 (fit* or train* or activit* or inactivit* or endur* or exercis*)).mp. [mp=title, abstract, heading word, table of contents, key concepts, original title, tests & measures, mesh]	58624
16	(active adj (travel*4 or transport* or commut*)).mp. [mp=title, abstract, heading word, table of contents, key concepts, original title, tests & measures, mesh]	919
17	(exercise* or sport* or sedentariness).mp. [mp=title, abstract, heading word, table of contents, key concepts, original title, tests & measures, mesh]	122860
18	(sedentary adj (lifestyle or behavio$r)).mp. [mp=title, abstract, heading word, table of contents, key concepts, original title, tests & measures, mesh]	3249
19	or/1-18	273792
20	exp Students/	279874
21	(child* or adolescen* or student* or minor* or kid* or teen* or preteen* or youth* or young* or juvenil*).mp. [mp=title, abstract, heading word, table of contents, key concepts, original title, tests & measures, mesh]	1880887
22	20 or 21	1882435
23	exp Environment/	213631
24	exp Built Environment/	1121

25	exp School Environment/	16265
26	exp Urban Environments/	26190
27	exp Neighborhoods/	9176
28	exp Recreation Areas/	1688
29	exp Social Environments/	172409
30	exp Home Environment/	14934
31	exp Facilities/	118491
32	exp School Facilities/	23894
33	exp Community Facilities/	15203
34	exp Crime/	126263
35	exp Transportation/	13811
36	exp Urban Planning/	718
37	Residence Characteristics.mp.	8475
38	street connectivity.mp.	116
39	or/23-38	450855
40	Africa.mp.	25993
41	(Algeria or Angola or Benin or Botswana or Burkina Faso or Burkina Fasso or Upper Volta or Burundi or Urundi or Cameroon or Cameroons or Cameron or Camerons or Cabo Verde or Central African Republic or Chad or Comoros or Comoro Islands or Comores or Mayotte or Congo or Zaire or Cote d'Ivoire or Ivory Coast or Djibouti or Egypt or United Arab Republic or Equatorial Guinea or Eritrea or Ethiopia or Gabon or Gabonese Republic or Gambia or Ghana or Guinea or Guinea-Bissau or Kenya or Liberia or Madagascar or Malawi or Nyasaland or Mali or Mauritania or Mauritius or Agalega Islands or Morocco or Ifni or Mozambique or Namibia or Niger or Nigeria or Rwanda or Ruanda or Sao Tome or Seychelles or Sierra Leone or Somalia or South Africa or Sudan or Swaziland or Tanzania or	53201

	Togo or Togolese Republic or Tunisia or Uganda or Zambia or Zimbabwe or Rhodesia).mp. [mp=title, abstract, heading word, table of contents, key concepts, original title, tests & measures, mesh]	
42	40 or 41	60803
43	19 and 22 and 39 and 42	173

CINAHL (EBSCO) (1958 - 22 October 2021) – 2631 results

#	Searches	Results
S1	(MH "Physical Fitness+")	19,866
S2	(MH "Running+")	14,137
S3	(MH "Walking+")	33,662
S4	(MH "Exercise+")	122,798
S5	(MH "Sports+")	86,576
S6	(MH "Sports Facilities")	199
S7	(MH "Dancing+")	4,056
S8	(MH "Physical Education and Training+")	4,321
S9	(MH "Motor Activity+")	12,785
S10	(MH "Yoga+")	10,017
S11	(MH "Fitness Centers")	1,799
S12	(MH "Play and Playthings+")	17,718
S13	(MH "Recreation+")	32,180
S14	(MH "Life Style, Sedentary+")	9,309
S15	"(physical fitness OR physical training OR physical activity OR physical inactivity OR physical endurance OR physical exercise))."	5,370
S16	(MH "Swimming")	4,624
S17	(MH "Aerobic Exercises+")	45,419
S18	(MH "Leisure Activities+") OR (MH "Human Activities+")	445,467

S19	S1 OR S2 OR S3 OR S4 OR S5 OR S6 OR S7 OR S8 OR S9 OR S10 OR S11 OR S12 OR S13 OR S14 OR S15 OR S16 OR S17 OR S18	474,786
S20	(MH "Child+")	712,458
S21	(MH "Adolescence+")	563,156
S22	(MH "Students+")	150,322
S23	(MH "Pupil")	1,086
S24	(MH "Minors (Legal)")	749
S25	TX child* or adolescen* or student* or minor* or kid* or teen* or preteen* or youth* or young* or juvenil*	2,368,868
S26	S20 OR S21 OR S22 OR S23 OR S24 OR S25	2,372,945
S27	(MH "Environment+")	147,043
S28	(MH "Built Environment")	251
S29	(MH "Environment and Public Health+")	1,412,445
S30	"Environment Design"	178
S31	(MH "Residence Characteristics+")	137,289
S32	(MH "Crime+")	111,972
S33	TX street connectivity	240
S34	TX Parks, Recreational	348
S35	(MH "Public Facilities+")	1,669
S36	(MH "Cycling")	9,448
S37	(MH "Social Environment+")	58,988
S38	(MH "Conservation of Natural Resources+")	4,695
S39	(MH "Urban Areas")	22,658
S40	(MH "Urban Health")	3,891
S41	(MH "Environmental Health")	7,914
S42	S27 OR S28 OR S29 OR S30 OR S31 OR S32 OR S33 OR S34 OR S35 OR S36 OR S37 OR S38 OR S39 OR S40 OR S41	1,606,831
S43	(MH "Africa+")	90,233

S44	(MH "Africa, Central+")	3,201
S45	(MH "Africa, Eastern+")	23,279
S46	(MH "Africa, Northern+")	7,127
S47	(MH "Africa South of the Sahara+")	75,401
S48	(MH "Africa, Southern+")	29,398
S49	(MH "Africa, Western+")	18,640
S50	TX Algeria or Angola or Benin or Botswana or Burkina Faso or Burkina Fasso or Upper Volta or Burundi or Urundi or Cameroon or Cameroons or Cameron or Camerons or Cabo Verde or Central African Republic or Chad or Comoros or Comoro Islands or Comores or Mayotte or Congo or Zaire or Cote d'Ivoire or Ivory Coast or Djibouti or Egypt or United Arab Republic or Equatorial Guinea or Eritrea or Ethiopia or Gabon or Gabonese Republic or Gambia or Ghana or Guinea or Guinea-Bissau or Kenya or Liberia or Madagascar or Malawi or Nyasaland or Mali or Mauritania or Mauritius or Agalega Islands or Morocco or Ifni or Mozambique or Namibia or Niger or Nigeria or Rwanda or Ruanda or Sao Tome or Seychelles or Sierra Leone or Somalia or South Africa or Sudan or Swaziland or Tanzania or Togo or Togolese Republic or Tunisia or Uganda or Zambia or Zimbabwe or Rhodesia	209,783
S51	S43 OR S44 OR S45 OR S46 OR S47 OR S48 OR S49 OR S50	216,682
S52	S19 AND S26 AND S42 AND S51	2,631

Scopus (electronic resource) (1788- 22 October 2021) – 7 results

#	Searches	Results
1	(TITLE-ABS-KEY ((physical AND fitness OR physical AND education OR physical AND training OR physical AND activit* OR physical AND inactivit*	7

	OR exercise* OR sport* OR ordinariness OR sedentary AND lifestyle OR sedentary AND behavio*)) AND TITLE-ABS-KEY ((child* OR adolescen* OR student* OR minor* OR kid* OR teen* OR youth* OR young OR juvenile*)) AND TITLE-ABS-KEY ((environment OR built AND environment OR environment AND design OR residence AND characteristics OR crime OR street AND connectivity OR parks OR social AND environment OR neighbourhood)) AND TITLE-ABS-KEY ((africa OR africans)))	

Web of Science (1900 - 22 October 2021) - 1358 results

#	Searches	Results
1	TS=((physical fitness OR physical education OR physical training OR physical activit* OR physical inactivit* OR exercise* OR sport* OR sedentariness OR sedentary lifestyle OR sedentary behavio*))	999,220
2	TS=((child* OR adolescen* OR student* OR minor* OR kid* OR teen* OR youth* OR young OR juvenile*))	5,041,630
3	TS=((Environment OR Built Environment OR Environment Design OR Residence Characteristics OR Public Facilities OR Parks OR Urban Health))	2,485,908
4	TS=((AFRICA OR AFRICAN OR Algeria or Angola or Benin or Botswana or Burkina Faso or Burkina Fasso or Upper Volta or Burundi or Urundi or Cameroon or Cameroons or Cameron or Camerons or Cabo Verde or Central African Republic or Chad or Comoros or Comoro Islands or Comores or Mayotte or Congo or Zaire or Cote d'Ivoire or Ivory Coast or Djibouti or Egypt or United Arab Republic or Equatorial Guinea or	1,198,023

	Eritrea or Ethiopia or Gabon or Gabonese Republic or Gambia or Ghana or Guinea or Guinea-Bissau or Kenya or Liberia or Madagascar or Malawi or Nyasaland or Mali or Mauritania or Mauritius or Agalega Islands or Morocco or Ifni or Mozambique or Namibia or Niger or Nigeria or Rwanda or Ruanda or Sao Tome or Seychelles or Sierra Leone or Somalia or South Africa or Sudan or Swaziland or Tanzania or Togo or Togolese Republic or Tunisia or Uganda or Zambia or Zimbabwe or Rhodesia)	
5	#4 AND #3 AND #2 AND #1	1461

