PREVALENCE AND CORRELATES OF OVERWEIGHT/OBESITY, PHYSICAL ACTIVITY, AND SEDENTARY BEHAVIOUR AMONG SCHOOL-AGED CHILDREN IN KENYA

By

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Thesis submitted to the Faculty of Graduate and Postdoctoral Studies

in partial fulfillment of the requirements for the PhD degree in Population Health

University of Ottawa

Ottawa, Ontario, Canada

May 2014

ABSTRACT

In recent years, physical activity and fitness transitions, described as declines in physical activity and aerobic fitness, coupled with increased sedentary behaviour, have been observed among school-aged children. Consequently, the prevalence of childhood overweight/obesity has also increased considerably. While there is a wealth of evidence supporting such behavioural transitions in higher income countries, there exists a paucity of data on the situation in lower income countries, such as those in Sub-Saharan Africa (SSA). The premise of this thesis was to investigate the robustness of these relationships in other global regions.

The first objective was to investigate the evidence for an overweight/obesity, physical activity, and fitness transition among SSA's school-aged children. Systematic review methodology was used to examine temporal trends and correlates of overweight/obesity, physical activity, fitness, and sedentary behaviour in apparently healthy or population based samples of children (5 - 17 years). The second objective of this thesis was to determine the prevalence and correlates of overweight/obesity and physical activity among Kenyan children aged 9 to 11 years, having contextualised Kenya within the broader situation in SSA. Further, the relationships between self-reported and directly assessed measures of physical activity and sedentary time by weight status in Kenyan children were investigated. The third objective was to examine moderate-to-vigorous physical activity (MVPA) patterns accrued by time of day among Kenyan children using the International Study of Childhood Obesity, Lifestyle and the Environment (ISCOLE)-Kenya data. Activity patterns in the Kenyan setting were then compared to similar ISCOLE-Canada data from Canadian children, revealing differences and similarities in the accumulation of MVPA, light physical activity, and sedentary time.

Systematic review data syntheses revealed a trend towards increasing proportions of overweight/obesity among Sub-Saharan Africa's school-aged children. Further, urbanization and higher socioeconomic status (SES) were associated with decreased physical activity and aerobic fitness, and increased sedentary behaviours and body composition measures. ISCOLE-Kenya data analyses found a prevalence of childhood overweight/obesity of 20.8% in Nairobi, with few children meeting global physical activity guidelines (12.6%). Mean daily sedentary time was 398 minutes, time spent in light physical activity was 463 minutes, and time spent in MVPA was 36 minutes. Higher SES and parental education attainment were associated with a higher likelihood of children being overweight/obese and a lower likelihood of children meeting the physical activity recommendations. Data analyses also revealed considerable discrepancies in both self-report and direct measures of physical activity by weight status, and weak to moderate correlations between self-report and direct measures of physical activity. Under/healthy weight children had significantly higher directly measured mean daily minutes of MVPA compared to overweight/obese children (39 verses 20 minutes); had lower mean weekend-day minutes of sedentary time (346 verses 365 minutes); and had a higher proportion who met physical activity guidelines (15.5% versus 2.6%). Lastly, while MVPA patterns among urban Kenyan children were largely similar to those of urban Canadian children with regard to relationships by sex, BMI category, and weekday/weekend days; in the Kenyan sample, much unlike many higher income countries, lower SES was associated with higher MVPA.

Key Words: Overweight/obesity, Physical Activity, Sedentary Behaviours, Physical Fitness, Behavioural Transitions, Accelerometry, Self-Report, Child, Sub-Saharan Africa, Kenya, Canada.

ACKNOWLEDGEMENTS

I would like to start by thanking all the school administrators, children, and families who participated in the ISCOLE-Kenya and the ISCOLE-Canada studies, for without them, this work would not have been accomplished. I would also like to thank the ISCOLE Coordinating Center staff at the Pennington Biomedical Research Center for overall study coordination and data management.

I was very fortunate to have Dr. Mark Tremblay as my thesis supervisor. Mark, you have been an amazing mentor to me. You saw my vision and what I desired to contribute to research, and helped me achieve it. You listened and advised but always allowed me to find my own way, you encouraged me to work harder, you continually provided great and prompt feedback on my manuscripts, and provided a good working environment for me. I am so eternally grateful to you. I would like to thank my thesis committee (Drs. Dafna Kohen and Joshua Ramisch) for their great feedback, support, and interest in my work. To my PhD in Population Health program, its administrators, and my cohort of fellow students, thank you for the immense learning and growing experience.

I would like to recognize and thank my collaborators and colleagues at the Children's Hospital of Eastern Ontario Research Institute in Ottawa, who significantly contributed to the development and completion of this thesis. It was an honour being around all you incredibly intelligent HALOites! To my other collaborators (Dr. Vincent Onywera and Lucy-Joy Wachira) and research assistants at Kenyatta University in Nairobi, who helped with various aspects of data collection and analysis, I thank you from the bottom of my heart.

To my parents, Jediel and Lucy Muthuri, "I am because you are". You are truly my inspiration to continually aim higher. Thank you for your never-ending love and support. To my siblings and friends, you who encouraged me through this journey, I thank you for being so generous with your time, prayers, and best wishes.

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ABBREVIATIONS

BMI - Body mass index

CDC - Centers for Disease Control and Prevention

CPM - Counts per minute

IOTF - International Obesity Task Force

ISCOLE - International Study of Childhood Obesity, Lifestyle and Environment

MVPA - Moderate-to-vigorous physical activity

NCDs - Non-communicable diseases

OW/OB - Overweight and obesity (overweight/obesity)

PA - Physical activity

SB - Sedentary behavior

SES - Socioeconomic status

SSA – Sub-Saharan Africa

WHO - World Health Organization

CHAPTER 1

1.1 General Introduction

Examination of a broad range of health determinants and the complexity of their interactions shows that populations are increasingly facing "modern risks" due to physical inactivity, overweight/obesity, and other behavioural transitions (1). This has in turn caused a shift in the major causes of death from "traditional risks" associated with poverty, such as under nutrition, unsafe water, and poor sanitation, to a growing burden of modifiable non-communicable diseases (NCDs), as shown in *Figure 1.1* (1). The World Health Organization (WHO) classifies physical inactivity and overweight/obesity as the fourth and fifth leading causes of global mortality, and two of the greatest health challenges and determinants for various chronic diseases such as heart disease, hypertension, diabetes, and psychosocial problems in the 21st century (1-6). In contrast, adequate participation in energy expending activities provides a wide spectrum of health benefits, including reductions in risk for a variety of diseases and improvements in functional ability (7, 8).

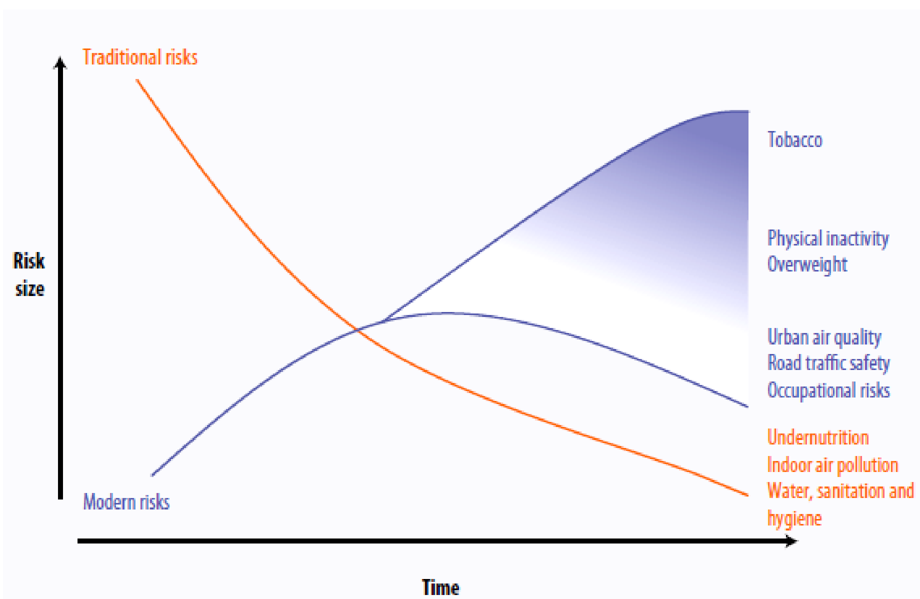

Figure 1.1: Risk Transition over time from Traditional to Modern Risks (WHO, 2004).

Physical inactivity and overweight/obesity are a particular problem in children due to the potential for long-term health concerns as highlighted by a large prospective cohort study in the United Kingdom which linked high body mass index in children 9 to 12 years of age to a higher likelihood of developing risk factors for cardiovascular disease in their adolescent years (9). Evidence has shown that overweight/obesity in childhood and adolescence is significantly associated with increased risk of incident severe obesity, physical morbidity, and premature mortality in adulthood (10, 11). However, children who were able to attain a normal weight by adolescence had better cardiovascular disease risk factor profiles when compared to those that remained overweight (9). Given that many lifelong diseases start in childhood, it is a crucial phase when basic life skills can be gained for their life course, including proper nutrition or how to accumulate sufficient levels of activity (12). Children are a vulnerable population, and measures ought to be taken to support them in attaining or preserving healthy and active living behaviours for their well being, particularly the right to enjoy regular physical activity and proper nutrition for the maintenance of health body weights (13). The WHO recommends that children and youth 5-17 years of age accumulate at least 60 minutes of daily moderate-to-vigorous intensity physical activity (MVPA) for positive health outcomes (14).

A growing body of evidence further revealed that sedentary behaviour, or low-energy expenditure activity, is associated with adverse health outcomes, which differ from those attributable to a lack of MVPA (15). The Canadian sedentary behaviour guidelines, the first ever evidence-based guidelines on sedentary behaviour, recommend that children of this age group should limit their recreational sedentary screen time to no more than 2 hours per day (16).

Given that much of the knowledge available on the influence of lifestyle behaviours on childhood overweight/obesity, physical activity, and sedentary behaviour is informed by studies conducted in North America and Europe (17, 18), there is a pressing need to determine the robustness of these relationships across all global regions (19). This is particularly crucial for many lower income countries such as Kenya, which are faced with an imminent double burden of both traditional and modern risks (20). While communicable diseases will remain the predominant health problem for the populations in Sub-Saharan Africa (SSA) in the coming years, there is growing concern about rapid increases in NCDs, particularly in urban areas (21). Decreased physical activity levels coupled with increased sedentarism, largely the result of modernization and greater access to technological advancements such as vehicles, as well as nutritional changes, such as increased consumption of high calorie foods, are thought to be the main contributors to the increasing prevalence of NCDs in SSA (22-26).

There is a lack of nationally representative data on the proportions and correlates of physical activity and overweight/obesity among Kenyan children; however, various studies have shown that there is emerging evidence of a physical inactivity and overweight/obesity threat in this population comparable to that in some higher income countries (27, 28, 29). The need for improved surveillance, particularly in the school-aged population, is crucial. Further, any interventions developed to tackle this growing concern will need to be socio-culturally, environmentally, and economically relevant to the Kenyan and Sub-Saharan populations in order to ensure uptake and sustainability since, for instance, while viewed negatively in the Western world, the socio-cultural belief in Kenya is that being overweight is an admired trait and seen as a sign of wealth and prestige (30).

1.2 The Conceptual Framework

Individual-level theories and models have been the dominant frameworks for research on various health outcomes; however, the exclusion of the ecological context fails to inform the inquirers about how the context may shape pertinent outcomes (31). Interventions based on these theories, such as those related solely to the psychological and social influences on individual behaviour may have led to a number of effective approaches, but are often fraught with considerable limitations including small to moderate effect sizes, modest recruitment rates, or poor maintenance (32). Conversely, epidemiological theories, driven by the biomedical sciences, often choose to exclude values, historical, and social context that make certain populations vulnerable (33). As a consequence, there is growing interest in socioecological theories and models, which offer a more productive framework for population health, since they incorporate people's interactions with their physical and socio-cultural surroundings, and are distinguished by their explicit inclusion of environmental and policy variables, which are expected to influence behaviour (32).

Socioecological models are particularly well suited for studying physical activity and related behaviours, because physical activity is done in different places (32). As shown in *Appendix A*, the socioecological model by Sallies et al. identifies potential environmental and policy influences on four main domains of active living, that is, **active recreation, active transport, occupational activities,** and **household activities**. Physical activity guidelines, guided by socioecological theory, provide age-specific recommendations on the appropriate health-protective amounts of physical activity for active living, a broader concept that incorporates exercise, active transportation, recreational, household, and occupational activities (16, 32).