SPORTDiscus (EBSCO) (1974 – 22 October 2021) – 279 results

#	Searches	Results
S1	(Physical fitness OR physical education OR physical training OR physical activit* OR physical inactivit* OR exercise* OR sport* OR sedentariness OR sedentary lifestyle OR sedentary behavio*) AND (child* OR adolescen* OR student* OR minor* OR kid* OR teen* OR youth* OR young OR juvenile*) AND (environment OR built environment OR environment design OR residence characteristics OR crime OR street connectivity OR parks OR social environment OR neighbourhood) AND (Africa or Algeria or Angola or Benin or Botswana or Burkina Faso or Burkina Fasso or Upper Volta or Burundi or Urundi or Cameroon or Cameroons or Cameron or Camerons or Cabo Verde or Central African Republic or Chad or Comoros or Comoro Islands or Comores or Mayotte or Congo or Zaire or Cote d'Ivoire or Ivory Coast or Djibouti or Egypt or United Arab Republic or Equatorial Guinea or Eritrea or Ethiopia or Gabon or Gabonese Republic or Gambia or Ghana or Guinea or Guinea-	279

	Bissau or Kenya or Liberia or Madagascar or Malawi or Nyasaland or Mali or Mauritania or Mauritius or Agalega Islands or Morocco or Ifni or Mozambique or Namibia or Niger or Nigeria or Rwanda or Ruanda or Sao Tome or Seychelles or Sierra Leone or Somalia or South Africa or Sudan or Swaziland or Tanzania or Togo or Togolese Republic or Tunisia or Uganda or Zambia or Zimbabwe or Rhodesia)	

Grey literature
ProQuest dissertations and Thesis A&I (electronic resource) (1975 – 22 October 2021) - 179 results

#	Searches	Results
1	ab(physical fitness OR physical education OR physical training OR physical activit* OR physical inactivit* OR exercise* OR sport* OR sedentariness OR sedentary lifestyle OR sedentary behavio*) AND ab(child* OR adolescen* OR student* OR minor* OR kid* OR teen* OR youth* OR young OR juvenile*) AND ab(environment OR built environment OR physical environment) AND ab(Africa OR Algeria OR Angola OR Benin OR Botswana OR Burkina Faso OR Burkina Fasso OR Upper Volta OR Burundi OR Urundi OR Cameroon OR Cameroons OR Cameron OR Camerons OR Cabo Verde OR Central African Republic OR Chad OR Comoros OR Comoro Islands OR Comores OR Mayotte OR Congo OR Zaire OR Cote d'Ivoire OR Ivory Coast OR Djibouti OR Egypt OR United Arab Republic OR Equatorial Guinea OR Eritrea OR Ethiopia OR Gabon OR Gabonese Republic OR Gambia OR Ghana OR Guinea OR Guinea-Bissau OR Kenya OR Liberia OR Madagascar OR Malawi OR Nyasaland OR Mali OR Mauritania OR Mauritius OR Agalega Islands OR Morocco OR Ifni OR Mozambique OR Namibia OR Niger	179

	OR Nigeria OR Rwanda OR Ruanda OR Sao Tome OR Seychelles OR Sierra Leone OR Somalia OR South Africa OR Sudan OR Swaziland OR Tanzania OR Togo OR Togolese Republic OR Tunisia OR Uganda OR Zambia OR Zimbabwe OR Rhodesia)	

Ethos (electronic resource - (2009 – 22 October 2021) - 2 results

#	Searches	Results
1	Physical activity AND Children OR Adolescents AND Africa.	2

Appendix 2: Ineligible studies following full-text review

Reference	Reason for exclusion
Essiet IA, Baharom A, Shahar HK, Uzochukwu B. Application of the Socio-Ecological Model to predict physical activity behaviour among Nigerian University students. Pan Afr Med J. 2017;26:110.	Ineligible population
Jones S, Hendricks S, Draper CE. Assessment of physical activity and sedentary behavior at preschools in Cape Town, South Africa. Child Obes. 2014;10(6):501-10.	Ineligible population
Larouche R, Mire EF, Belanger K, Barreira TV, Chaput J-P, Fogelholm M, et al. Relationships Between Outdoor Time, Physical Activity, Sedentary Time, and Body Mass Index in Children: A 12-Country Study. Pediatr Exerc Sci. 2019;31(1):118-29.	Ineligible population
Mowafi M, Khadr Z, Bennett G, Hill A, Kawachi I, Subramanian S. Is access to neighborhood green space associated with BMI among Egyptians? A multilevel study of Cairo	Ineligible population

neighborhoods. Health Place. 2012;18(2):385-90.	
Oyeyemi AL, Adegoke BOA, Oyeyemi AY, Sallis JF. Perceived Environmental Correlates of Physical Activity and Walking in African Young Adults. Am J Health Promot. 2011;25(5):e10-e9.	Ineligible population
Ryan GJ, Dzewaltowski DA. Comparing the relationships between different types of self-efficacy and physical activity in youth. Health Educ Behav. 2002;29(4):491-504.	Ineligible population
Whitaker KM, Xiao Q, Gabriel KP, Larsen PG, Jacobs Jr DR, Sidney S, et al. Perceived and objective characteristics of the neighborhood environment are associated with accelerometer-measured sedentary time and physical activity, the CARDIA Study. Prev Med. 2019;123:242-9.	Ineligible population
Amosun SL, Reddy PS, Kambaran N, Omardien R. Are students in public high schools in South Africa physically active? Outcome of the 1st South African National Youth	Ineligible exposure

risk behaviour survey. Can J Public Health. 2007;98(4):254-8.	
Aounallah-Skhiri H, Ben Romdhane H, Maire B, Elkhdim H, Eymard-Duvernay S, Delpeuch F, et al. Health and behaviours of Tunisian school youth in an era of rapid epidemiological transition. East Mediterr Health J. 2009;15(5):1201-14.	Ineligible exposure
Bonnema J, Coetzee D, Lennox A. Effect of a three-month HOPSports Brain Breaks® intervention programme on the attitudes of Grade 6 learners towards physical activities and fitness in South Africa. J Phys Educ Sports. 2020;20(1):196-205.	Ineligible exposure
El-Gilany A, Badawi K, El-Khawaga G, Awadalla N. Physical activity profile of students in Mansoura University, Egypt. East Mediterr Health J. 2011;17(8):694-702.	Ineligible exposure
Garnier D, Benefice E. Habitual physical activity of Senegalese adolescent girls under different	Ineligible exposure

working conditions, as assessed by a questionnaire and movement registration. Ann Hum Biol. 2001;28(1):79-97.	
Garnier D, Ndiaye G, Benefice E. Influence of urban migration on physical activity, nutritional status and growth of Senegalese adolescents of rural origin. Bull Soc Pathol Exot. 2003;96(3):223.	Ineligible exposure
Hamrani A, Mehdad S, El Kari K, El Hamdouchi A, El Menchawy I, Belghiti H, et al. Physical activity and dietary habits among Moroccan adolescents. Public Health Nutr. 2015;18(10):1793-800.	Ineligible exposure
Hanson SK, Munthali RJ, Micklesfield LK, Lobelo F, Cunningham SA, Hartman TJ, et al. Longitudinal patterns of physical activity, sedentary behavior and sleep in urban South African adolescents, Birth-To-Twenty Plus cohort. BMC Pediatr. 2019;19.	Ineligible exposure
Harrington DM, Gillison F, Broyles ST, Chaput JP,	Ineligible exposure

Fogelholm M, Hu G, et al. Household-level correlates of children's physical activity levels in and across 12 countries. Obesity. 2016;24(10):2150-7	
Hosny G, Moloukhia TM, Elsalam GA, Elatif FA. Environmental behavioural modification programme for street children in Alexandria, Egypt. East Mediterr Health J. 2007;13(6):1438-48.	Ineligible exposure
Kubayi N, Surujlal J. Perceived benefits of and barriers to exercise participation among secondary school students. Mediterr J Soc Sci. 2014;5(20):121.	Ineligible exposure
Micklesfield LK, Pedro TM, Kahn K, Kinsman J, Pettifor JM, Tollman S, et al. Physical activity and sedentary behavior among adolescents in rural South Africa: levels, patterns and correlates. BMC Public Health. 2014;14(1):40-.	Ineligible exposure
Minnaar E, Grant CC, Fletcher L. Physical activity of children from a small rural town, South	Ineligible exposure

Africa. S Afr Fam Pract (2004). 2016;58(2):68-73.	
Mogre V, Aneyire ES, Gyamfi EK. Physical activity and BMI status of school-age children in Tamale, Northern Ghana. Pak J Nutr. 2013;12(5):484-90.	Ineligible exposure
Moselakgomo VK, Monyeki MA, Toriola AL. Relationship between physical activity and risk factors of body weight disorders among south African primary school children. Biomedical Research (India). 2015;26(4):730-8.	Ineligible exposure
Musaiger AO, Al-Mannai M, Tayyem R, Al-Lalla O, Ali EYA, Kalam F, et al. Perceived barriers to healthy eating and physical activity among adolescents in seven arab countries: A cross-cultural study. ScientificWorldJournal. 2013;2013 (no pagination)(232164).	Ineligible exposure
Muthuri SK, Wachira L-JM, Onywera VO, Tremblay MS. Comparative study of physical activity patterns among school children in Kenya and Canada:	Ineligible exposure