Of particular interest in this thesis was the influence of intrapersonal factors (demographic and family level factors), the perceived environment (parental perceptions), neighbourhood factors, the school environment (the occupational domain for children), and the school policy environment, in promoting healthy active living behaviours among children. Findings from higher income countries have shown that individual and social characteristics (intrapersonal factors), parental or caregiver perceptions of the physical environment, and aspects of the school environment have an immense influence on children's overweight/obesity status and physical activity behaviours (34, 35). Positive parental perceptions of the neighborhood environment are associated with less screen time, more physical activity, and increased active transport such as walking or cycling to and from school or during leisure time (35, 36). Further, school environments and policies that encourage physical activity, healthy eating, and that discourage sedentary activities, are strongly associated with higher physical activity and fitness outcomes in students, habits that are continued in adult life (15, 34, 37-43).

1.3 Thesis Organization, Objectives, and Hypotheses

The main focus of this thesis was to examine the prevalence and correlates of overweight/obesity, physical activity, and sedentary behaviour among school-aged children in Kenya, after exploring the broader situation in SSA, and thereafter comparing activity patterns to those in Canada.

1.3.1 Systematic Reviews

The thesis was organized such that the **first phase** included two systematic reviews that would provide a synopsis of the trends and factors associated with overweight/obesity, physical activity, fitness, and sedentary behaviours among school-aged children and youth in SSA. The objective of the first review – included as ***Chapter 2*** of the thesis – was to determine if children in SSA are indeed undergoing an overweight/obesity transition. Specifically, this review aimed to examine time trends in the proportions of overweight/obesity among apparently healthy or population-based samples of school-aged children (5-17 years) living in SSA. The objective of the second systematic review – included as ***Chapter 3*** of the thesis – was to examine temporal trends and correlates of physical activity, sedentary behaviour, and physical fitness among school-aged children and youth in SSA. It was hypothesized that the results of these systematic reviews would provide evidence of an increasing prevalence of overweight/obesity and sedentarism, and a decline in physical activity and fitness levels in the region. The reviews would also help contextualise Kenyan findings with respect to the growing concern of childhood overweight/obesity and physical inactivity in SSA, while highlighting areas for further research, such as the subsequent phase of this project.

1.3.2 Primary Data Collection in Kenya

The **second phase** of the thesis comprised the bulk of the research project's work and included primary data collection in Kenya as part of a larger International Study of Childhood Obesity, Lifestyle and Environment (ISCOLE), conducted in 12 countries from the five major regions of the world including Africa, Eurasia, Latin America, North America and the Pacific. Data collection was conducted in the urban city of Nairobi, for ISCOLE-Kenya's assessments, following ethical approval from Kenyatta University (the local coordinating institution), the Nairobi City Council, and the National Council for Science and Technology. Ethical approval was also obtained from collaborating institutions in Canada including the University of Ottawa and the Children's Hospital of Eastern Ontario (CHEO). These approval letters are shown in *Appendices B to F*. The co-principal investigators for the ISCOLE-Kenya project were Drs. Mark Tremblay (University of Ottawa) and Vincent Onywera (Kenyatta

University). I, alongside other research staff, collected, entered, and cleaned up ISCOLE-Kenyan data.

Project recruitment targeted a sex-balanced sample of 500 boys and girls 9 – 11 years of age at the time of the assessment. Conservative sample size determinations were based on cross-sectional data analyses, and were driven by the relationship between physical activity and body mass index, which anticipates that dietary variables will be more strongly associated with body mass index than total calories (19). The sample size was estimated as the minimum number of schools with an average of 25 students per school, required with at least 90% power to detect significance at the 5% level for a predictor that independently contributes to, or explains 3% of the variability in body mass index (19). A design effect of 1.3 was also applied to account for student sampling in clusters by schools (19). To accommodate an estimated 20% failure to provide valid accelerometer data, the enrolment target was set at 570 students (19).

Data collection commenced at the beginning of the Kenyan school year in January 2012 and proceeded to the end of the school year in December 2012. Following school acceptance to participate, parental consent, and child assent, objective body composition and physical activity measures of participating children were accomplished by anthropometric assessment and accelerometry. Self- and proxy-report information was collected by administration of questionnaires related to diet and lifestyle, and the neighbourhood and school environment. All study documents that were sent to parents were translated from English to Swahili to allow them a choice of either language. Confidentiality of participant data was enhanced by the use of unique identifiers for each child on all forms and in the study database. A secure list of linked subject identifiers and personal information was stored separately. Further, all participant data were entered into an encrypted web-based study interface to ensure that data were protected at all times (19). Full details of the ISCOLE study protocol, measurements, and questionnaires are provided elsewhere (19).

The objective of the first ISCOLE-Kenya manuscript – included as ***Chapter 4*** of the thesis – was to describe the proportions of overweight/obesity, children meeting the WHO physical activity guidelines, and time spent at various levels of movement intensity based on cut-points corresponding to sedentary, light, moderate, and vigorous physical activity in children recruited from public and private schools in Nairobi. Data analysis also sought to investigate the relationships between overweight/obesity or physical activity and factors at the individual, parental, household, neighbourhood, and school environment levels. It was hypothesised that the results of this study would show further evidence of an emerging overweight/obesity and inadequate physical activity threat in school-aged children in Kenya, while also providing new evidence of correlates of these outcomes in Kenya. Further, it was envisaged that this ISCOLE-Kenya study may serve as a model for a nationally representative survey.

The objective of the second ISCOLE-Kenya study – included as ***Chapter 5*** of the thesis – was to investigate the relationships between self-reported (questionnaire-based) and directly assessed (accelerometry) measures of physical activity and sedentary behaviours, by weight status, in school-aged children recruited from the city of Nairobi in Kenya. Given that previous work, largely informed by studies conducted in high income countries, has shown little association between self-report and directly measured physical activity (44-47), it was important to investigate whether a similar reporting bias existed in developing countries such as Kenya. It was hypothesised that the results of this study would reveal a similar but perhaps less pronounced bias between self-report and directly measured physical activity and sedentary behaviour.

1.3.3 Kenyan-Canadian Comparative Data Analysis

The **third phase** of the thesis included a comparative assessment of activity patterns in the Kenyan setting, with comparable data collected in Canada. ISCOLE-Kenyan data was compared to ISCOLE-Canadian data collected in the Ottawa Region, whereby recruitment was conducted from schools stratified into four groups with proportional representation among English Public, French Public, English Catholic, and French Catholic schools. The objective of this study – included as ***Chapter 6*** of the thesis – was to examine the levels of MVPA accrued by time of day among Kenyan children, by sex, BMI category, type of school (an indicator of SES), and on weekdays compared to weekend-days. Thereafter, activity patterns in the Kenyan setting were compared to patterns in the Canadian setting, in order to investigate the similarities or differences in accumulation of moderate-to-vigorous physical activity, light physical activity, and sedentary time among school-aged children, by time of day and on weekdays/weekend-days. It was hypothesized that the estimates MVPA in the Kenyan setting would be higher than those of Canadian children, but that the difference in the results of these urban samples between the two countries would not be pronounced.

Bridging of the manuscripts was included as ***Chapter 7*** of the thesis, while ***Chapter 8*** offers a brief description of various dissemination activities that arose from this work. More generally, the premise was that the information gained within the scope of this project would serve to promote collaboration in surveillance and dissemination efforts, and innovative thinking among researchers as they attempt to address the population health problems caused by childhood overweight/obesity, physical inactivity, and other related factors, such that interventions and strategies developed to curb the potential health consequences are effective.

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CHAPTER 2

Evidence of an Overweight/Obesity Transition among School-Aged Children and Youth in Sub-Saharan Africa: A Systematic Review

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Formatted for submission to: PLOS ONE in July 2013 [**Current Status:** Published].

The objective(s): Transitions to higher proportions of overweight/obesity – referred to as an overweight/obesity transition – are well documented in higher income countries, but not in lower income countries such as those comprising Sub-Saharan Africa (SSA). This systematic review was conducted in order to examine the evidence for an overweight/obesity transition among children in SSA. This was achieved by the investigation of time trends in the proportions of overweight/obesity among healthy samples of school-aged children, 5 to 17 years of age. Correlates of overweight/obesity were also examined for children and youth in this region.

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Evidence of an Overweight/Obesity Transition among School-Aged Children and Youth in Sub-Saharan Africa: A Systematic Review

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Abstract

Background: Prevalence of childhood overweight/obesity has increased considerably in recent years. The transition to higher rates of overweight/obesity has been well documented in high income countries; however, consistent or representative data from lower income countries is scarce. It is therefore pertinent to assess if rates of overweight/obesity are also increasing in lower income countries, to inform public health efforts.

Objective: This systematic review aimed to investigate the evidence for an overweight/obesity transition occurring in school-aged children and youth in Sub Saharan Africa.

Methods: Studies were identified by searching the MEDLINE, Embase, Africa Index Medicus, Global Health, Geobase, and EPPI-Centre electronic databases. Studies that used subjective or objective metrics to assess body composition in apparently healthy or population-based samples of children and youth aged 5 to 17 years were included.

Results: A total of 283 articles met the inclusion criteria, and of these, 68 were used for quantitative synthesis. The four regions (West, Central, East, and South) of Sub Saharan Africa were well represented, though only 11 (3.9%) studies were nationally representative. Quantitative synthesis revealed a trend towards increasing proportions of overweight/obesity over time in school-aged children in this region, as well as a persistent problem of underweight. Weighted averages of overweight/obesity and obesity for the entire time period captured were 10.6% and 2.5% respectively. Body composition measures were found to be higher in girls than boys, and higher in urban living and higher socioeconomic status children compared to rural populations or those of lower socioeconomic status.

Conclusions: This review provides evidence for an overweight/obesity transition in school-aged children in Sub Saharan Africa. The findings of this review serve to describe the region with respect to the growing concern of childhood overweight/obesity, highlight research gaps, and inform interventions.

PROSPERO Registration Number: CRD42013004399

Citation: Muthuri SK, Francis CE, Wachira L-JM, LeBlanc AG, Sampson M, et al. (2014) Evidence of an Overweight/Obesity Transition among School-Aged Children and Youth in Sub-Saharan Africa: A Systematic Review. PLoS ONE 9(3): e92846. doi:10.1371/journal.pone.0092846

Editor: Kaberi Dasgupta, McGill University, Canada

Received August 11, 2013; **Accepted** February 27, 2014; **Published** March 27, 2014

Funding: The authors have no support or funding to report.

Competing Interests: The authors have declared that no competing interests exist.

Introduction

Worldwide populations are facing "modern" health risks due to increasing prevalence of overweight and obesity (overweight/obesity), physical inactivity, and sedentary behaviours, which are associated with obesogenic environments. This has caused a shift in the major causes of death from "traditional" health risks associated with poverty such as undernutrition, unsafe water, and poor sanitation, to a growing burden of modifiable non-communicable diseases (NCDs) [1]. The World Health Organization (WHO) classifies overweight/obesity as the fifth leading cause of global mortality, and one of the greatest health challenges and determinants for various chronic diseases such as heart disease, hypertension, diabetes, and psychosocial problems, in the 21st century [1,2–6]. This growing population health threat has garnered much attention in view of the declaration and global campaign on the prevention and control of NCDs signed by the United Nations in 2011 [7].

While the health benefits of maintaining healthy body weights and an active lifestyle are well established [6], consumption of calorie-dense foods, declines in habitual physical activity, and increases in sedentary behaviour have been on the rise across developing nations [8]. Traditional practices such as walking long distances, and habitual physical labour have been replaced by motorized transport, and sedentary activities, particularly in urban settings [9]. Furthermore, in many Sub Saharan Africa (SSA) countries, an increased level of body fat is associated with beauty, prosperity, health, and prestige, while in contrast, thinness is perceived to be a sign of ill health or poverty [9]. These factors are now leading to increases in the occurrence of overweight/obesity and related risk factors for NCDs in SSA's children and youth [1,9].

The health risks associated with overweight/obesity are particularly problematic in children due to the potential for long-term health concerns. A growing body of evidence has shown that overweight/obesity in childhood is significantly associated with increased risk of obesity, physical morbidity, and premature mortality in adulthood [10,11,12]. Fortunately, children who are able to attain a normal weight by adolescence have better cardiovascular disease risk factor profiles when compared to those that remain overweight [10]. Childhood is therefore a crucial time to learn basic life skills, including proper nutrition, and how to accumulate sufficient levels of activity in order to attain healthy body weights.

While we must recognise the diversity of populations in SSA, there are certain long-term developmental problems in this region that tend to adversely affect most or all of its countries and peoples [13]. Being the poorest continent in the world, with the highest population growth rate, the concern for an immense double burden of disease due to persistent infectious diseases and modern risks such as an overweight/obesity transition is troubling. The need for population wide interventions to reduce or prevent the adoption of less healthy lifestyles and body weights, particularly for children in SSA has never been greater [9,14].

The objective of this systematic review was to determine if SSA is indeed undergoing an overweight/obesity transition. Specifically, this review aimed to examine time trends in the proportions of overweight/obesity in school-aged children and youth in SSA, thereby highlighting any research gaps and identifying areas of need for healthy active living interventions.

Methods

Study inclusion criteria

Studies were included if they reported using either subjective (e.g., parent or self-report questionnaires) or objective (e.g., directly measured) measures of body composition (weight, height, body mass index, waist/hip circumference, skin-folds, or body image assessment) in children aged 5–17 years. No date or language limits were set, but due to feasibility, only studies presented in either English or French were included. In addition, only studies of populations from SSA countries were included.

Study exclusion criteria

All published, peer-reviewed studies were eligible for inclusion; however, in order to obtain information on a general population living under ordinary conditions, intervention programs and studies were excluded unless they conducted baseline assessments. Studies done on children with chronic conditions were excluded.

Search strategy

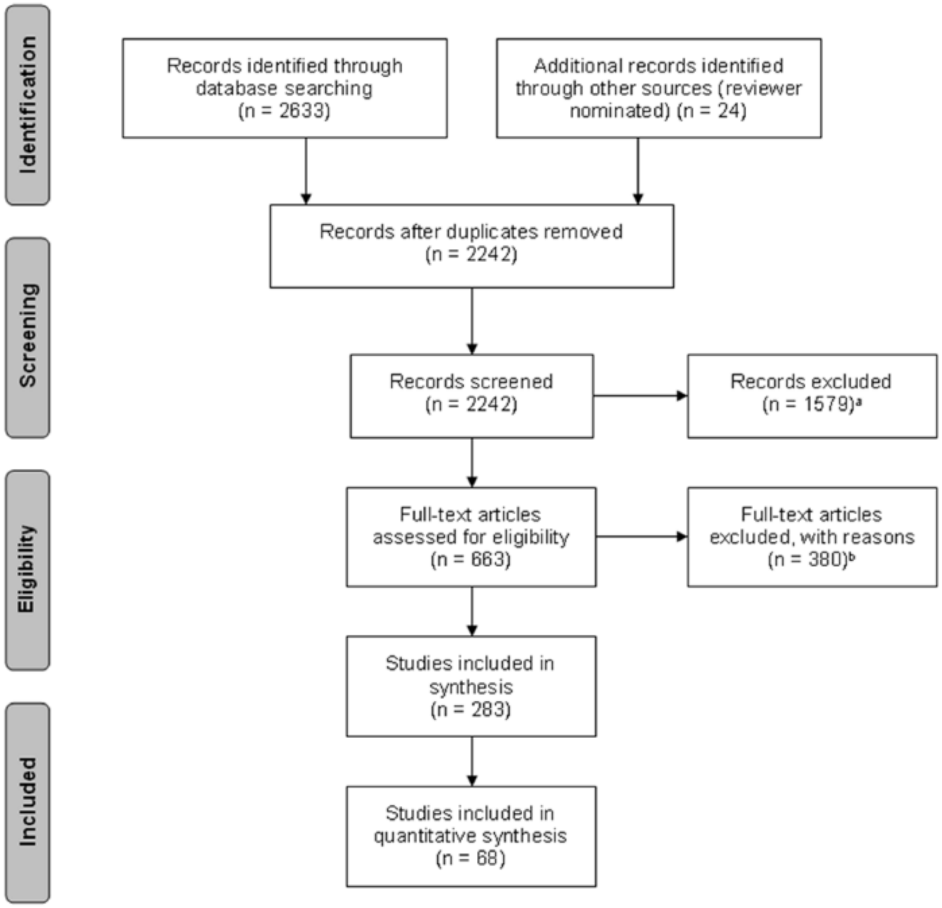
Studies were identified using the following electronic databases: Ovid MEDLINE (1948 to May, Week 4, 2013), Ovid Embase (1974 to Week 21, 2013), Africa Index Medicus (database dates not available, latest search on June 3, 2013), Global Health (1973 to June 3, 2013, through the CAB direct interface), Geobase (1884-June 3, 2013 through the Engineering Village interface), and EPPI-Centre database of health promotion research (Bibliomap) (dates of coverage not available, latest search on June 3, 2013). In addition, several open access journals relevant to SSA were identified and those journal web sites were searched for additional relevant papers. The search strategy for this systematic review was completed in tandem with a sister publication examining the evidence for a physical activity, sedentary behaviour, and physical fitness transition among school-age children and youth in SSA; hence, the inclusion of these terms in the search strategy. The search strategy was created and run by MS. The complete search strategy used for MEDLINE is presented in *table 1*. The PRISMA flow chart in *figure 1* accounts for the number of articles included to inform this systematic review. References were exported, de-duplicated and reviewed using Reference Manager Software (Version 11, Thompson Reuters, San Francisco, CA). Titles and abstracts of potentially relevant articles were screened by two independent reviewers (SKM and one of CEF or LJW), and full text copies were obtained for articles meeting initial screening criteria. Full text articles were screened in duplicate for inclusion in the review (SKM and one of CEF or LJW), and any discrepancies were discussed and resolved by the reviewers. This review is registered with the international prospective register of systematic reviews PROSPERO network (registration number: CRD42013004399); available at http://www.crd.york.ac.uk/prospero/.

Data extraction, quality assessment, and synthesis

Data extraction was completed using a standardized data extraction template (SKM, CEF, AGL, and LJW). Study quality was assessed by SKM and CEF using a modified Downs and Black instrument [15]. Due to limitations in study design, questions selected from the Downs and Black quality assessment instrument excluded any questions that referred to intervention and trial study methodology. Ten out of the possible 27 questions were used for quality assessment as represented in *table 2*. *Table 3* provides the score out of ten for all studies included in this systematic review. Due to heterogeneity in study methodology and cut-points used to categorize samples into under, healthy, overweight, and obese, we were unable to carry out a meta-analysis in this review. However, quantitative syntheses were conducted by calculating the weighted averages (by sample size) of the prevalence of overweight/obesity. Our goal was to examine time trends and thereafter compute an overall prevalence of overweight/obesity in the region, by comparing the crude rates or prevalence of overweight/obesity in the individual populations or samples. As such, we attempted to standardize the crude rates by acknowledging and adjusting with respect to the sample sizes in each of the included studies, and indicating graphically the sample size upon which a particular data point was based. Findings from the quantitative synthesis were also complemented with narrative syntheses of the included studies.

Results

Figure 1 shows the PRISMA flow chart with numbers of included and excluded articles at each step of the review process, while *table 3* provides a summary of all studies that met the inclusion criteria. A total of 2657 records were identified through database searches and other sources. Following de-duplication, 2242 articles were screened for eligibility, and 663 articles were selected for a full-text review. Of these, 283 articles met the inclusion criteria, and 68 of the studies (comprising 190,149 participants) were used in quantitative synthesis. Reasons for exclusion included: ineligible population (e.g., studies that did not involve children 5–17 years of age with no pre-existing condition) (n = 181); ineligible country (e.g., population living in a country/region outside of SSA) (10); ineligible outcome (n = 122); or ineligible study design (n = 67). It is important to note that all the studies included in this review were



[a] Includes 6 studies whose full text articles could not be located.
[b] Reasons for exclusion included irrelevant population (181 studies), irrelevant geographic location/not Sub Saharan Africa (10 studies), irrelevant outcomes (122 studies), and irrelevant content/study design e.g. intervention programs or review articles (67 studies).
[c] Includes 25 articles that used participant data from the same study presented in another included manuscript.

Figure 1. PRISMA flow chart of search strategy results.
doi:10.1371/journal.pone.0092846.g001

found to have used objective methods of collecting body composition data.

Regional representation

As shown in *table 3*, which includes a summary of the 283 studies included in the review, the four regions of SSA were well represented, with 91 (32.1%) from West African countries - with Nigeria represented in 60 of these records; 7 (2.5%) from Central African countries; 75 (26.5%) from East African countries - with Kenya represented in 28 of these records; 108 (38.2%) from South African countries - with South Africa represented in 102 of these records; and 2 (0.7%) that were East and West combined. In total, 27 countries were captured in this review.

Publication rate

The earliest relevant record captured was published in 1964. There was a marked increase in the publishing rate from the earliest to the current studies: 5 articles between 1960 and 1969, 15 from 1970–1979, 32 from 1980–1989, 31 from 1990–1999, 92 from 2000–2009, and 108 articles from 2010 to May/June 2013.

Data quality assessment

The average modified Downs and Black score out of ten for all studies included in this systematic review was 7.4; indicative that data quality was fairly high among the included records, within the prescribed limitations of study designs included in this review. The majority of studies used in the quantitative synthesis scored 7 or higher. As presented in *table 3*, the scoring process further revealed that only 38 (13.4%) of 283 included articles *targeted* a sample that was representative of their population of interest, and 31 (11.0%) *recruited* a sample that was representative of their population of interest. Only 11 (3.9%) articles explicitly mentioned using a nationally representative sample, one of which used the same study sample as that of another already included study.

Table 1. MEDLINE search strategy; Ovid interface.

1	exp "Africa South of the Sahara"/
2	(sub-sahar* or east afric* or south afric* or keny* or (south adj3 sahar*)).mp.
3	1 or 2
4	sedentar$.tw.
5	Sedentary Lifestyle/
6	((chair or sitting or car or automobile or auto or bus or indoor or in-door or screen or computer) adj time).tw.
7	low energy expenditure.tw.
8	(computer game* or video game* or ((television adj watch*) or tv watch*)).tw.
9	television/or computers/or video games/
10	(screen based entertainment or screen-based entertainment or screen time).tw.
11	physical inactivit*.tw.
12	bed rest.mp.
13	sitting.tw.
14	exp obesity/
15	(obesit* or obese).tw.
16	exp overweight/
17	(overweight or over weight).tw.
18	exp Body Fat Distribution/
19	exp body composition/
20	Waist Circumference/
21	waist circumference.tw.
22	Skinfold Thickness/
23	(skin folds or skin fold*).tw.
24	(body composition* or BMI or body mass index).tw.
25	exp "body weights and measures"/
26	(bio-impedance analysis or BIA).tw.
27	Absorptiometry, Photon/
28	(absorptiometery or densitometry or photodensitometry or DXA or DEXA).tw.
29	Physical Fitness/
30	(physical conditioning or physical fitness).tw.
31	musculoskeletal fitness.tw.
32	physical endurance/
33	cardiovascular fitness.tw.
34	motor activit$.tw.
35	physical exertion/
36	aerobic exercise.tw.
37	exp sports/
38	play/
39	exp physical education/
40	musculoskeletal physiological processes/or exercise/or movement/or locomotion/or running/or swimming/or walking/or motor activity/
41	or/4-40
42	(child* or adolescent* or youth* or pediatric* or paediatric*).tw.
43	3 and 41 and 42

Note: The search strategy for this systematic review was completed in tandem with a sister publication examining the evidence for a physical activity, sedentary behaviour, and physical fitness transition among school-age children and youth in Sub Saharan Africa; hence, the inclusion of these terms in the search strategy.
doi:10.1371/journal.pone.0092846.t001

Body composition measures

Of the 283 included studies, 88 (31.1%) articles [16–103] reported on mean BMI, BMI-z-score, and/or weight z-scores of the sample population, 50 (17.7%) articles [104–153] reported on body fat percentage, waist circumference, skin fold measures, and/or weight and height measures, and a total of 30 (10.6%) articles [154–183] reported finding no prevalence of overweight/obesity in their study samples. Of the remaining 115 (40.6%) records, 82

Table 2. Modified Downs and Black checklist (Downs & Black, 1998).

Reporting	
Objective Clearly Stated	Question 1 from full checklist (Y = 1/N = 0)
Main Outcomes Clearly Described	Question 2 (Y = 1/N = 0)
Patient Characteristics Clearly Defined	Question 3 (Y = 1/N = 0)
Main Findings Clearly Defined	Question 6 (Y = 1/N = 0)
Random Variability in Estimates Provided	Question 7 (Y = 1/N = 0)
Actual Probability Values Reported	Question 10 (Y = 1/N = 0)
External Validity	
Sample Targeted Representative of Population	Question 11 (Y = 1/N = 0)
Sample Recruited Representative of Population	Question 12 (Y = 1/N = 0)
Internal Validity/Bias	
Statistical Tests Used Appropriately	Question 18 (Y = 1/N = 0)
Primary Outcomes Valid/Reliable	Question 20 (Y = 1/N = 0)

doi:10.1371/journal.pone.0092846.t002

articles [184–265] used the more widely accepted international cut-points (namely, the International Obesity Task Force (IOTF), the Centers for Disease Control and Prevention (CDC), and the most recent WHO cut-points) to further categorize their samples into underweight, normal-weight, and overweight/obese. The other 33 articles [266–298] mentioned using one of a number of other cut-points and reference standard groups including but not limited to Tanner et al., 1966, Seoane & Latham, 1971, Frisancho 1990, Rosner et al., 1998, Harvard Standards, Waterlow 1972/77, and various US and UK reference samples. Of the 30 studies reporting no prevalence of overweight/obesity, a majority had not used the more widely accepted international cut-points, while the reminder did not provide the required prevalence estimates to be included in the quantitative synthesis.