Results from the ISCOLE Project. Afr J Phys Health Educ Recreat Dance. 2014;20(2.2):765-79.	
Muthuri SK, Wachira LJM, Onywera VO, Tremblay MS. Correlates of objectively measured overweight/obesity and physical activity in Kenyan school children: results from ISCOLE-Kenya. BMC Public Health. 2014;14:436.	Ineligible exposure
Muthuri SK, Wachira LJ, Onywera VO, Tremblay MS. Direct and self-reported measures of physical activity and sedentary behaviours by weight status in school-aged children: results from ISCOLE-Kenya. Ann Hum Biol. 2015;42(3):237-45.	Ineligible exposure
Ojiambo RMe. Assessment of physical activity in children and adolescents [Ph.D.]. Ann Arbor: University of Glasgow (United Kingdom); 2012.	Ineligible exposure
Ojiambo RM, Easton C, Casajus JA, Konstabel K, Reilly JJ, Pitsiladis Y. Effect of urbanization on objectively	Ineligible exposure

measured physical activity levels, sedentary time, and indices of adiposity in Kenyan adolescents. J Phys Act Health. 2012;9(1):115-23.	
Ojiambo R, Gibson AR, Konstabel K, Lieberman DE, Speakman JR, Reilly JJ, et al. Free-living physical activity and energy expenditure of rural children and adolescents in the Nandi region of Kenya. Ann Hum Biol. 2013;40(4):318-23.	Ineligible exposure
Olaitan OL, Bakinde ST, Ibraheem TO. Recreational activities and body exercise among secondary school students in Kwara state, Nigeria. Int J Res Ayurveda Pharm. 2012;3(5):690-5.	Ineligible exposure
Oyeyemi AL, Ishaku CM, Oyekola J, Wakawa HD, Lawan A, Yakubu S, et al. Patterns and associated factors of physical activity among adolescents in Nigeria. PLoS One. 2016;11(2):e0150142.	Ineligible exposure
Pienaar AE, Kruger HS, Steyn HS, Naude D. Change over three years in adolescents'	Ineligible exposure

physical activity levels and patterns after a physical activity intervention: play study. J Sports Med Phys Fitness. 2012;52(3):300-10.	
Phillips JS, Kirenga L, Steyl T, Kagwiza J. Perceived support for physical activity in the school environment. Afr J Phys Health Educ Recreat Dance. 2015:40-7.	Ineligible exposure
Prista A, Nhantumbo L, Saranga S, Lopes V, Maia J, e Seabra A, et al. Physical activity assessed by accelerometry in rural African school-age children and adolescents. Pediatr Exerc Sci. 2009;21(4):384-99.	Ineligible exposure
Senbanjo IO, Oshikoya KA. Physical activity and body mass index of school children and adolescents in Abeokuta, Southwest Nigeria. World J Pediatr. 2010;6(3):217-22.	Ineligible exposure
Takomana G, Kalimbira A. Weight gain, physical activity and dietary changes during the seven months of first-year university life in Malawi. South	Ineligible exposure

Afr J Clin Nutr. 2012;25(3):132-7.	
Van Biljon A, McKune AJ, Dubose KD, Kolanisi U, Semple SJ. Physical activity levels in urban-based south african learners: A cross-sectional study of 7 348 participants. S Afr Med J. 2018;108(2):126-31.	Ineligible exposure
Walter CM. Promoting physical activity: A low cost intervention programme for disadvantaged schools in Port Elizabeth, South Africa. Afr J Phys Health Educ Recreat Dance. 2014;20(2.1):357-71.	Ineligible exposure
De Wet N, Somefun O, Rambau N. Perceptions of community safety and social activity participation among youth in South Africa. PLoS One. 2018;13(5):e0197549.	Ineligible outcome
Sullivan SM, Broyles ST, Barreira TV, Chaput JP, Fogelholm M, Hu G, et al. Associations of neighborhood social environment attributes	Duplicate cohort

and physical activity among 9–11 year old children from 12 countries. Health and Place. 2017;46:183-91.	
Kirenga BL, Phillips JS, Steyl T. High school girls' perceptions of environmental and social support for physical activity. Physiotherapy. 2015;1):eS760.	Only abstract was available
Micklesfield L, Pedro T, Twine R, Kinsman J, Pettifor J, Tollman S, et al. Physical activity patterns and determinants in rural South African adolescents. J Sci Med Sport. 2012;15:S251.	Only abstract was available
Pienaar A. After school physical activity intervention: Changes and challenges over a three-year-period. J Sci Med Sport. 2012;15 (SUPPL.1):S117-S8	Only abstract was available

Appendix 3: Detailed characteristics and main findings of included studies.

Title	Author	Study period	Study design	Country	Population characteristics	Inclusion and exclusion criteria	Sample size	Recruitment method	Data collection procedure and tool	Built environment construct assessed and definition	Mode of measurement of the built environment construct	Mode of measurement of physical activity/ Active transportation	Data analysis techniques	Results	Author's conclusion
Prevalence and correlates of adherence to movement guidelines among urban and rural children in Mozambique: a cross-sectional study	Manyanga T, Barnes JD, Chaput J-P, Katzmarzyk PT, Prista A, Tremblay MS.	August 2017 - May 2018	Cross-Sectional	Mozambique	Mean age 10.1; Males 47.1%, Females 52.9%	Primary school children representation from urban and rural districts	683	Recruitment was set to maximise variability in levels of neighbourhood socioeconomic status (SES). 10 urban schools and 7 rural schools were randomly picked.	Physical activity was measured by accelerometers were used and a self report questionnaire was used to assess the other correlates	Crime rate in the neighbourhood	Perceived	With an accelerometer	Multilevel, multivariable logit models were used to determine the correlates of movement behaviours.	OR (95% CI) 1.54 (0.85 - 2.78)	Prevalence and correlates of meeting movement guidelines differed between urban and rural school children in Mozambique.

Is inadequate play area in schools associated with overweight among students in Addis Ababa, Ethiopia ? A comparative cross-sectional study	Moges T, Gebremichael B, Shiferaw S, Yirgu R.	February to March 2016	Cross - Sectional	Ethiopia	Mean age 14.4 years, males 50%, female 50%	Private schools categorized by adequacy of playground and private school adolescents aged 10-19 years	1276	3 stage random sampling technique	Self-administered questionnaire - GPAQ.	Size of playground > 1092m2 was referred to as being adequate	Objective	With GPAQ questionnaire	Logistic regression	OR (95% CI) 1.68(1.35 - 2.10)	Findings of the study yield insights into the effect of inadequate play area in schools as an important contibutor to the burden of overweight/obesity

Associations Between Parental Perceptions of the Neighborhood Environment and Childhood Physical Activity: Results from ISCOLE-Kenya	Muthuri SK, Wachira LJ, Onywera VO, Tremblay MS.	2012	Cross-Sectional	Kenya	Aged 9 to 11.9 years; 46.5% males, 53.5% females	School children aged 9-11 years old.	563	sex-balanced sample. Conveniently recruited	Physical activity was measured by accelerometery, and the neighbourhood questionnaire were filled by the parents.	A. Street Connectivity B. Crime Safety C. Traffic Safety D. Aesthetics E. Walkability:	Perceived	With an accelerometer	Percentages of child and parent level factors were reported. Univariate analysis was done. Multivariable analysis yielded no significant results	A. (i) p=0.004 (ii) p=0.245 B. (i) p=0.766 (ii) p=0.548 (iii) p=0.054 (iv) p=0.425 (v) p= 0.399 C. (i) p=0.668 (ii) p = 0.518 (iii) p= 0.538 D. (i) p= 0.464 (ii) p= 0.435 E.(i) p = 0.0004 (ii) p = 0.045 (iii) p=0.627 (iv) p= 0.617 (v) p = 0.143	Parental perception of positive neighborhood physical environs and street connectivity was associated with meeting MVPA guidelines. Parental perception of negative child safety concerns was associated with sufficient activity among children.

Perception of built environmental factors and physical activity among adolescents in Nigeria	Oyeyemi AL, Ishaku CM, Deforche B, Oyeyemi AY, De Bourdeaudhuij I, Van Dyck D.	February - May 2011	Cross - Sectional	Nigeria	Mean age 15.6 years; 49.6% male, 50.4% female	Schol adolescents aged 12-19 years old	1006	Multistage sampling technique across different area level SES	Self-reported questionnaires supervised by researchers.	A. Residential density B. Walkability C. Street connectivity D. Facilities and Infrastructure E. Esthetics F. Crime Safety	Perceived	With a self-report questionnaire	Hierarchical multiple moderated linear regression was used. Pearson correlations was used to test for collinearity.	β (95% CI) Physical activity A. 0.01(-0.22, 0.25)B 0.00(-0.13, 0.14)G B. 0.00(-0.22, 0.23)B 0.01(-0.22, 0.23)G C. -0.00(-0.14, 0.14)B -0.01(-0.18, 0.16)G D. 0.23(0.07, 0.38)B 0.01(-0.19, 0.21)G E. 0.01(-0.26, 0.28)B 0.00(-0.15, 0.15)G F.0.01(-0.21,0.22)G Active transportation A. 0.00(-0.09,	A limited number of environmental attributes were associated with adolescents' physical activity. Only three out of seven environmental charcterisitics were associated with physical activity in boys only.