Quantitative synthesis

Of the 82 articles that used more widely accepted international cut-points, 11 studies [187,191,192,198,206,215,224,225,234, 246,265] were removed due to having an identical study sample as an already included study, and 3 studies [214,218,264] were removed for having not indicated the sample sizes in the age range of interest. As represented in *table 4*, the remaining 68 (24.0%) articles [184–186,188–190,193–197,199–205,207–213,216,217, 219–223,226–233,235–245,247–263] were used in quantitative synthesis. Of these, the largest proportion (44.1%) used the IOTF cut-points [299], 30.9% used CDC cut-points [300], and 25.0% used the most recent WHO cut-points [301] for weight status. Briefly, the IOTF methodology involved obtaining the body mass index for children from six large nationally representative cross sectional surveys on growth from Brazil, Great Britain, Hong Kong, the Netherlands, Singapore, and the United States. Thereafter, centile curves for body mass index were constructed for each dataset by sex, and passed though the widely used cut off points of 25 and 30 kg/m2 for adult overweight and obesity at age 18 years. The resulting curves were averaged to provide age and sex specific cut off points for children 2–18 years of age [299]. In the case of the CDC cut-points, growth charts were developed based on data from five national health examination surveys conducted in the United States, including limited supplemental data. Smoothed percentile curves were created by first smoothing selected empirical percentiles, then creating parameters obtain the final curves, additional percentiles, and z-scores [300]. Finally, the WHO cut-points were developed after data from the 1977 National Center for Health Statistics (NCHS)/WHO growth reference for 1–24 years, were merged with data from the under-fives growth standards' cross-sectional sample to smooth the transition between the two samples. The new curves filled the gap in growth curves and provided an appropriate reference for the 5 to 19 years age group [301].

Figure 2 shows a distinctive time trend towards increasing proportions of overweight/obesity in school-aged children in SSA. The figure also shows a similar but less prominent trend towards increasing proportions of obesity over time. *Figure 3*, shows increasing trends in proportions of overweight/obesity over time for both boys and girls; however, the proportions are consistently higher in girls than in boys. To determine the robustness of these findings, we examined the trends in overweight/obesity over time using the few studies that indicated having recruited a representative sample of the population. We similarly found a trend towards increasing proportions of overweight/obesity among school-aged children in this region. The findings were also similar when boys and girls were assessed separately. While not the focus of this manuscript, as shown in *Figure 4*, we also examined trends in underweight over time for the included studies that had also reported this proportion. We found a trend towards decreasing proportions of underweight over time in boys, a trend towards increasing proportions over time in girls, and a largely unaltered trend over time - at approximately 20% - when boys and girls were considered together.

The weighted averages (for the entire time period and all studies included in the quantitative analysis) of overweight/obesity proportions in boys and girls were calculated as 7.6% and 15.4% respectively. Weighted averages of obesity alone for boys and girls were 2.0% and 3.9% respectively. Weighted averages of overweight/obesity and obesity proportions for boys and girls combined were 10.6% and 2.5%. Weighted proportion of underweight was calculated as 25.0% for boys, 8.3% for girls, and 17.6% for boys and girls combined.

Narrative synthesis

Narrative descriptions of the relationship between body composition and age, sex, socioeconomic status (SES), and urban/rural differences are discussed below based largely on the studies not included in the quantitative synthesis:

Table 3. Descriptive characteristics of included studies.

First Author	Year	Study Design	Country	Sample Size	Age Range (Years)	Body Composition Measure or Categorization System	D&B Score
Prinsloo [104]	1964	Cross sectional	South Africa	261	5–6	Weight, height	7
Sloan [105]	1967	Cross sectional	South Africa	393	15–17	Weight, height	7
Smit [106]	1967	Cross sectional	South Africa	2250	6–15	Weight, height, skin fold measures	7
Leary [107]	1969	Cross sectional	South Africa	301	7–15	Weight, height	7
Areskog [108]	1969	Cross sectional	Ethiopia	153	9–14	Weight, height, skin fold measures	7
Fisher [109]	1970	Cross sectional	Zambia	195	7–16	Weight, height	7
Davies [266]	1971	Cross sectional	Rhodesia (now Zimbabwe)	252	7–15	Harvard standards	7
Davies [111]	1973	Cross sectional	Tanzania	141	7–17	Weight, height	7
Davies [110]	1974	Cross sectional	Tanzania	1038	7–16	Weight, height	7
Walker [112]	1974	Cross sectional	South Africa	400	16–17	Weight, height	5
Margo [268]	1976	Cross sectional	South Africa	195	5–16	None OW/OB	7
Booyens [113]	1977	Cross sectional	South Africa	488	6–7	Weight, height	6
Richardson [267]	1977	Cross sectional	South Africa	804	17	Harvard standards	7
Richardson [270]	1977	Cross sectional	South Africa	6598	7–17	None OW/OB	6
Richardson [271]	1977	Cross sectional	South Africa	4655	7, 12 and 17	None OW/OB	7
van Rensburg [272][a]	1977	Cross sectional	South Africa	488	6–7	None OW/OB	6
Clegg [114]	1978	Cross sectional	Ethiopia	203	5–16	Weight, height	6
Coovadia [269]	1978	Cross sectional	South Africa	5743	5–12	Weight, height	3
Walker [273]	1978	Cross sectional	South Africa	705	10–12	None OW/OB	7
Sukkar [274][a]	1979	Cross sectional	Sudan	855	5–13	Tanner et al., 1966	7
Haller [154]	1980	Cross sectional	Côte d'Ivoire	430	5–15	None OW/OB	6
Walker [115]	1980	Cross sectional	South Africa	1240	16–17	Weight, height	7
Grassivaro [116][b,c]	1980	Cross sectional	Somalia	1206	6–17	Weight, height	9
Rao [117][b]	1981	Cross sectional	Zambia	2487	5–17	Weight, height	7
Carswell [275]	1981	Cross sectional	Tanzania	238	10–14	Tanner et al., 1966	6
Singer [118]	1981	Cross sectional	Namibia	306	5–17	Weight, height	7
Oyemade [276]	1981	Cross sectional	Nigeria	353	6–14	None OW/OB	7
Griffin [277]	1982	Cross sectional	Kenya	109	7–13	Other NCHS based system	7
Nnanyelugo [155]	1982	Cross sectional	Nigeria	1347	6–15	Weight, height	7
Kulin [119]	1982	Cross sectional	Kenya	656	10–17	Weight, height	7
Sukkar [278]	1982	Mixed	Sudan	1864	5–14	Harvard standards	7
Power [279][b,c]	1982	Cross sectional	South Africa	790	6–8	Other NCHS based system	9
Richardson [280][b,c]	1983	Cross sectional	South Africa	1337	8, 11, 14, and 17	Harvard standards	9
Akesode [281]	1983	Cross sectional	Nigeria	394	6–17	Other categorization system	7
Little [120]	1983	Cross sectional	Kenya	265	5–17	Weight, height	7

Table 3. Cont.

First Author	Year	Study Design	Country	Sample Size	Age Range (Years)	Body Composition Measure or Categorization System	D&B Score
Ng'andu [282]	1984	Cross sectional	Zambia	374	7–14	Other WHO based system	6
Rekart [121]	1985	Cross sectional	Sudan	227	13–17	Weight, height	6
Stephenson [122]	1985	Cross sectional	Kenya	12	7–15	Weight, height, skin fold measures	7
Ndamba [123]	1986	Cross sectional	Zimbabwe	147	8–15	Weight, height	7
Ogunranti [124]	1986	Cross sectional	Nigeria	1165	5–12	Weight	7
Corlett [125]	1986	Cross sectional	Botswana	721	6–14	Weight, height	7
Adams-Campbell [126]	1987	Cross sectional	Nigeria	254	6–17	BMI	7
Wagstaff [243]	1987	Longitudinal	South Africa	864	5–14	NCHS reference	6
Villiers [244]	1987	Cross sectional	South Africa	375	10–17	NCHS reference	7
Ogunranti [127]	1987	Cross sectional	Nigeria	600	5–10	Mid upper arm circumference	5
Corlett [128]	1988	Cross sectional	Botswana	612	7–12	Weight, height	7
Corlett [129]	1988	Cross sectional	Botswana	483	7–14	Weight, height	7
Adeniran [130]	1988	Cross sectional	Nigeria	18	13–17	Weight, height, body fat %	7
Adeniran [131]	1988	Cross sectional	Nigeria	23	13–17	Weight, height, body fat %	7
Jacobs [283]	1988	Cross sectional	South Africa	430	5–10	Other NCHS based system	6
Sigman [16]	1989	Longitudinal	Kenya	138	7 and 8	Weight z-scores	7
Prazuck [132][b,c]	1989	Cross sectional	Mali	844	15–17	Weight, height	9
Ekpo [17]	1990	Cross sectional	Nigeria	1552	5–16	BMI	6
Walker [284][b,c]	1991	Cross sectional	South Africa	1015	14–17	Other NCHS based system	7
Neumann [18]	1992	Cross sectional	Kenya	133	7–9	Weight, height	7
Ng'andu [133]	1992	Cross sectional	Zambia	372	7–16	BMI	7
Benefice [19]	1992	Cross sectional	Senegal	100	9–14	BMI	7
Goduka [134]	1992	Cross sectional	South Africa	300	5–6	Weight, height	7
Adams-Campbell [20]	1992	Longitudinal	Nigeria	208	6–17	Skin fold measures	7
Williams [21]	1992	Cross sectional	Kenya and Nigeria	350	10–15	BMI	6
Ng'andu [285]	1992	Cross sectional	Zambia	800	12–17	Nominal/adjusted classification system	7
Oli [135]	1994	Cross sectional	Ethiopia	1850	7–14	Weight, height	7
McDonald [22]	1994	Longitudinal	Kenya	138	7–8	Weight z-scores	8
Lawless [23]	1994	Longitudinal	Kenya	86	6–11	Weight z-scores	7
Mabrouk [136]	1995	Cross sectional	Sudan	400	7–12	Weight, height	7
Dufetel [137]	1995	Cross sectional	Senegal	72	8–14	Weight, height	7
Walker [156][b,c]	1996	Cross sectional	Nigeria	1192	6–12	None OW/OB	8
Proctor [24]	1996	Cross sectional	Cameroon	119	9–14	BMI	7
Benefice [25]	1996	Cross sectional	Senegal	348	5–13	Weight, height, skin fold measures	7
Pettifor [26]	1997	Cross sectional	South Africa	651	6–17	BMI z-scores	8

Table 3. Cont.