														0.09)B 0.01 (-0.09, 0.10)G B. 0.21 (0.10, 0.32)B 0.01(-0.13, 0.12)G C. 0.00(-0.08, 0.08)B 0.01(-0.08,0.10)G D. 0.00(-0.11, 0.11)B -0.01(-0.11,0.10)G E. 0.00(-0.11, 0.11)B -0.01(-0.13,0.11)G F.0.01 (-0.15, 0.16)B -0.01(-0.14,0.13)G	

Influence of parental attitude and perception of built environment attributes on children's active travel to school in Ghana	Alhassan Siiba		Cross-Sectional	Ghana	6-16 years, 53% female	School children and adolescents aged 6-16 years old.	842	Recruitment was done using a random technique to select 97 schools within Tamale and to ensure that subjects from approximately closed areas were not over-represented.	Perceived using a questionnaire	A. Facilities and infrastructure B. Crime safety C. Traffic safety D. Walkability	Perceived	With a self-report questionnaire	Logistic regression	OR (95% CI) A. 0.85 (0.75 - 1.03) B. (i) 1.06 (0.99 - 1.14) (ii) 1.13 (0.93 - 1.36) C. (i) 0.75 (0.57-1.02) (ii) 0.99 (0.96-1.03) (iii) 0.78 (0.57-1.06) (iv) 0.86 (0.69 - 1.07) (v) 0.97 (0.93 - 1.01) D. 0.89 (0.76 - 1.03)	The findings of the study suggest that parents' perceptions of their local environment may possibly have some influence on their children's active travel to school.

Perceived and objective neighborhood support for outside of school physical activity in South African children	Uys M, Broyles ST, E. Draper C, Hendricks S, Rae D, Naidoo N, Peter T. Katzmarzyk and Estelle V. Lambert.	April 2012 to May 2013	Cross-Sectional	South Africa	Ages 9-11, 43.8% males. 56.2% females	School children aged 9-11 years old.	258	Random selection of schools across five social strata	Physical activity measurement was both objective and self-reported, Neighbourhood environment was also assessed by perception (parents) and objective measurement	A. Facilities and infrastructure B. Crime safety C. Traffic safety D. Walkability	Perceived and Objective	With an accelerometer	Multilevel linear regression was used.	β (SE) A. 0.96(2.26) B. 0.37(0.42) C -0.32(0.70) D. 0.7(0.43)	Objective measurements of the neighbourhood environment were significantly associated with children's outside of school MVPA while parents' perceptions were unrelated.

Appendix 4: Summary of findings

Summary of findings:

Association of built environment constructs and physical activity among children and adolescents in Africa: a systematic review and meta-analysis

Patient or population: Children and Adolescents
Setting: Africa
Intervention: Built environment constructs
Comparison:

Outcomes	Comments	№ of participants (studies)	Certainty of the evidence (GRADE)
Built environment construct: perceived residential density			
Physical activity	Perceived residential density may lead to little or no difference on physical activity. MD 0.01 minutes (95% CI -0.11 to 0.12).	(1 observational study)	⨁⨁◯◯ Low
Built environment construct: perceived street connectivity			
Physical activity	Perceived street connectivity may lead to little or no difference on physical activity. MD -0.01 minutes (95% CI -0.11 to 0.10).	(1 observational study)	⨁⨁◯◯ Low
Built environment construct: perceived crime safety			
Physical activity	Perceived crime safety may lead to little or no difference on physical activity. MD 0.03 minutes (95% CI -0.18 to 0.24).	(2 observational studies)	⨁⨁◯◯ Low
Built environment construct: objective crime safety			
Physical activity	It is uncertain whether objective crime safety improves physical activity. MD 2.72 minutes (95% CI 0.07 to 5.37).	(1 observational study)	⨁◯◯◯ Very low[a]
Built environment construct: perceived availability of physical activity facilities and infrastructure			
Physical activity	Perceived availability of physical activity facilities and infrastructure may lead to little or no difference on physical activity. MD 0.13 minutes (95% CI -0.04 to 0.31).	(2 observational studies)	⨁⨁◯◯ Low
Built environment construct: objective availability of physical activity facilities and infrastructure			
Physical activity	It is uncertain whether objective availability of physical activity facilities and infrastructure improves physical activity. MD -0.03 minutes (95% CI -0.44 to 0.38)	(1 observational study)	⨁◯◯◯ Very low[b]
Built environment construct: perceived walkability			
Physical activity	Perceived walkability may lead to little or no difference on physical activity. MD 0.04 minutes (95% CI -0.15 to 0.23).	(2 observational studies)	⨁⨁◯◯ Low

Summary of findings:

Association of built environment constructs and physical activity among children and adolescents in Africa: a systematic review and meta-analysis

Patient or population: Children and Adolescents
Setting: Africa
Intervention: Built environment constructs
Comparison:

Outcomes	Comments	№ of participants (studies)	Certainty of the evidence (GRADE)
Built environment construct: perceived esthetics			
Physical activity	Perceived esthetics may lead to little or no difference on physical activity. MD 0.00 minute (-0.13 to 0.13)	(1 observational study)	⨁⨁◯◯ Low
Built environment construct: perceived traffic safety			
Physical activity	It is uncertain whether perceived traffic safety decreases physical activity. MD -0.32 minutes (-1.69 to 1.05)	(1 observational study)	⨁◯◯◯ Very low[b]
Built environment construct: objective traffic safety			
Physical activity	It is uncertain whether objective traffic safety increases physical activity.. MD 2.63 minutes (0.16 to 5.1)	(1 observational study)	⨁◯◯◯ Very low[a]
Built environment construct: perceived residential density			
Active transportation	Perceived residential density may lead to little or no difference in active transportation. MD 0.00 minute (95% CI -0.06 to 0.07)	(1 observational study)	⨁⨁◯◯ Low
Built environment construct: perceived street connectivity			
Active transportation	Perceived street connectivity may lead to little or no difference in active transportation. MD 0.00 minute (95% CI -0.05 to 0.06)	(1 observational study)	⨁⨁◯◯ Low
Built environment construct: perceived crime safety			
Active transportation	Perceived crime safety may lead to little or no difference in active transportation. MD 0.00 minute (95% CI -0.10 to 0.10)	(1 observational study)	⨁⨁◯◯ Low
Built environment construct: perceived availability of physical activity facilities and infrastructure			
Active transportation	Perceived availability of physical activity facilites and infrastructure may lead to little or no difference in active transportation. MD -0.00 minute (95% CI -0.08 to 0.07)	(1 observational study)	⨁⨁◯◯ Low
Built environment construct: perceived walkability			

Summary of findings:

Association of built environment constructs and physical activity among children and adolescents in Africa: a systematic review and meta-analysis

Patient or population: Children and Adolescents
Setting: Africa
Intervention: Built environment constructs
Comparison:

Outcomes	Comments	№ of participants (studies)	Certainty of the evidence (GRADE)
Active transportation	Perceived walkability may lead to little or no difference in active transportation. MD 0.10 minute (95% CI -0.11 to 0.31)	(1 observational study)	⊕⊕◯◯ Low
Built environment construct: perceived esthetics			
Active transportation	Perceived esthetics may lead to little or no difference in active transportation. MD -0.00 minute (95% CI -0.08 to 0.08)	(1 observational study)	⊕⊕◯◯ Low

CI: confidence interval; **MD:** mean difference

GRADE Working Group grades of evidence
High certainty: we are very confident that the true effect lies close to that of the estimate of the effect.
Moderate certainty: we are moderately confident in the effect estimate: the true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different.
Low certainty: our confidence in the effect estimate is limited: the true effect may be substantially different from the estimate of the effect.
Very low certainty: we have very little confidence in the effect estimate: the true effect is likely to be substantially different from the estimate of effect.

Appendix 5: Questionnaire

Study questionnaire.

Thank you for participating in this survey. This survey is about physical activity and some factors that may affect it. The information you give will be used to develop interventions to promote physical activity.

DO NOT write your name on this survey. The answers you give will be kept private. No one will know how you answer. Answer the question based on what you really do or know. There are no right or wrong answers.

Make sure to read every question. Fill in the boxes that match your answer. You are free to ask questions if in doubt.

Section A: Demographic information

The following questions ask about your personal characteristics, please tick the response that is appropriate to you or fill in the requested information

1. What is your sex
   - 1 ☐ Male
   - 2 ☐ Female
   - 3 ☐ Prefer not to say
2. What is your date of birth (dd/mm/yy) _____
3. What is your ethnicity?
   1. ☐ Hausa
   2. ☐ Igbo
   3. ☐ Yoruba
   4. ☐ Others
4. What class are you in?
   1. ☐ J.S.S.1
   2. ☐ J.S.S.2
   3. ☐ J.S.S.3
   4. ☐ S.S.S.1
   5. ☐ S.S.S.2
   6. ☐ S.S.S.3
5. How many cars does your family have?
   1. ☐ No car
   2. ☐ One car
   3. ☐ More than one car
6. Which of the following home appliances do your parents(s)/guardians have at home? You can choose more than one answer.
   1. ☐ Computer
   2. ☐ Television
   3. ☐ Fridge/Freezer

4. ☐ Radio
5. ☐ Others please specify _____

7. Is the house you live in owned by your parents or guardian?
   1. ☐ No
   2. ☐ Yes
8. Do you have electricity in your house ?
   1. ☐ No
   2. ☐ Yes
9. How many people do you sleep with in the same room? _____

10. Which of the following best describes the house where you live?
    0. ☐Mud/bamboo/wood house with thatch roofing
    1. ☐ Mud/bamboo/wood house with sheet roofing
    2. ☐ Uncemented block house
    3. ☐ Block house cemented and painted
    4. ☐ Other (specify)_____

11. Weight (1) _____kg (2) _____kg
12. Height (1) _____cm (2) _____cm
13. WaistCircumference(1)_____cm(2)_____cm
14. HipCircumference (1)_____cm (2) _____cm

Section B: Physical activity

The following questions are about physical activity. Think about the past week (**seven days**). Please indicate how many days in this week you performed the following activities per day; and if (applicable) how strenuous these activities were for you.