First Author	Year	Study Design	Country	Sample Size	Age Range (Years)	Body Composition Measure or Categorization System	D&B Score
Brabin [138]	1997	Cross sectional	Nigeria	914	14–17	Weight, height	7
Cole [286]	1997	Cross sectional	Nigeria	22	11–17	Ketz 1990 system	7
Owa [287]	1997	Cross sectional	Nigeria	904	5–15	US reference sample	8
Longo-Mbenza [27]	1998	Cross sectional	Zaire (now Democratic Republic of Congo - DRC)	4848	5–16	BMI	6
Benefice [157]	1998	Cross sectional	Senegal	348	5–13	None OW/OB	7
Prista [158]	1998	Cross sectional	Mozambique	593	8–15	None OW/OB	8
Benefice [28]	1999	Cross sectional	Senegal	221	12–13	BMI	8
Oelofse [159]	1999	Cross sectional	South Africa	131	5–11	None OW/OB	6
Levitt [29]	1999	Prospective Cohort Study	South Africa	818	5	BMI	7
Monyeki [245]	1999	Cross sectional	South Africa	1149	5–10	NCHS reference	8
Nyirongo [160]	1999	Cross sectional	Zimbabwe	930	5–16	None OW/OB	8
Akinkugbe [139]	1999	Cross sectional	Nigeria	1076	11–15	Weight, height	8
Sellen [30][a]	1999	Cross sectional	Tanzania & Kenya	234	5–17	BMI	7
Hamidu [140]	2000	Cross sectional	Nigeria	1712	5–16	Weight, height	7
Sellen [288]	2000	Cross sectional	Tanzania	169	5–12	Seoane & Latham 1971	8
Dibba [141]	2000	Cross sectional	Gambia	160	8–11	Weight, height	8
Zverev [161]	2001	Cross sectional	Malawi	493	6–17	None OW/OB	7
Garnier [31]	2001	Cross sectional	Senegal	80	13–15	BMI	8
Benefice [32][a]	2001	Cross sectional	Senegal	40	13	BMI	8
Benefice [33][a]	2001	Cross sectional	Senegal	40	13	BMI	8
Jinabhai [246][a]	2001	Cross sectional	South Africa	579	8–10	NCHS reference	7
Beasley [162]	2002	Cross sectional	Chad	1024	6–15	None OW/OB	7
Pawloski [34]	2002	Cross sectional	Mali	1056	10–17	Weight z-scores	7
Perzanowski [142]	2002	Cross sectional	Kenya	265	8–15	Weight, height, body fat %	6
Underhay [187][a,b]	2002	Cross sectional	South Africa	1242	10–15	IOTF categories	9
Bhargava [35]	2003	Longitudinal	Kenya	100	6–9	BMI	6
Eckhardt [36]	2003	Cross sectional	South Africa	86	6–16	BMI	7
Garnier [37]	2003	Cross sectional	Senegal	331	14–16	Weight z-scores	8
Grillenberger [38]	2003	Cross sectional	Kenya	110	7	Weight z-scores	7
Mabalia-Babela [289]	2003	Cross sectional	DRC	1087	6–13	BMI percentiles per Rolland-Cachera 1994	8
Mukundi [163]	2003	Cross sectional	Kenya	851	10–17	None OW/OB	7
Prista [247]	2003	Cross sectional	Mozambique	2316	6–17	NCHS reference	8
Leman [39]	2003	Cross sectional	Nigeria	39	5–8	BMI	7
Jinabhai [184][b,c,d]	2003	Cross sectional	South Africa	29535	8–11	WHO and IOTF categories	9

Table 3. Cont.

First Author	Year	Study Design	Country	Sample Size	Age Range (Years)	Body Composition Measure or Categorization System	D&B Score
Schutte [40][a,b]	2003	Cross sectional	South Africa	1244	10–15	BMI	9
Gray [143]	2004	Cross sectional	Kenya	183	5–16	Weight, height	7
Micklesfield [290]	2004	Cross sectional	South Africa	198	7–11	US reference sample	7
Larsen [41]	2004	Cross sectional	Kenya	11	15–17	BMI	7
Benefice [188]	2004	Cross sectional	Senegal	507	16	IOTF categories	6
Benefice [42]	2004	Cross sectional	Senegal	40	13–15	Weight z-scores	7
Monyeki [43]	2004	Longitudinal	South Africa	85	7	BMI	8
McVeigh [44][a]	2004	Cross sectional	South Africa	386	9	BMI	7
Cameron [144][a]	2004	Cross sectional	South Africa	214	9	Body fat %	7
Mukuddem-Petersen [164][a,b]	2004	Cross sectional	South Africa	1257	10–15	None OW/OB	9
Prista [45]	2005	Cross sectional	Mozambique	2271	16–17	BMI	8
Agyemang [189][b,c]	2005	Cross sectional	Ghana	1277	8–16	IOTF categories	9
Garnier [165]	2005	Longitudinal	Senegal	1806	5–17	CDC categories	7
Calvert [291]	2005	Cross sectional	South Africa	393	8–12	BMI z-score	8
Monyeki [292]	2005	Longitudinal	South Africa	855	7–14	US reference sample	8
Benefice [46]	2005	Cross sectional	Senegal	99	10–13	BMI	8
Friedman [47]	2005	Cross sectional	Kenya	272	10–13	BMI z-score	8
Jinabhai [190][b,c,d]	2005	Secondary analysis	South Africa	643	8–11	IOTF categories	9
Steyn [248][b,c,d]	2005	Secondary analysis	South Africa	544	7–8	NCHS reference	10
Underhay [192][a,b]	2005	Cross sectional	South Africa	1242	10–15	IOTF categories	9
Monyeki [191][a]	2006	Longitudinal	South Africa	1884	6–13	IOTF categories	8
Zerfu [249]	2006	Cross sectional	Ethiopia	1208	9–17	NCHS reference	6
Armstrong [193][b,c,d]	2006	Cross sectional	South Africa	10195	6–13	IOTF categories	10
Kruger [194][b]	2006	Cross sectional	South Africa	1257	10–15	IOTF categories	9
Aandstad [48]	2006	Cross sectional	Tanzania	156	9–10	BMI	7
Munday [49]	2006	Longitudinal	Gambia	62	5–10	BMI z-scores	7
Djarova [50]	2006	Cross sectional	Zimbabwe	49	6–14	BMI	6
Onyewadume [51]	2006	Cross sectional	Botswana	30	11–14	BMI	8
Nyati [145][a]	2006	Cross sectional	South Africa	369	9	Weight, height	8
Vidulich [52][a]	2006	Cross sectional	South Africa	476	10	BMI	7
Micklesfield [146]	2007	Cross sectional	South Africa	64	9	Weight, height	7
Micklesfield [53]	2007	Cross sectional	South Africa	400	9	BMI	8
Ben-Bassey [54]	2007	Cross sectional	Nigeria	1504	12–17	BMI	8
Longo-Mbenza [250]	2007	Cross sectional	DRC	1535	5–17	NCHS reference	6
Rohner [166]	2007	Cross sectional	Côte d'Ivoire (Ivory Coast)	281	5–15	None OW/OB	7

Table 3. Cont.

First Author	Year	Study Design	Country	Sample Size	Age Range (Years)	Body Composition Measure or Categorization System	D&B Score
Jinabhai [195][b,c,d]	2007	Cross sectional	South Africa	5322	13–17	IOTF categories	10
Madhavan [167]	2007	Cross sectional	South Africa	117	5–14	None OW/OB	7
Vidulich [55]	2007	Cross sectional	South Africa	476	10	BMI	7
Monyeki [56]	2007	Longitudinal	South Africa	702	7–14	Weight z-score	8
Semproli [196]	2007	Cross sectional	Kenya	1,383	5–17	IOTF categories	7
Andries [57]	2007	Longitudinal	South Africa	702	7–14	Weight z-score	7
Bovet [197][b,c,d]	2007	Cross sectional	Seychelles	4343	12–15	IOTF categories	9
Goon [147]	2007	Cross sectional	Nigeria	2015		Body fat %	8
Travill [293]	2007	Cross sectional	South Africa	720	8–17	Waterlow et al., 1977	7
Makgae [198][a]	2007	Longitudinal	South Africa	1902	6–13	IOTF categories	8
Ejike [58]	2008	Cross sectional	Nigeria	923	10–17	BMI	8
Ekpo [168]	2008	Cross sectional	Nigeria	228	5–15	None OW/OB	8
Anyiam [169][b,c]	2008	Cross sectional	Nigeria	3802	5–13	None OW/OB	10
Nienaber [59]	2008	Cross sectional	South Africa	195	15	BMI	8
Olivieri [170]	2008	Cross sectional	Zimbabwe	982	6–17	None OW/OB	7
Monyeki [199]	2008	Longitudinal	South Africa	1817	7–13	IOTF categories	7
Jeremiah [294]	2008	Cross sectional	Nigeria	144	5–8	Other WHO based system	7
Funke [60]	2008	Cross sectional	Nigeria	315	10–17	BMI	7
Lennox [61]	2008	Cross sectional	South Africa	318	15	BMI	8
Goon [62][a]	2008	Cross sectional	Nigeria	2015	9–12	BMI	8
Alaofe [251]	2009	Cross sectional	Benin	180	12–17	NCHS reference	7
Prista [227]	2009	Cross sectional	Mozambique	256	6–16	WHO categories	8
Micklesfield [63]	2009	Cross sectional	South Africa	400	9	BMI	8
Demerath [64]	2009	Secondary analysis	South Africa	196	9	Other NCHS based system	8
Cameron [65]	2009	Secondary analysis	South Africa	227	8–11	BMI	7
Hawley [66]	2009	Secondary analysis	South Africa	1164	9–11	Weight z-scores	6
Berntsen [67]	2009	Cross sectional	Tanzania	190	9–10	BMI	8
Dapi [255]	2009	Cross sectional	Cameroon	581	12–16	CDC categories	7
Ayoola [171]	2009	Cross sectional	Nigeria	349	7–16	None OW/OB	7
Senbanjo [68]	2009	Cross sectional	Nigeria	392	5–14	BMI	8
Padez [228]	2009	Cross sectional	Mozambique	1417	9–17	WHO categories	7
Mulugeta [148]	2009	Cross sectional	Ethiopia	413	10–15	BMI z-scores	7
Naiho [69]	2009	Cross sectional	Nigeria	200	5–10	BMI	6
Adegoke [70]	2009	Cross-sectional	Nigeria	704	6–17	BMI	8
Amuta [172]	2009	Cross sectional	Nigeria	600	6–17	None OW/OB	6

Table 3. Cont.

First Author	Year	Study Design	Country	Sample Size	Age Range (Years)	Body Composition Measure or Categorization System	D&B Score
Poopedi [74][b,c]	2009	Cross sectional	South Africa	385	10	BMI	10
Kimani-Murage [252][b,c]	2010	Cross sectional	South Africa	1914	5–14	IOTF categories	9
Bamidele [173]	2010	Cross sectional	Nigeria	139	5–15	Other WHO based system	7
Omigbodun [229]	2010	Cross sectional	Nigeria	1503	10–17	WHO categories	7
Harmse [72]	2010	Cross sectional	South Africa	221	13–17	BMI	7
Senbanjo [256]	2010	Cross sectional	Nigeria	392	5–14	CDC categories	8
Goon [73]	2010	Cross sectional	Nigeria	563	12–17	BMI	7
Mosha [230]	2010	Cross sectional	Tanzania	428	6–12	WHO categories	5
Olumakaiye [174]	2010	Cross sectional	Nigeria	315	10–17	Other NCHS based system	8
Goon [186]	2010	Cross sectional	Nigeria	2015	9–12	CDC and IOTF categories	8
Goon [200]	2010	Cross sectional	Nigeria	219	7–14	IOTF categories	7
Opara [231]	2010	Cross sectional	Nigeria	770	5–14	WHO categories	7
Ejike [253]	2010	Cross sectional	Nigeria	563	10–17	NCHS reference	7
Truter [254]	2010	Cross sectional	South Africa	280	9–13	NCHS reference	7
Ansa [75]	2010	Cross sectional	Nigeria	964	10–17	BMI	8
Bogale [175]	2010	Cross sectional	Ethiopia	100	5	None OW/OB	7
Mulugeta [176]	2010	Cross sectional	Ethiopia	413	10–15	None OW/OB	8
Hawkesworth [295]	2010	Cross sectional	Gambia	171	5–10	BMI	8
Poopedi [71]	2011	Cross sectional	South Africa	385	10	BMI	7
Micklesfield [76]	2011	Cross sectional	South Africa	471	13	BMI	7
Salman [257]	2011	Cross sectional	Sudan	304	6–12	CDC categories	7
Nagwa [232]	2011	Cross sectional	Sudan	1138	10–17	WHO categories	7
Griffiths [77]	2011	Mixed	South Africa	281	9–10	BMI	7
Dabone [233]	2011	Cross sectional	Burkina Faso	649	7–14	WHO categories	7
Henry-Unaeze [78][b,c]	2011	Cross sectional	Nigeria	200	12–17	BMI	9
Hadley [79][b,c]	2011	Cross sectional	Ethiopia	1943	13–17	BMI	8
Odenigbo [258]	2011	Cross sectional	Nigeria	119	6–12	CDC categories	7
Thrandrayen [80][b,c]	2009	Retrospective longitudinal	South Africa	672	10 and 15	BMI z-scores	8
Goon [81]	2012	Cross sectional	South Africa	1136	9–13	BMI	7
Kruger [82][b,c]	2012	Cross sectional	South Africa	582 and 462	7–9	Weight z-scores	6
Semproli [83]	2011	Cross sectional	Kenya	1383	5–17	BMI z-scores	7
Koueta [201]	2011	Cross sectional	Burkina Faso	204	13–16	IOTF categories	7
Stevens [84]	2011	Cross sectional	Ghana	181	9–16	BMI	7
Peltzer [202][d]	2011	Secondary analysis	Ghana & Uganda	5613	13–15	IOTF categories	9
Goon [234][a,b,c]	2011	Cross sectional	Nigeria	2015	9–12	WHO categories	9

Table 3. Cont.