1. COMMUTING ACTIVITIES (From and to school)		
Walking to/from school	A. days per week	_____days
	B. average time a day	_____hours _____ minutes
	C. effort	☐ slow ☐ moderate ☐fast
Cycling to/from school	A. days per week	_____days
	B. average time a day	_____hours _____ minutes
	C. effort	☐ slow ☐ moderate ☐fast
Public transport, car or motor cycle to school	A. days per week	_____days
	B. average time a day	_____hours _____ minutes
Not applicable ☐		
2. ACTIVITY AT SCHOOL		
Light work E.g. sitting/standing with some walking, writing/copying notes during classes		
	A. days per week	_____days
	B. average time a day	_____hours _____ minutes
Moderate work E.g work with regular walking (the stairs), carrying light objects, sweeping/cleaning		
	A. days per week	_____days
	B. average time a day	_____hours _____ minutes
Intense work E.g walking (the stairs) carrying heavy objects like a heavy schoolbag, cutting grass		
	A. days per week	_____days
	B. average time a day	_____hours _____ minutes
I haven't engaged in any physical activity at school in the past 7 days ☐		
3. HOUSEHOLD ACTIVITIES (In and around the house)		
Light household work E.g. cooking, washing dishes, making the bed, tidying the room.		
	A. days per week	_____days
	B. average time a day	_____hours_____ minutes
Moderate household work E.g cleaning, walking/carrying light objects, sweeping		
	A. days per week	_____days
	B. average time a day	_____hours_____ minutes

Intense household work E.g Fetching water and walking with heavy shopping loads		
	A. days per week B. average time a day	_____days _____hours_____ minutes
I haven't done any household activity in the last 7 days ☐		
4. LEISURE TIME ACTIVITIES commuting activities to/from school and other things mentioned before excluded		
Walking E.g to/from the supermarket, church, mosque cinema	A. days per week B. average time a day C. effort	_____days _____hours_____ minutes ☐ slow ☐ moderate ☐ fast
Bicycling E.g to/from the supermarket, sports club, cinema	A. days per week B. average time a day C. effort	_____days _____hours_____ minutes ☐ slow ☐ moderate ☐ fast
Gardening/Odd jobs E.g. mowing the lawn (non-electric), painting walls, carpentry	A. days per week B. average time a day C. effort	_____days _____hours_____ minutes ☐ slow ☐ moderate ☐ fast
Not applicable ☐		
Watching television	A. days per week B. average time a day	☐ days ☐☐ hours ☐☐ minutes
Using the computer E.g. surfing the internet at home, using a tablet or smartphone, playing sedentary computer games (excluding exercise games)	A. days per week B. average time a day	☐ days ☐☐ hours ☐☐ minutes
Reading/doing home work	A. days per week B. average time a day	☐ days ☐☐ hours ☐☐ minutes
Other sedentary activities E.g talking with friends, board games, sitting in the car	A. days per week B. average time a day	☐ days ☐☐ hours ☐☐ minutes

Not applicable ☐			
5. ACTIVE SPORTS Write down the sports you performed the last week (maximum of 3 sports). Start with the most active sport. **(Please do not include any activity that has already been mentioned.**			
Sport	Days Per week	Average time a day	Effort
1……	…….day(s)	…..hour(s), ……mins	Light/moderate/intense
2……	…….day(s)	…..hour(s), ……mins	Light/moderate/intense
3. ……	…….day(s)	…..hour(s), ……mins	Light/moderate/intense
I haven't performed any active sports in the last 7 days ☐			

Section C: Self efficacy

Please rate your agreement with the following:

	Strongly disagree	Disagree	Not sure	Agree	Strongly agree
1. I can be physically active on most days of the week					
2. I can ask my parent or other adult to do physically active things with me					
3. I can be physically active during my free time on most days even if I could watch TV or play (sedentary) video games instead					
4. I can be physically active on most days even if it is very hot or cold outside					

	Strongly disagree	Disagree	Not sure	Agree	Strongly agree
5. I can ask my best friend to be physically active with me on most days					
6. I can be physically active even at home					
7. I can be physically active because I know how to do them					
8. I can be physically active during my free time on most days no matter how busy my day is					

Section D: Perceived Benefits

Please rate your agreement with the following effect of physical activity

Physical activity helps me with	Strongly disagree	Disagree	Not sure	Agree	Strongly agree
1. My weight and physical appearance					
2. My Health and fitness – helps me feel healthier and stronger					
3. Social interaction – helps me meet new people					
4. Pleasure – gives me enjoyment					
5. Competition – helps me compete better					
6. Relief from stress and depression – helps me feel less stressed and depressed					

Physical activity helps me with	Strongly disagree	Disagree	Not sure	Agree	Strongly agree
7. Admiration of others – helps others to admire me					
8. Relaxation from (school) work – helps me relax from school work.					

Section E: Perceived Barriers

Could you please say the frequency with which the following barriers prevented you from exercising

	Strongly disagree	Disagree	Not sure	Agree	Strongly agree
1. Lack of time					
2. Lack of discipline					
3. Lack of interest					
4. Health problems					
5. Personal problems					
6. Not skilled enough					
7. Too expensive					
8. No transportation					
9. Not liking to sweat					
10. Fear of being laughed at					
11. Cultural factors					
12. The climate is not suitable for practicing exercise					

	Strongly disagree	Disagree	Not sure	Agree	Strongly agree
13. Lack of facilities					

Appendix 6: Dealing with missing data

Comparison of participants with and without missing MVPA level data by predictors

Predictor	With missing MVPA level data (n=192) n (%) or otherwise indicated	Without missing MVPA level data (n=528) n (%) or otherwise indicated	p-value
Age (years)	15.2 (1.5)*	14.9 (1.6)*	0.005
Gender			0.271
Male	96 (50.3)	234 (44.3)	
Female	95 (49.7)	292 (55.3)	
Prefer not to say	0	2 (0.4)	
Ethnicity			0.141
Hausa	3 (1.6)	6 (1.1)	
Ibo	48 (25.1)	172 (32.6)	
Yoruba	110 (57.6)	291 (55.2)	
Others	30 (15.7)	58 (11.0)	
Socioeconomic status			0.025
Low	95 (51.1)	229 (44.3)	
Middle	56 (30.1)	213 (41.2)	
High	35 (18.8)	75 (14.5)	
School			0.705
Public	113 (58.9)	319 (60.4)	
Private	79 (41.2)	209 (39.6)	
Class			<0.001
Junior	44 (22.9)	231 (43.8)	
Senior	148 (77.1)	297 (56.3)	
BMI			0.569
Grade III-I thinness	35 (19.3)	111 (21.1)	
Normal	127 (70.2)	356 (67.7)	
Overweight	14 (7.7)	51 (9.7)	
Obese	5 (2.8)	8 (1.5)	
Waist-to-hip ratio	0.8 (0.05)	0.8 (0.04)	0.378
Sedentary behaviour			0.402
Low	78 (46.2)	214 (42.5)	
High	91 (53.8)	290 (57.5)	
Self-efficacy	3.5 (0.6)*	3.6 (0.7)*	0.311
Perceived benefits	3.8 (0.6)*	3.8 (0.6)*	0.416
Perceived barriers	2.7 (0.6)*	2.6 (0.6)*	0.413

* Mean (SD)

Comparing the participants with missing MVPA data with those without MVPA data across the different physical activity domains

Domain	Missing MVPA level data (N), median (IQR)	Without missing MVPA level data (N), median (IQR)	p-value
Active transportation	N= 162 14.3 (0, 46.4)	N=528 14.3 (0. 35.3)	0.70
School based	N= 172 20.7 (2.1, 51.4)	N=528 21.4 (4.3, 50.4)	0.57
House based	N= 166 34 (8, 75)	N= 528 1.4 (4.3, 50.4)	0.03
Sports based	N= 117 0 (0, 42.9)	N= 528 8.6 (0, 58.9)	0.03
Leisure based	N= 94 4.6 (0, 21.4)	N =528 8.6 (1.1, 34.3)	0.09

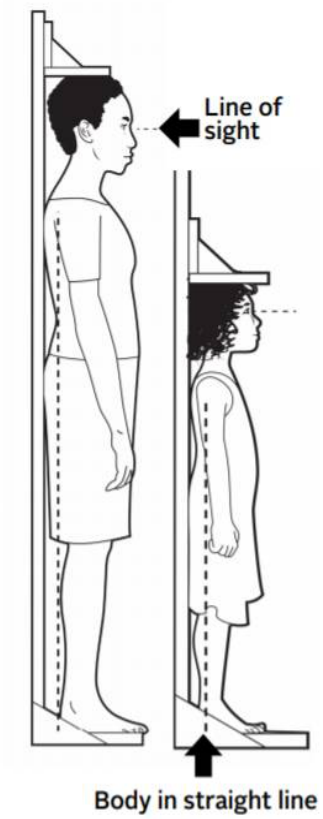
Logistic regression for best case scenario

	Adjusted OR	95% CI	p-value
School			<0.001
Private	1.00		
Public	3.60	2.26-5.74	

Logistic regression for worst case scenario

	Adjusted OR	95% CI	p-value
School			<0.001
Private	1.00		
Public	1.91	1.41-2.60	

Appendix 7: Protocol for measuring height



Appendix 8: Decision makers' Interview guide

Interview guide

This study is being conducted by the University of Nottingham, School of Medicine, Division of Epidemiology and Public Health. My name is Busola Adebusoye and I am currently a PhD student at the school. The aim of the project is to investigate the physical activity patterns of adolescents in Lagos State and to explore the barriers and facilitators to physical activity participation in Schools.

Your taking part in this research study will help us to understand the barriers to physical activity participation in adolescents, thereby identifying opportunity areas to improve physical activity amongst this target group. We have the pleasure to invite you to take part in this research study. (*check if participant has signed consent, and if they have any questions before starting the interview*)

Part 1: INTRODUCTION/PHYSICAL ACTIVITY IN SCHOOLS

1. How long have you been in this school in this capacity (as a principal or administrator or physical and health teacher)
2. Is physical and health education offered in your school as a subject?

   (Probe-if yes, could you please tell me about the curriculum? is it purely academic or does it involve some physical activities, if no, ask why)
3. Could you please tell me about the physical activity participation of the students in your school?

   (Probe- On what days of the week and what time do you have physical activity in your schools)

4. Can you please tell me about the physical activity levels of the students in your school?

   (Probe- Do you think it is sufficient, do you think more could be done)
5. Could you please share your thoughts on the kind of things that prevent students from getting more exercise in school?
6. What kind of things do you think the school could do to make it easier for students to get more physical activity at school?
7. If physical activity opportunities are improved, how do you think that this might affect the current schools' curriculum

Part 2: Inclusion

8. How inclusive will you describe the physical activities offered in your school? (By inclusive, I mean involving all the students in school, irrespective of age and gender and athletic abilities)

   (Probe- What do you think might be responsible for the poor inclusion/good inclusion -this is asked, depending on the interviewee's response to the previous question)
9. Could you please share your view on how culturally sensitive issues (religion, culture) influences physical activity participation amongst the students?

Part 3: Teachers involvement

10. How will you describe teachers' motivation to be involved during physical activities in your school (probe on respondent's view on the value that she thinks teachers attach to physical activity.)

Appendix 9: Participant information sheet- Survey

Study Title: Physical activity in school attending adolescents in Lagos, Nigeria: levels, correlates, barriers, and facilitators.

PARTICIPANT INFORMATION SHEET

Research Ethics Reference:
FMHS 429-1912
LREC/06/10/1319
Version 1.0 Date: 31/10/2019

We would like to invite your school to take part in a research study. Before you decide, it is important for you to understand why the research is being done and what it will involve. Please take time to read this carefully and discuss it with others if you wish. One of our team will go through the information sheet with your students and answer any questions that s/he may have.

1. **What is the purpose of the research?**

The World Health Organization (WHO) recommends that children and adolescents should spend at least 60 minutes daily engaging in moderate to vigorous physical activity. Meeting the recommended levels offers immense benefits to adolescents ranging from muscular development, psychological benefits and improves their academic achievements. The aim of this study is to estimate the proportion of school attending adolescents that meet the recommended level and also to identify the factors that encourage or inhibit physical activity amongst school attending adolescents.

2. **Why has my school been invited to take part?**

Your school has been invited to take part in this research because the target audience for this project are adolescents and your students fall within the age range of 12 -19. We will be recruiting up to 630 adolescents in this study.

3. Do I have to take part?

No. It is up to you to decide if you want your school to take part in this research. We will describe the study and go through this information sheet with your school/students to answer any questions you may have. However, your school or your any of the students would still be free to withdraw from the study at any time, without giving a reason and without any negative consequences, by advising the researchers of this decision. This would not affect your legal rights.

4. What will happen to me if I take part?

A researcher will go over the information sheet with your students and explain the procedures which are:

1. We will ask your students to fill a questionnaire which will ask questions related to your students' characteristics (age, gender) and also some questions related to your students' participation in physical activity.
2. We will measure your students' height, weight, waist and hip circumference.

We will give your students the chance to ask any questions. Your students will be involved in this study for approximately 30-45 minutes.

5. Are there any risks in taking part?

We are not aware of any risks of taking part in this study.

6. Are there any benefits in taking part?

There will be no direct benefit to anyone from taking part in this research but your students' contribution may help to identify the factors that are responsible for physical inactivity in school attending adolescents, thereby leading to the knowledge of possible interventions that can encourage physical activity.

7. Will my time/travel costs be reimbursed?

Participants will not receive an inconvenience allowance to participate in this study as the lead researcher will be going to them. Travel expenses will be offered for any visits incurred as a result of participation.

8. ***What happens to the data provided?***

The **research data** will be stored confidentially and anonymized in an encrypted electronic storage device/laptop. Your students will not be identifiable in any report or publication. All research information will only be accessed by the research team [i.e researcher, supervisor, collaborator / translator / transcribe]. However, we would like your permission to use anonymised data in future studies, and to share our research data (e.g. in online databases) with other researchers in other

Universities and organisations both inside and outside the European Union. This would be used for research in health and social care. Sharing research data is important to allow peer scrutiny, re-use (and therefore avoiding duplication of research) and to understand the bigger picture in particular areas of research. All personal information that could identify you will be removed or changed before information is shared with other researchers or results are made public. All research data and records will be stored for a minimum of 7 years after publication or public release of the work of the research.

9. What will happen if I don't want to carry on with the study?

Even after you have accepted to your students participating in the study, your students are free to withdraw from the study at any time without giving any reason and without their legal rights being affected. If your students withdraw we will no longer collect any information about them but we will keep the anonymous research data that has already been collected and stored as we are not allowed to tamper with study records. This information may have already been used in some analyses and may still be used in the final study analyses. To safeguard your students' rights, we will use the minimum personally-identifiable information possible.

10. Who will know that I am taking part in this research?

All information collected about your students during this research would be kept strictly confidential. All such data are kept on password-protected databases sitting on a restricted access computer system and any paper information (such as opt out form your consent form, contact details and any research questionnaires) would be stored safely in lockable cabinets in a swipe-card secured building and would only be accessed by the research team. Under UK Data Protection laws the University is the Data Controller (legally responsible for the data security) and the Chief Investigator of this study (named above) is the Data Custodian (manages access to the data). This means we are responsible for looking after your information and using it properly. Your rights to access, change or move your information are limited as we need to manage your information in specific ways to comply with certain laws and for the research to be reliable and accurate. To safeguard your rights we will use the minimum personally – identifiable information possible. You can find out more about how we use your information and to read our privacy notice at:

https://www.nottingham.ac.uk/utilities/privacy.aspx/

Designated individuals of the University of Nottingham may be given access to data for monitoring and/or audit of the study to ensure we are complying with guidelines.

11. What will happen to the results of the research?

The research will be written up as a thesis. On successful submission of the thesis, it will be deposited both in print and online in the

University archives, to facilitate its use in future research. The thesis will be published open access. Result of the thesis may also be used for scientific presentation or publication. The research will be written up as dissertation for the degree of PhD.

12. Who has reviewed this study?

All research involving people is looked at by an independent group of people, called a Research Ethics Committee, to protect your interests. This study has been reviewed and given favourable opinion by the Faculty of Medicine and Health Sciences Research Ethics Committee (Reference number: 429-1912) and the Lagos State Health research Ethics Committee (Reference number: LREC/06/10/1319)

13. Who is organising and funding the research?

The research is being organised by the University of Nottingham and is being funded by the University of Nottingham Vice chancellor scholarship.

14. What if something goes wrong?

If you have a concern about any aspect of this project, please speak to the researcher Busola Adebusoye or the Principal Investigator Dr Kaushik Chattopadhyay, who will do their best to answer your query. The researcher should acknowledge your concern within 10 working days and give you an indication of how she intends to deal with it. If

you remain unhappy and wish to complain formally, you can do this by contacting the FMHS Research Ethics Committee Administrator, c/o The University of Nottingham, Faculty PVC Office, B Floor, Medical School, Queen's Medical Centre Campus, Nottingham University Hospitals, Nottingham, NG7 2UH.

Contact Details

If you would like to discuss the research with someone beforehand (or if you have questions afterwards), please contact:

Primary Researcher:

Busola Adebusoye

Division of Epidemiology and Public Health

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University of Nottingham

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Email: busola.adebusoye@nottingham.ac.uk

Supervisors

Kaushik Chattophadyay, PhD

Assistant Professor in Evidence Based Healthcare, Faculty of Medicine & Health Sciences

University of Nottingham, United Kingdom

Email: Kaushik.Chattopadhyay@nottingham.ac.uk

Appendix 10: School consent form

SCHOOL'S REPRESENTATIVE CONSENT FORM

Research Ethics Reference:

University of Nottingham's Faculty of Medicine and Health Sciences Research Ethics committee :429-1912

Lagos State Health Research and Ethics Committee: LREC/06/10/1319

Statement of person obtaining informed consent:

I have fully explained this research to _____ and have given sufficient information, including about risks and benefits, to make an informed decision.