First Author	Year	Study Design	Country	Sample Size	Age Range (Years)	Body Composition Measure or Categorization System	D&B Score
Nwizu [85]	2011	Cross sectional	Nigeria	728	10–17	BMI	7
Naude [86]	2011	Cross sectional	South Africa	162	12–16	BMI z-scores	5
Abolarin [87]	2011	Cross sectional	Nigeria	560	6–12	BMI	8
Abrahams [88]	2011	Cross sectional	South Africa	717	10–12	BMI z-scores	8
Motswagole [89]	2011	Cross sectional	South Africa	919	9–15	BMI	8
Croteau [259]	2011	Cross sectional	Kenya	72	8–12	CDC categories	8
Fetuga [226]	2011	Cross sectional	Nigeria	1690	6–16	CDC categories	7
Rankin [149]	2011	Cross sectional	South Africa	81	13–16	Weight	7
Larbi [260]	2011	Cross sectional	Ghana	1482	6–15	CDC categories	8
Mchiza [90]	2011	Secondary analysis	South Africa	201	9–12	BMI	6
Armstrong [203][b,c,d]	2011	Secondary analysis	South Africa	30365	8–11	IOTF categories	10
Benefice [91]	2011	Cross sectional	Senegal	791	5–15	BMI	8
Kimani-Murage [204]	2011	Cross sectional	South Africa	944	10–14	IOTF categories	7
Dapi [92]	2011	Cross sectional	Cameroon	227	12–16	BMI	8
Vidulich [150]	2011	Cross sectional	South Africa	419	10	Weight, height	8
Faye [296][b,c]	2011	Cross sectional	Senegal	2356	11–17	Rolland-Cachera et al., 1991	8
Fetuga [235]	2011	Cross sectional	Nigeria	1016	6–10	WHO categories	8
Cameron [93]	2011	Cross sectional	South Africa	119	9–10	BMI	6
Goon [151][b]	2011	Cross sectional	South Africa	1136	9–13	Weight, height	9
Amusa [205]	2011	Cross sectional	South Africa	409	7–13	IOTF categories	8
Ramos [177]	2011	Cross sectional	Kenya	215	9–10	None OW/OB	7
Puckree [236]	2011	Cross sectional	South Africa	120	10–12	WHO categories	7
Armstrong [94][a,d]	2011	Cross sectional	South Africa	10295	6–13	BMI	10
Adamo [206][a]	2011	Cross sectional	Kenya	179	9–13	IOTF categories	7
Goon [261]	2011	Cross sectional	Nigeria	553	12–1 7	CDC categories	7
Kamau [237][b,c]	2011	Cross sectional	Kenya	5325	10–15	WHO categories	9
Ojofeitimi [297]	2011	Cross sectional	Nigeria	280	10–14	Other similar study	8
Kemp [207][b,c]	2011	Cross sectional	South Africa	816	6–7	IOTF categories	10
Oldewage-Theron [238]	2011	Cross sectional	South Africa	97	6–13	WHO categories	7
Okoh [262]	2012	Cross sectional	Nigeria	1302	6–12	CDC categories	7
Naidoo [263]	2012	Cross sectional	South Africa	170	7–10	CDC categories	7
Ene-Obong [209]	2012	Cross sectional	Nigeria	1,599	5–9	IOTF categories	7
Prentice [152]	2012	Longitudinal	Gambia	80	8–16	Weight, height	7
Kramoh [239]	2012	Cross sectional	Côte d'Ivoire	2038	12	WHO categories	7
Musa [95]	2012	Cross sectional	Nigeria	3243	9–15	BMI	7

Table 3. Cont.

First Author	Year	Study Design	Country	Sample Size	Age Range (Years)	Body Composition Measure or Categorization System	D&B Score
Adesina [96]	2012	Cross sectional	Nigeria	884	10–17	BMI	8
Cordeiro [178][b,c]	2012	Cross sectional	Tanzania	670	10–15	None OW/OB	9
Monyeki [210][a]	2012	Longitudinal	South Africa	256	14	IOTF categories	8
Griffiths [211]	2012	Cross sectional	South Africa	358	16	IOTF categories	7
Onywera [185]	2012	Cross sectional	Kenya	169	9–12	WHO categories	7
Bafor [97]	2012	Cross sectional	Nigeria	369	5–10	BMI	7
Reddy [212][b,c,d]	2012	Secondary analysis	South Africa	9522 and 9371	14–17	IOTF categories	9
Opare-Addo [240]	2012	Cross sectional	Ghana	720	7–17	WHO categories	8
Ojiambo [98]	2012	Cross sectional	Kenya	200	12–16	BMI z-scores	7
Chinedu [264]	2012	Cross sectional	Nigeria	926	6–16	CDC categories	5
Craig [179]	2012	Cross sectional	South Africa	1519	7, 11, and 15	None OW/OB	5
Amare [180]	2012	Cross sectional	Ethiopia	100	5–15	None OW/OB	8
Moselakgomo [213]	2012	Cross sectional	South Africa	1172	10–16	IOTF categories	8
Micklesfield [214]	2012	Cross sectional	South Africa	381	11–15	IOTF categories	6
Monyeki [215]	2012	Cross sectional	South Africa	256	14	IOTF categories	8
Monyeki [298]	2012	Cross sectional	South Africa	153	14–15	Not indicated	8
Truter [216]	2012	Cross sectional	South Africa	280	9–13	IOTF categories	7
Musa [217]	2012	Cross sectional	Nigeria	3240	9–16	IOTF categories	8
Bovet [218][b,c]	2012	Cross sectional	Seychelles	8462	9–16	IOTF categories	9
Fetuga [299]	2012	Cross sectional	Nigeria	1557	5–11	Weight standard deviation scores	8
Girma [100]	2012	Cross sectional	Ethiopia	116	7–9	Weight z-scores	6
Motswagole [241]	2012	Cross sectional	South Africa	2111	6–15	WHO categories	7
Wolff [101]	2012	Cross sectional	Madagascar	1236	6–15	BMI	8
Toriola [265][a]	2012	Cross sectional	South Africa	1172	10–16	CDC categories	7
Wolff [102][a]	2012	Cross sectional	Madagascar	1236	6–15	BMI	7
Goon [153][a,b,c]	2012	Cross sectional	Nigeria	2015	9–12	Weight, height	10
Toriola [219]	2012	Longitudinal	South Africa	283	14	IOTF categories	8
Feeley [208]	2013	Longitudinal	South Africa	1298	13, 15, and 17	IOTF categories	7
Wilson [220][b,c,d]	2013	Secondary analysis	Seychelles	580	11–17	IOTF categories	8
Ginsburg [221]	2013	Cross sectional	South Africa	1613	15	IOTF categories	7
Senbanjo [103]	2013	Cross sectional	Nigeria	548	5–17	BMI	7
Malete [222]	2013	Cross sectional	Botswana	756	13–16	IOTF categories	7
Neumann [181]	2013	Cross sectional	Kenya	910	6–14	None OW/OB	7
Degarege [182]	2013	Cross sectional	Ethiopia	403	5–15	None OW/OB	8
Puoane [242]	2013	Cross sectional	South Africa	162	10–15	WHO categories	7

Table 3. Cont.

First Author	Year	Study Design	Country	Sample Size	Age Range (Years)	Body Composition Measure or Categorization System	D&B Score
Amare [183]	2013	Cross sectional	Ethiopia	405	9–14	None OW/OB	8
Mang'eni [223][a]	2013	Cross sectional	Kenya	200	13–16	IOTF categories	7
Onywera [224][a]	2013	Cross sectional	Kenya	179	9–13	IOTF categories	7
Heroux [225][a]	2013	Cross sectional	Kenya	179	9–13	IOTF categories	7
						Average (D&B) score	**7.4**

Acronyms: D & B score (Downs & Black score); None OW/OB (none were overweight/obese); BMI (Body Mass Index); CDC-NCHS (Centers for Disease Control and Prevention – National Center for Health Statistics); WHO (World Health Organization); IOTF (International Obesity Task Force).

[a] = Identical study sample as used in another included manuscript (not included in quantitative synthesis) ($n = 27$).

[b] = Article indicated targeting a sample size representative of the population of interest ($n = 38$).

[c] = Article indicated recruiting a sample size representative of the population of interest ($n = 31$).

[d] = Article indicated that the sample size was nationally representative ($n = 11$).

doi:10.1371/journal.pone.0092846.t003

Sex differences. Of the 96 studies [16–18,20,24–26,29, 36,39,40,43,45,46,48,51,53–56,59–61,63–68,70–72,74,76–80,83, 85,86,89,91,92,95,96,98,103–105,107,109–114,116–120,123,124, 126,128,129,132,133,135,136,140,143,147,149–152,163,169,170, 214,215,218,225,281,287,289,292,293,295] that reported their data by sex, 31 articles [20,25,29,40,45,59,67,68,70,71,74,76,78,79, 85,86,89,92,95,96,103,107,124,126,132,147,151,163,170,214,215] reported that girls had higher body composition measures than boys, while 5 articles [265,267,289,292,293] reported that boys had higher body composition measures than girls. The remaining studies either found no significant difference or did not report a difference between boys and girls.

Urban/rural differences. Thirty-three articles compared body composition measures in urban and rural populations. Of these, 29 studies (including 7 studies used in the quantitative synthesis) [17, 24, 27, 31, 34, 37, 54, 58, 79, 84, 87, 98, 119, 128, 129, 138, 156, 163, 206, 212, 282, 298, (185, 189, 200, 217, 233, 240, 260)] reported significantly higher body composition measures in the urban compared to the rural sample, with the remaining studies [110,111,140,280] reporting no significant difference between the two populations.

Socioeconomic status (SES) differences. Twenty four articles reported on outcomes of interest by some measure of socioeconomic status (e.g., income quartile, public/private school attendance). Of these, 19 articles (including 8 studies used in the quantitative synthesis) [45, 54, 61, 68, 75, 77, 84, 92, 99, 101, 156, 163, 169, 218, 296, 297, (212, 228, 231, 237, 247, 250, 255, 256)] reported that higher SES was associated with higher body composition measures, whilst the remaining articles [54,75,92, 169,256] found no significant association of SES on body composition.

Age differences. Of the articles that reported on body composition measures by age, 15 studies found a largely positive relationship with age [287,170,70,147,103,95,151,20,42, 242,256,229,230,199,297], while 7 studies found a largely negative relationship with age [83,264,233,19,190,196,245]. In some cases, the relationship between age and body composition measures differed between sexes; as such, we may conclude that there was no convincing or consistent evidence of an independent age effect.

Discussion

To our knowledge, this systematic review is the first to comprehensively examine if there is evidence supporting an overweight/obesity transition in school-aged children and youth in SSA.

An overweight/obesity transition

Due to vast heterogeneity in types of measurement, classification, and analysis, both narrative and quantitative analyses (weighted proportions and bubble plots of overweight/obesity) were presented in this review. Quantitative synthesis was completed using 68 studies that categorized children and youth based on internationally accepted cut-points for weight status. The weighted averages of overweight/obesity proportions in boys and girls was 7.6% and 15.4% respectively, while obesity proportions in boys and girls was 2.0% and 3.9% respectively. Weighted averages of overweight/obesity, and obesity for the total population were 10.6% and 2.5%. Current evidence revealed a clear transition of increasing proportions of overweight/obesity in school-aged children in SSA, and a similar, but less prominent trend towards increasing proportions of obesity over time. This transition to higher proportions of overweight/obesity is similar to observed trends in developed countries; however, the weighted

Table 4. Proportions of overweight/obesity as reported by studies used in quantitative synthesis.

					Sample Size (*n*)			Proportions in Males				Proportions in Females				Proportions in Both Males and Females			
First Author	**Year**	**Country**	**Cut Off**	**Age Range (years)**	**M**	**F**	**Total**	**UW**	**NW**	**OW**	**OB**	**UW**	**NW**	**OW**	**OB**	**UW**	**NW**	**OW**	**OB**
Villiers [244]	1987	South Africa	1	14–15		57	57								1.8				1.8
Wagstaff [243]	1987[a] (1981)	South Africa	1	5–14			937									27.3		3.9	3.4
Wagstaff [243]	1987[a] (1983)	South Africa	1	5–14			864									21.9		7.1	4.0
Monyeki [245]	1999	South Africa	1	5–10	595	557	1152			0.5				0.7				0.6	
Prista [247]	2003	Mozambique	1	6–17	1094	1222	2316	21.9		4.8		10.0		7.7		15.6		6.3	
Jinabhai [184]	2003	South Africa	2	8–11	17351	12025	29376			3.0	0.7			4.5	1.2			3.6	0.9
Benefice [188]	2004	Senegal	3	16	188	319	507	50.0		0.0	0.0	17.9		1.6	0.0	29.8		1.0	0.0
Agyemang [189]	2005	Ghana	3	8–16	616	661	1277			3.1				6.4				4.8	
Jinabhai [190]	2005	South Africa	3	8–11	292	351	643											5.1	0.6
Steyn [248]	2005	South Africa	1	7–8			544									6.4	85.4	5.0	3.3
Zerfu [249]	2006	Ethiopia	1	9–17			918									23.8		3.5	
Armstrong [193]	2006	South Africa	3	6–13	5603	4680	10283			10.8	3.2			13.0	4.9			11.8	4.0
Kruger [194]	2006	South Africa	3	10–15	608	649	1257			4.1	1.5			8.3	1.7			6.3	1.6
Longo-Mbenza [250]	2007	DRC	1	≥12	362	124	486			24.0				68.5				35.5	
Jinabhai [195]	2007	South Africa	3	13–17	2398	2924	5322	18.4		4.2		2.6		20.9		9.7		13.4	
Semproli [196]	2007	Kenya	3	5–17	702	681	1383	10.6				6.3						3.2	
Bovet [197]	2007	Seychelles	3	12–15	2202	2141	4343			8.1	3.1			13.1	4.4			10.6	3.7
Monyeki [199]	2008	South Africa	3	7–13	938	879	1817			1.1				2.1				1.6	
Alaofe [251]	2009	Benin	1	12–17		180	180					8.0	81.0	8.0	3.0	8.0	81.0	8.0	3.0
Prista [227]	2009	Mozambique	2	6–16	139	117	256											1.1	0.0
Dapi [255]	2009	Cameroon	1	12–16	248	333	581	6.0		4.0		1.0		14.0		3.0		10.0	
Padez [228]	2009	Mozambique	2	9–17	298	400	698			0.7	0.0			1.3	0.3			1.0	0.2
Goon [186]	2010	Nigeria	1	9–12	979	1036	2015	87.1		2.1	1.6			3.2	2.8			2.7	2.2
Kimani-Murage [252]	2010	South Africa	3	5–14			1884									6.5		5.0	1.5
Omigbodun [229]	2010	Nigeria	2	10–17	763	740	1503	22.3		1.2		15.5		3.9		19.0		2.5	
Senbanjo [256]	2010	Nigeria	1	5–14	202	190	392	37.1	61.9	1.0		23.2	74.7	2.1		30.4	68.1	1.5	
Mosha [230]	2010	Tanzania	2	6–9	60	145	205									21.4	68.8	5.8	4.0
Goon [200]	2010	Nigeria	3	7–14	107	112	219											2.7	1.0
Odenigbo [258]	2010	Nigeria	1	6–12			119									29.4	63.0	6.7	0.8
Opara [231]	2010	Nigeria	2	5–12.5			378									29.1			10.3

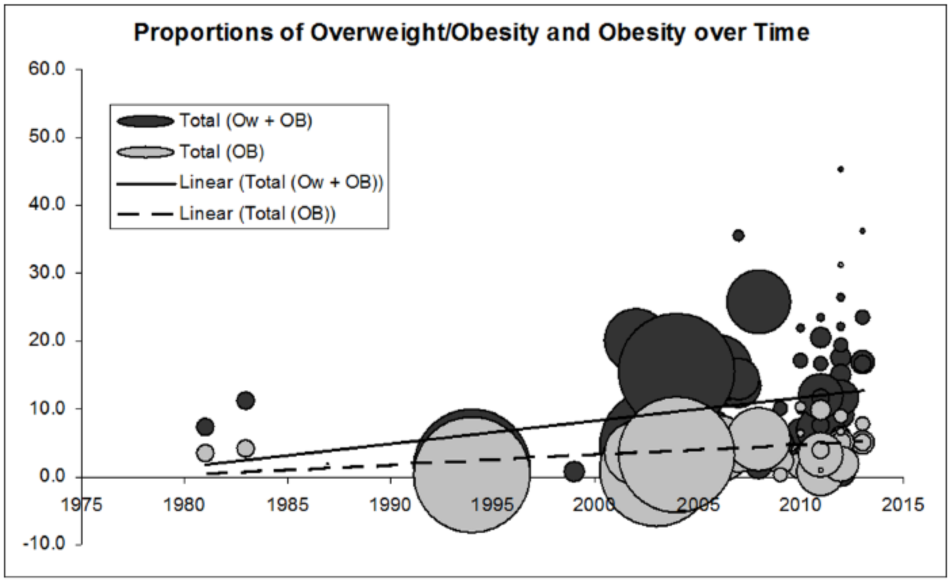
Table 4. Cont.

					Sample Size (*n*)			Proportions in Males				Proportions in Females				Proportions in Both Males and Females			
First Author	Year	Country	Cut Off	Age Range (years)	M	F	Total	UW	NW	OW	OB	UW	NW	OW	OB	UW	NW	OW	OB
Ejike [253]	2010	Nigeria	1	10–17	337	226	563	5.3		23.7		2.7		7.2		4.3		17.1	
Salman [257]	2010	Sudan	1	6–12	68	236	304		82.4	11.8	5.9		75.0	14.0	11.0		76.7	13.5	9.9
Truter [254]	2010	South Africa	1	9–12	128	152	280		78.9	15.6	5.5		77.6	15.1	7.2		78.2	15.4	6.4
Nagwa [232]	2011	Sudan	2	10–17	526	612	1138	17.7	61.0	9.9	11.4	10.6	69.6	11.6	8.2	13.9	65.6	10.8	9.7
Dabone [233]	2011	Burkina Faso	2	7–14	312	337	649									13.7		2.3	
Koueta [201]	2011	Burkina Faso	3	13–16			204											3.9	
Peltzer [202]	2011	Ghana & Uganda	3	13–15	2738	2875	5613			2.7	0.5			9.5	0.9			6.2	0.7
Croteau [259]	2011	Kenya	1	8–12	29	43	72									11.1	84.7	4.2	
Fetuga [226]	2011	Nigeria	2	6–16	821	669	1690			2.5				3.3				2.5	
Larbi [290]	2011	Ghana	1	6–15	706	776	1482									7.9	78.7	13.4	
Kimani-Murage [204]	2011	South Africa	3	10–14			944											7.5	
Fetuga [235]	2011	Nigeria	2	6–10	479	537	1016	23.8		3.8		20.8		3.3		22.2		3.5	
Amusa [205]	2011	South Africa	3	7–13	193	216	409			2.6				2.9				2.8	
Puckree [236]	2011	South Africa	2	10–12	48	72	120									66.2	28.8	5.0	
Goon [261]	2011	Nigeria	1	12–17	0	553	553					5.4	77.0	11.1	5.4	5.4	77.0	11.1	5.4
Kamau [237]	2011	Kenya	2	10–15	2620	2705	5325			6.5	2.6			10.9	3.6			8.7	3.1
Kemp [207]	2011	South Africa	3	6–7	419	397	816		90.2	6.4	3.3		86.4	9.3	4.3		88.4	7.8	3.8
Oldewage-Theron [238]	2011	South Africa	2	6–13	43	54	97	4.7	90.7	2.3	2.3	5.7	90.5	3.8	0.0	5.2	90.7	3.1	1.0
Armstrong [203]	2011[a] (1994)	South Africa	3	8–11	17756	12609	30365			1.1				1.4				1.2	0.2
Armstrong [203]	2011[a] (2004)	South Africa	3	8–11	17756	12609	30365			9.5	2.2			16.5	4.4			12.4	3.1
Okoh [262]	2012	Nigeria	1	6–12	585	717	1302									11.7	76.7	5.7	5.9
Naidoo [263]	2012	South Africa	1	7–10	70	100	170		54.3	11.4	34.3		55.0	16.0	29.0		54.7	14.1	31.2
Ene-Obong [209]	2012	Nigeria	3	5–9			706									19.0	68.7	9.5	2.8
Kramoh [239]	2012	Côte d'Ivoire	2	12	856	1182	2038				1.8				6.8	64.0	27.0	4.0	5.0
Monyeki [210]	2012	South Africa	3	14	100	156	256	44.0	48.0	8.0		30.7	51.9	17.3		35.9	50.4	13.7	
Griffiths [211]	2012	South Africa	3	16	190	168	358			6.3	3.7			22.2	8.4			13.3	5.7
Onywera [185]	2012	Kenya	2	9–12	85	84	169			6.8				16.7				12.0	
Opare-Addo [240]	2012	Ghana	2	7–17	0	720	720									6.0	74.6	10.4	8.9
Moselakgomo [213]	2012	South Africa	3	10–16	541	631	1172	4.6	80.8	9.1	5.5	5.2	79.4	11.0	4.4	4.9	80.0	10.1	4.9
Truter [216]	2012	South Africa	3	9–13	128	152	280			15.6	5.5			15.1	7.2			15.5	6.5

Table 4. Cont.

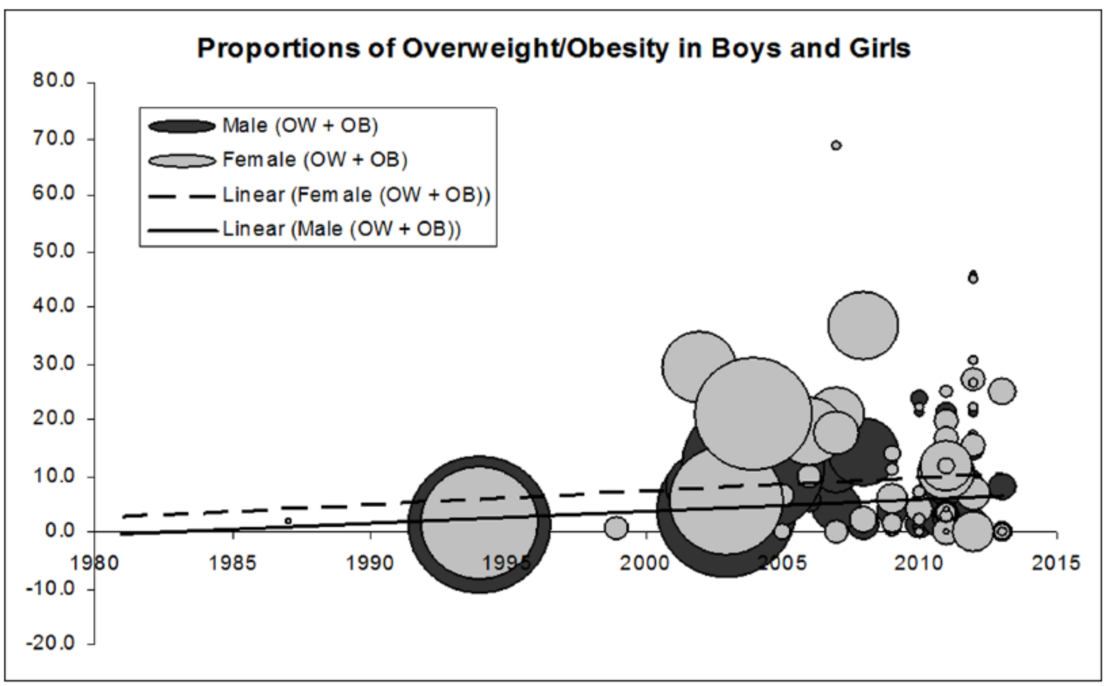
					Sample Size (*n*)			Proportions in Males				Proportions in Females				Proportions in Both Males and Females			
First Author	**Year**	**Country**	**Cut Off**	**Age Range (years)**	**M**	**F**	**Total**	**UW**	**NW**	**OW**	**OB**	**UW**	**NW**	**OW**	**OB**	**UW**	**NW**	**OW**	**OB**
Musa [217]	2012	Nigeria	3	9–16	1526	1,714	3240										88.5	9.7	1.8
Motswagole [241]	2012	South Africa	2	6–15			2111									34.2		0.6	
Toriola [219]	2012	South Africa	3	14	111	172	283	34.2	48.6	17.1		26.2	41.0	32.4		29.3	44.0	26.4	
Reddy [212]	2012[a] (2002)	South Africa	3	14–17	4184	5338	9522			6.3	1.6			24.3	5.0			16.4	3.5
Reddy [212]	2012[a] (2008)	South Africa	3	14–17	4565	4806	9371			11.0	3.3			29.0	7.5			20.2	5.5
Feeley [208]	2013	South Africa	3	13–17	607	616	1223			8.1				27.0				17.6	
Wilson [220]	2013	Seychelles	3	11–17	278	302	580									13.4		15.6	7.7
Ginsburg [221]	2013	South Africa	3	15	773	840	1613	20.3	71.8	5.4	2.5	9.6	65.4	17.5	7.5	14.2	68.5	11.7	5.1
Malete [222]	2013	Botswana	3	13–16	464	292	756									5.0	78.4	11.6	5.1
Puoane [242]	2013	South Africa	2	10–15	0	162	162									2.4	61.4	36.2	
Mang'eni [223]	2013	Kenya	3	13–16	98	102	200											5.0	
					95885	**84455**	**190149**	**25.0**	**68.0**	**5.6**	**2.0**	**8.3**	**68.6**	**11.5**	**3.9**	**17.6**	**68.5**	**8.1**	**2.5**
					Sample totals			**(M) – weighted averages**				**(F) – weighted averages**				**(T) – weighted averages**			

Acronyms: M (male); F (female); UW (underweight); NW (normal weight); OW (overweight); OB (obese).
Weighted averages: Proportions may not add up to 100% for M, F, and T since some of the included studies did not report in each of the UW, NW, OW, and, OB categories.
[a]Year of publication (year that corresponding data was collected included in brackets).
doi:10.1371/journal.pone.0092846.t004



Note: Bubble size proportional to sample size.