DATE: _____ SIGNATURE: _____

NAME: _____

Statement of person giving consent:

I have read the description of the research. I understand that my students' participation is voluntary. I know enough about the purpose, methods, risks and benefits of the research study to judge that I want my students to take participate in it. I understand that I may freely stop being part of this study at any time. I have received a copy of this consent form and additional information sheet to keep for myself.

DATE: _____ SIGNATURE: _____

NAME: _____

NAME OF SCHOOL: _____

WITNESS' SIGNATURE (if applicable): _____

WITNESS' NAME (if applicable): _____

Appendix 11: Assent form

Study Title: Physical activity in school attending adolescents in Lagos, Nigeria: levels, correlates, barriers and facilitators.

My name is Busola Adebusoye and I am a PhD student at the University of Nottingham, UK.

I am asking you to take part in this research study because I am trying to learn more about physical activity of people in your age group.

If you agree, you will be asked to complete a survey. You will be asked some questions that can tell me about your physical activity patterns. I will also be taking your height, weight, waist and hip circumference. This will take about 30-45 minutes. You do not have to put your name on the survey.

You do not have to be in this study. No one will be angry at you if you decide not to do this study. Even if you start, you can stop later if you want. You may ask questions about the study.

If you decide to be in the study I will not tell anyone else what you say or do in the study. Even if your parents or teachers ask, I will not tell them about what you say or do in the study.

Signing here means that you have read this form, or have had it read to you, and that you are willing to be in this study.

Signature of participant_____

Signature of investigator_____

Date_____

Appendix 12: Participant information sheet (key decision makers)

PARTICIPANT INFORMATION SHEET (Key decision makers)

Research Ethics Reference:

429-1912

LREC/06/10/1319

We would like to invite you to take part in a research study. Before you decide, it is important for you to understand why the research is being done and what it will involve. One of our team will go through the information sheet with you and answer any questions you have. Please take time to read this carefully and discuss it with others if you wish. Ask us anything that is not clear.

What is the purpose of the research?

The World Health Organization (WHO) recommends that children and adolescents should spend at least 60 minutes daily engaging in moderate to vigorous physical activity. Meeting the recommended levels offers immense benefits to adolescents ranging from muscular development, psychological benefits and improves their academic achievements. The aim of this study is to estimate the proportion of school attending adolescents that meet the recommended level and also

to identify the factors that encourage or inhibit physical activity amongst school attending adolescents.

Why have I been invited to take part?

You are being invited because you are identified as a key decision maker in secondary schools in Lagos State, Nigeria. 20 participants will be recruited for this study.

Do I have to take part?

No. It is up to you to decide if you want to take part in this research. We will describe the study and go through this information sheet with you to answer any questions you may have. If you agree to participate, we will ask you to sign a consent form and will give you a copy to keep. However, you would still be free to withdraw from the study at any time, without giving a reason and without any negative consequences, by advising the researchers of this decision. This would not affect your legal rights.

1. ***What will happen to me if I take part?***

A researcher will go over the information sheet, explain the procedure which involves having an interview with the researcher. We will ask you about your thoughts on the barriers and facilitators of physical activity participation in school attending adolescents. This interview will last for approximately 45 to 60 minutes. If you are happy to take part, then you will be asked to sign a consent form.

2. *Are there any risks in taking part?*

We are not aware of any risks of taking part in this study.

3. *Are there any benefits in taking part?*

There will be no direct benefit to anyone from taking part in this research. The study is being undertaken to identify the factors that are responsible for physical inactivity in school attending adolescents, thereby leading to the knowledge of possible interventions that can encourage physical activity.

4. *Will my travel costs be reimbursed?*

Participants will not receive any travel allowance to participate in this study as the researchers will be going to them.

5. *What happens to the data provided?*

The research data will be stored confidentially and anonymized in an encrypted electronic storage device/laptop. We will not ask for your name and you will not be identifiable in any report or publication. All research information will only be accessed by the research team [i.e researcher, supervisor]. However, we would like your permission to use anonymised data in future studies, and to share our research data (e.g. in online databases) with other researchers in other Universities and organisations both inside and outside the European Union. This would be used for

research in health and social care. Sharing research data is important to allow peer scrutiny, re-use (and therefore avoiding duplication of research) and to understand the bigger picture in particular areas of research. We would like your permission to use fully anonymised direct quotes in research publications. All personal information that could identify you will be removed or changed before information is shared with other researchers or results are made public. Data sharing in this way is usually anonymised All research data and records will be stored for a minimum of 7 years after publication or public release of the work of the research.

Personal / sensitive data will be stored confidentially using password protected computers. The research team will have access to personal/sensitive data collected in this study. To help ensure your privacy, you will be assigned a volunteer study identification number (for example P01 for participant number 1), and it will be used instead of your name. Your name and any information about you will not be disclosed outside the study centre.

6. What will happen if I don't want to carry on with the study?

Even after you have signed the consent form, you are free to withdraw from the study at any time without giving any reason and without their legal rights being affected. If you withdraw we will no longer collect any information about you or from you but we will keep the anonymous research data that has already been collected and stored as we are not allowed to tamper with study records. This information may have already

been used in some analyses and may still be used in the final study analyses. To safeguard your rights, we will use the minimum personally-identifiable information possible.

7. Who will know that I am taking part in this research?

All information collected about you during this research would be kept strictly confidential. All such data are kept on password-protected databases sitting on a restricted access computer system and any paper information (such as your consent form, contact details and any research questionnaires) would be stored safely in lockable cabinets in a swipe-card secured building and would only be accessed by the research team. Under UK Data Protection laws the University is the Data Controller (legally responsible for the data security) and the Chief Investigator of this study (named above) is the Data Custodian (manages access to the data). This means we are responsible for looking after your information and using it properly. Your rights to access, change or move your information are limited as we need to manage your information in specific ways to comply with certain laws and for the research to be reliable and accurate. To safeguard your rights we will use the minimum personally – identifiable information possible. You can find out more about how we use your information and to read our privacy notice at:

https://www.nottingham.ac.uk/utilities/privacy.aspx/

Designated individuals of the University of Nottingham may be given access to data for monitoring and/or audit of the study to ensure we are complying with guidelines. With your consent, we will keep your personal

information on a secure database in order to contact you for future studies. Anything you say during the interview will be kept confidential, unless you reveal something of concern that may put yourself or anyone else at risk. It will then be necessary to report to the appropriate persons.

8. What will happen to the results of the research?

The research will be written up as a thesis. On successful submission of the thesis, it will be deposited both in print and online in the University archives, to facilitate its use in future research. The thesis will be published open access. Result of the thesis may also be used for scientific presentation or publication. The research will be written up as a dissertation for the degree of PhD.

9. Who has reviewed this study?

All research involving people is looked at by an independent group of people, called a Research Ethics Committee, to protect your interests. This study has been reviewed and given favourable opinion by the responsible Research Ethics Committees.

10. Who is organising and funding the research?

The research is being organised by the university of Nottingham and is being funded by the University of Nottingham Vice chancellor scholarship.

11. What if something goes wrong?

If you have a concern about any aspect of this project, please speak to the researcher Busola Adebusoye or the Principal Investigator Dr Kaushik Chattopadhyay, who will do their best to answer your query. The researcher should acknowledge your concern within 10 working days and give you an indication of how she intends to deal with it.

12. Contact Details

If you would like to discuss the research with someone beforehand (or if you have questions afterwards), please contact:

Primary Researcher:

Busola Adebusoye

Division of Epidemiology and Public Health

School of Medicine

University of Nottingham

Tel: +44 (0) 7586136173

Email: busola.adebusoye@nottingham.ac.uk

Lead supervisor

Kaushik Chattophadyay, PhD

Assistant Professor in Evidence Based Healthcare, Faculty of Medicine & Health Sciences

University of Nottingham, United Kingdom

Email: Kaushik.Chattopadhyay@nottingham.ac.uk

Appendix 13: Consent form (Interviews)

Participants Consent Form

Title of Study: Physical activity in secondary school attending adolescents in Lagos, Nigeria: levels, correlates, barriers and facilitators

REC ref:

Name of Researchers:
Busola Adebusoye, Lead investigator
Supervisors: Dr Kaushik Chattopadhyay, Dr Revati Phalkey, Prof Jo Leonardi-Bee

Please initial box

Name of Participant:

1. I confirm that I have read and understand the information sheet for the above study which is attached and have had the opportunity to ask questions.

2. I understand that my participation is voluntary and that I am free to withdraw at any time, without giving any reason.

3. I understand that should I withdraw, more than 7 days after the interview has taken place then the information collected so far cannot be erased and that this information may still be used in the study analysis.

4. I understand that relevant sections of my data collected in the study may be looked at by the research group and by other responsible individuals for monitoring and audit purposes. I give permission for these individuals to have access to these records and to collect, store, analyse and publish information obtained from my participation in this study. I understand that my personal details will be kept confidential.

5. I understand that the interview will be audio recorded using a digital device and that anonymous direct quotes from the interview may be used in the study reports.

6. I understand that what I say during the interview will be kept confidential unless I reveal something of concern that may put myself or someone else at any risk. It will then be necessary to report this to the appropriate persons.

7. I understand that information about me recorded during the study will be made anonymous before it is stored. It will be uploaded into a secure database on a computer kept in a secure place.

Data will be kept for 7 years after the study has ended and then destroyed.

8. I agree to take part in the above study. ☐

_____	_____	
Name of Participant	Date	Signature
_____	_____	
Name of Person taking consent	Date	Signature

Appendix 14: Ethics approval – University of Nottingham

University of Nottingham
UK | CHINA | MALAYSIA

Faculty of Medicine & Health Sciences
Research Ethics Committee
Faculty Hub
Room E41, E Floor, Medical School
Queen's Medical Centre Campus
Nottingham University Hospitals
Nottingham, NG7 2UH
Email: FMHS-ResearchEthics@nottingham.ac.uk

20 January 2019

Busola Adebusoye
PhD Student
Division of Epidemiology and Public Health
School of Medicine
Clinical Sciences Building
City Hospital Campus
Nottingham University Hospitals
Hucknall Road
Nottingham, NG7 2UH

Dear Busola Adebusoye

Ethics Reference No: 429-1912 – **please always quote**	
Short Study Title: Physical activity in School attending adolescents in Lagos State, Nigeria: levels, correlates, barriers and facilitors.	
Chief Investigator/Supervisor: Dr Kaushik Chattopadhyay, Assistant Professor in Evidence Based Healthcare, Epidemiology and Public Health, School of Medicine.	
Lead Investigators/student: Busola Adebusoye, PhD Student, Epidemiology and Public Health	
Other Key investigators: Dr Ravati Phalkey, Head, Climate Change and Health Group, Public Health England, Dr Jo Leonardi-Bee, Professor of Medical Statistics, Epidemiology and Public Health, School of Medicine.	
Proposed Start Date: 01/02/2020	**Proposed End Date:** 01/07/2021

Thank you for submitting the above application to the meeting held on 13 December 2019 and the following documents were received:

- FMHS REC Application form and supporting documents version 1.0: 31/10/2019
- Letter of permission Lagos State Government Education District IV dated 03/09/2019

These have been reviewed and are satisfactory and the project has been given a favourable opinion.

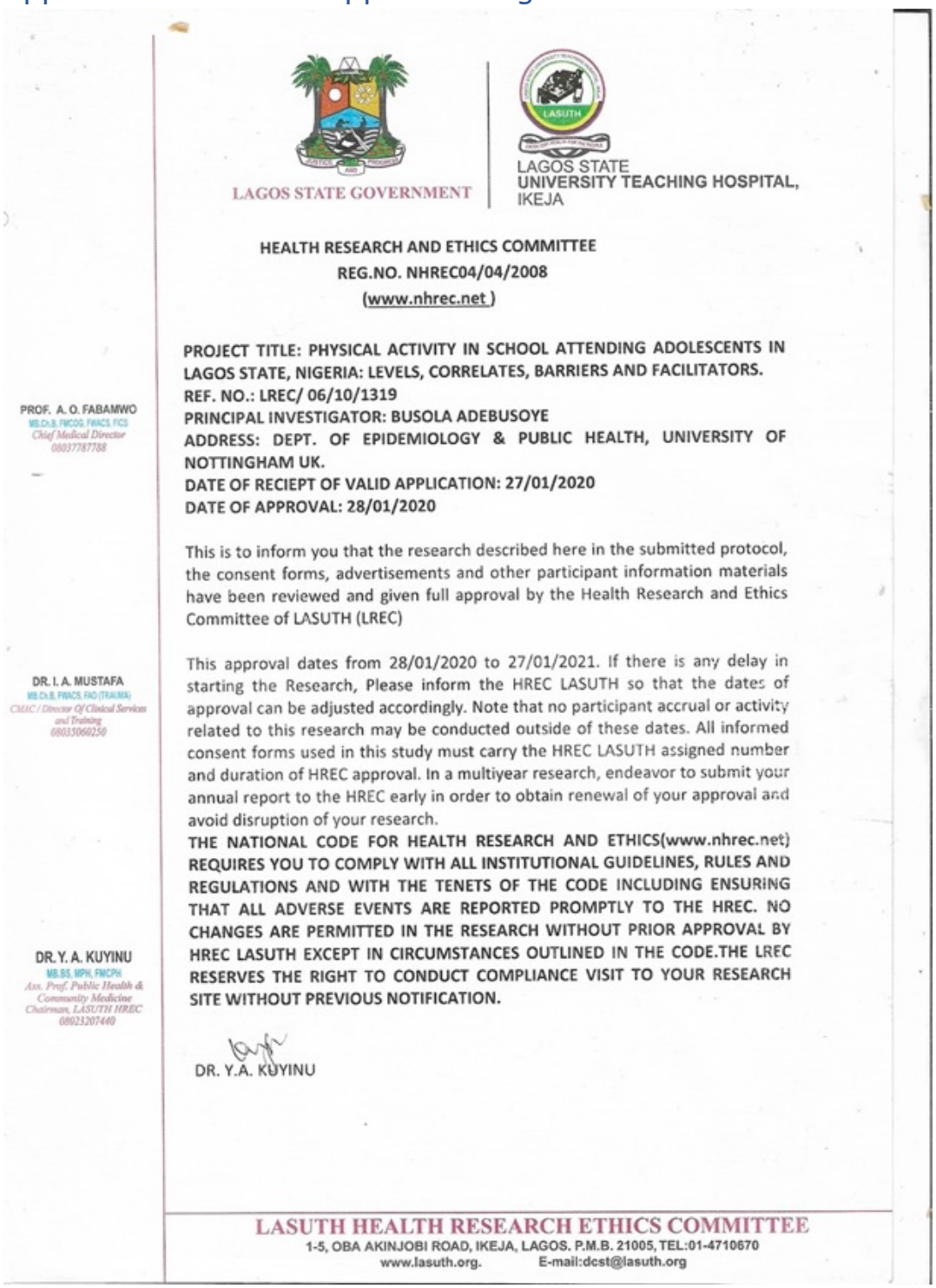
A favourable opinion has been given on the understanding that:

1. All appropriate ethical and regulatory permissions are respected and followed in accordance with all local laws of the country in which the study is being conducted and those required by the host organisation/s involved
2. The protocol agreed is followed and the Committee is informed of any changes using a notice of amendment form (please request a form).
3. The Chair is informed of any serious or unexpected event.
4. An End of Project Progress Report is completed and returned when the study has finished (Please request a form).

Yours sincerely

Professor Ravi Mahajan
Chair, Faculty of Medicine & Health Sciences Research Ethics Committee

Appendix 15: Ethical approval -Lagos State



LAGOS STATE GOVERNMENT

LAGOS STATE
UNIVERSITY TEACHING HOSPITAL,
IKEJA

HEALTH RESEARCH AND ETHICS COMMITTEE
REG.NO. NHREC04/04/2008
(www.nhrec.net)

PROJECT TITLE: PHYSICAL ACTIVITY IN SCHOOL ATTENDING ADOLESCENTS IN LAGOS STATE, NIGERIA: LEVELS, CORRELATES, BARRIERS AND FACILITATORS.
REF. NO.: LREC/ 06/10/1319
PRINCIPAL INVESTIGATOR: BUSOLA ADEBUSOYE
ADDRESS: DEPT. OF EPIDEMIOLOGY & PUBLIC HEALTH, UNIVERSITY OF NOTTINGHAM UK.
DATE OF RECIEPT OF VALID APPLICATION: 27/01/2020
DATE OF APPROVAL: 28/01/2020

This is to inform you that the research described here in the submitted protocol, the consent forms, advertisements and other participant information materials have been reviewed and given full approval by the Health Research and Ethics Committee of LASUTH (LREC)

This approval dates from 28/01/2020 to 27/01/2021. If there is any delay in starting the Research, Please inform the HREC LASUTH so that the dates of approval can be adjusted accordingly. Note that no participant accrual or activity related to this research may be conducted outside of these dates. All informed consent forms used in this study must carry the HREC LASUTH assigned number and duration of HREC approval. In a multiyear research, endeavor to submit your annual report to the HREC early in order to obtain renewal of your approval and avoid disruption of your research.

THE NATIONAL CODE FOR HEALTH RESEARCH AND ETHICS(www.nhrec.net) REQUIRES YOU TO COMPLY WITH ALL INSTITUTIONAL GUIDELINES, RULES AND REGULATIONS AND WITH THE TENETS OF THE CODE INCLUDING ENSURING THAT ALL ADVERSE EVENTS ARE REPORTED PROMPTLY TO THE HREC. NO CHANGES ARE PERMITTED IN THE RESEARCH WITHOUT PRIOR APPROVAL BY HREC LASUTH EXCEPT IN CIRCUMSTANCES OUTLINED IN THE CODE.THE LREC RESERVES THE RIGHT TO CONDUCT COMPLIANCE VISIT TO YOUR RESEARCH SITE WITHOUT PREVIOUS NOTIFICATION.

DR. Y.A. KUYINU

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Chief Medical Director
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DR. I. A. MUSTAFA
MB.Ch.B, FWACS, FAO (TRAUMA)
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DR. Y. A. KUYINU
MB.BS, MPH, FMCPH
Ass. Prof. Public Health & Community Medicine
Chairman, LASUTH HREC
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