Figure 2. Proportions of overweight/obesity (combined) and obesity over time in Sub Saharan Africa.
doi:10.1371/journal.pone.0092846.g002



Note: Bubble size proportional to sample size.

Figure 3. Proportions of overweight/obesity (combined) in Sub Saharan Africa's boys and girls.
doi:10.1371/journal.pone.0092846.g003

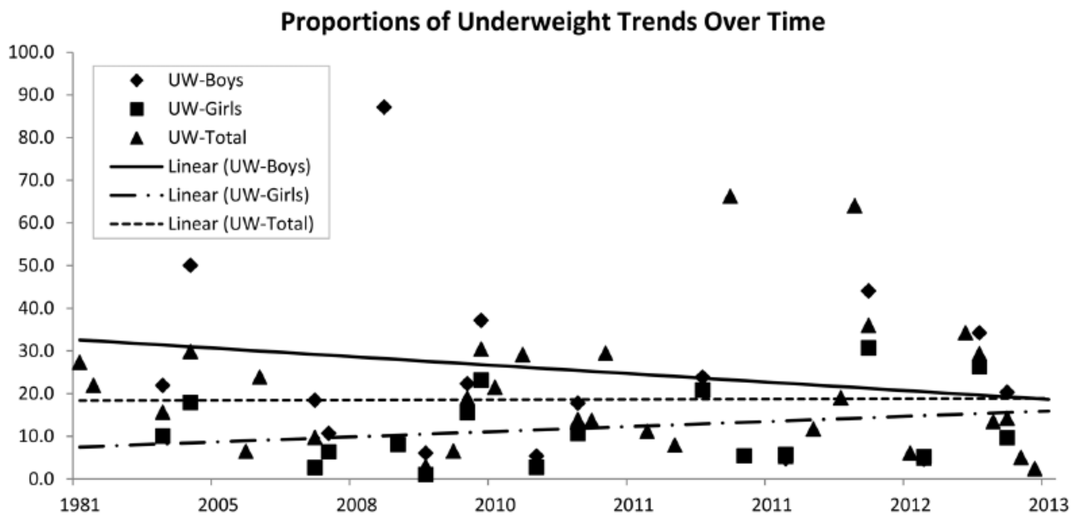


Figure 4. Proportions of underweight over time in Sub Saharan Africa.
doi:10.1371/journal.pone.0092846.g004

averages fall far below proportions in various high income countries. For example, in Canada, research has shown that the prevalence of overweight/obesity has more than doubled (14% to 29%) and the obesity rate has tripled (3% to 9%) over the last 25 years in children and youth 5 to 17 years of age [302,303]. In the USA, 33% of children and youth 6–19 years are considered to be overweight/obesity, and 18% are considered to obese [304].

It is important to note that across all age groups, WHO cut-points yield higher proportions of boys and girls classified as overweight/obesity than do the IOTF, or CDC cut-points [305]. While studies that used any of the three cut-points were analysed together in this review, when interpreting prevalence estimates of overweight/obesity, it is important to consider the choice of cut-point used in each study. With the largest proportion of included studies using IOTF cut-points, it could be argued that this may "dilute" the weighted average of the proportions of overweight/obesity calculated for SSA. Nonetheless, these results indicate that while there is an imminent threat of continued increases in levels of childhood overweight/obesity in SSA, implementing viable population health interventions may mitigate the associated health risks in these earlier stages.

Persistence of underweight

In discussing an overweight/obesity transition, it is important to recognize that child under-nutrition remains one of SSA's most fundamental challenge for improved human development [306,307,308]. This is particularly concerning when considering the school-aged child population as malnutrition affects their education outcomes, and consequently opportunities for success in later years [306]. Inadequate access to food and health services as a result of poverty and broader social determinants of health are some of the underlying determinants of child under-nutrition. The underweight trend over time was largely unaltered at approximately 20% for boys and girls combined, providing the evidence of a persisting underweight problem among SSA's children and youth, and substantiating the emergence of a public health double-edged sword. This persistence in underweight coupled with an overweight/obesity transition may place undue strain on the limited healthcare resources in SSA countries [14]. As such, frameworks for interventions to improve the nutritional status of SSA children will have to account for broader concepts such as societal organization, economic structures, and political ideologies [306]. We would however like to caution the reader that describing an underweight trend was not an objective of this systematic review; as such, pertinent articles reporting on underweight may have been omitted during the literature search thereby skewing these results.

Sex differences

Both quantitative and narrative synthesis revealed that there were increasing trends in proportions of overweight/obesity over time for both boys and girls; however, body composition measures and the proportions of overweight/obesity were proportionally higher in girls than in boys. In contrast, in North America, obesity is more common in boys than in girls, with the most significant differences observed among younger children 5–11 years [304,309]. Higher proportions of overweight/obesity in SSA girls may be related to differences in gender roles particularly those requiring higher physical exertion (e.g., boys participating in higher energy expending roles/activities); and, cultural desirability whereby being overweight (i.e., "rounder") is an admired trait and seen as a sign of wealth and prestige, particularly in girls.

Urban/rural and SES differences

Narrative synthesis revealed higher body composition measures in the urban compared to the rural population. In addition, higher SES was associated with higher body composition measures, pointing to a positive SES relationship. Factors associated with overweight/obesity span various behavioural, social, environmental, and biological constructs making them difficult to ascertain; however, urban residence and higher SES may be positively associated with overweight/obesity in SSA owing to improved access to governance, health care, education, employment and income, in addition to increased availability of packaged foods high in saturated fats and sugars and increased sedentary behaviour, all of which are more accessible to and/or affordable for those of higher SES or individuals living in urban areas.

Strengths, limitations, and future directions

The main strength of this review was the use of high quality standards to conceptualize and conduct the methodology and synthesis. Further, as many decisions as possible were made *a priori* to limit possible bias, and all levels of the review process were conducted in duplicate, ensuring a higher level of accuracy. Our assessment indicated that the quality of included studies was relatively high. The main limitation of this study lies in the vast heterogeneity in study methodology. The variety in the types of body composition measurements, analyses, definitions of SES, and reference standards limited our interpretation and presentation of the results. Quantitative synthesis was limited to those using the more widely accepted cut-points to further categorise study samples by weight status. It is also unclear if any material relevant for this review may have been published in un-indexed journals and hence not captured by the literature search.

Recognizing that future studies may increasingly employ WHO cut-points, since they represent a more robust criterion-based standard, we recommend that studies use the WHO cut-points for categorizing childhood overweight/obese in SSA, as this would allow for improved comparability and time trend analyses as attempted in this paper. A repository of studies, particularly those that are representative may be set up to this end, to allow for periodic comparative analysis for the whole of SSA. Measurements on more population representative samples are also required e.g., a multi-country survey using common measurement techniques and sampling procedures would be most desirable.

Conclusion

This systematic review provides evidence for an overweight/obesity transition in school-aged children in SSA. While the weighted averages of overweight/obesity in SSA are lower, this transition to higher proportions of overweight/obesity is similar to findings in various developed countries. The weighted average of overweight/obesity was higher in girls than in boys, and higher in those with higher SES. The review also revealed a persisting problem of underweight in the region, underpinning a double burden of risk factors. Findings of this review indicate that more nationally representative studies are needed to strengthen this field of research, and that interventions and strategies to address the growing threat of childhood overweight/obesity should focus on the higher SES and urban populations, with greater attention placed on girls.

Acknowledgments

The authors are grateful to Alison McFarlane and Afekwo Mbonu for their contributions towards locating the full text articles and for assistance with manuscript formatting.

Supporting Information

Checklist S1 PRISMA checklist.
(DOC)

Author Contributions

Conceived and designed the experiments: SKM LMW AGL MS VOO MST. Performed the experiments: SKM CEF LMW AGL MS VOO MST. Analyzed the data: SKM CEF LMW. Contributed reagents/materials/analysis tools: MS MST. Wrote the paper: SKM CEF LMW AGL MS VOO MST.

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CHAPTER 3

Temporal Trends and Correlates of Physical Activity, Sedentary Behaviour, and Physical Fitness among School-Aged Children in Sub-Saharan Africa: A Systematic Review

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Formatted for submission to: International Journal of Environmental Research and Public Health in January 2014 [**Current Status:** Published].

The objective(s): Having determined that school-aged children in SSA were experiencing and overweight/obesity transition, this subsequent systematic review aimed to elucidate whether children and youth in this region were also in the midst of a physical activity and fitness transition, that is, behavioural shifts to less active and more sedentary lifestyles, coupled with deceased aerobic fitness aptitude. Consequently, temporal trends and correlates of physical activity, sedentary behavior, and physical fitness were investigated.

Int. J. Environ. Res. Public Health **2014**, *11*, 3327-3359; doi:10.3390/ijerph110303327

OPEN ACCESS

International Journal of
Environmental Research and Public Health
ISSN 1660-4601
www.mdpi.com/journal/ijerph

Review

Temporal Trends and Correlates of Physical Activity, Sedentary Behaviour, and Physical Fitness among School-Aged Children in Sub-Saharan Africa: A Systematic Review

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Received: 9 January 2014; in revised form: 7 March 2014 / Accepted: 10 March 2014 / Published: 20 March 2014

Abstract: Recent physical activity (PA) and fitness transitions, identified as behavioural shifts from traditionally active lifestyles to more industralised and sedentary lifestyles, have been observed among school-aged children. There is a wealth of supporting evidence of such behavioural transitions in high income countries; however, a paucity of data on lower income countries exists. These transitions pose a particular threat to the welfare of children by accelerating the onset of chronic diseases. This systematic review investigated the evidence for a PA and fitness transition among Sub-Saharan Africa's school-aged children. Temporal trends and correlates of PA, SB, and fitness were examined. Studies were identified by searching the MEDLINE, Embase, Africa Index Medicus, Global Health, Geobase, and EPPI-Centre electronic databases, and were included if they measured outcomes of interest in apparently healthy samples of children (5–17 years). A total of 71 articles met the inclusion criteria (40 informed PA, 17 informed SB, and 37 informed fitness). Vast heterogeneity in study methodology complicated analysis of transitions over time and no temporal trends were immediately discernible. However, higher socioeconomic status, urban living, and female children were found to engage in lower levels of PA, higher SB, and performed worse on aerobic fitness measures compared to lower socioeconomic status, rural living, and male children. Data revealed that urbanization was associated with a trend towards decreased PA, increased SB, and decreased aerobic fitness over time. Representative, temporally sequenced data examining a PA and fitness transition are lacking in this region (PROSPERO Registration Number: CRD42013004399).

Keywords: motor activity; sedentary lifestyle; physical fitness; child; adolescent; Sub-Saharan Africa

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1. Introduction

Global surveillance efforts have revealed a behavioural shift from traditionally active lifestyles, to more industrialised and sedentary lifestyles [1]. The resultant decline in physical activity levels, coupled with increasing sedentary behaviours over time, is referred to as a "physical activity transition" [1]. The World Health Organization (WHO) classifies physical inactivity as the fourth leading cause of global mortality, and a major determinant for various chronic diseases [2]. Indeed, maintaining an adequate level of physical activity and reducing the amount of time spent in sedentary pursuits is important for the prevention of chronic disease morbidity and mortality [1]. Global physical activity transitions may pose a particular threat to the welfare of children and youth due to the possibility of long-term co-morbidities.

While communicable diseases will likely remain the predominant health problem for the populations in Sub-Saharan Africa (SSA) in the coming years, there is growing concern about rapid increases in non-communicable diseases (NCDs) such as heart disease, diabetes, and hypertension, particularly in urban areas [3]. SSA is currently undergoing rapid socio-cultural developments and urbanization, which have led to the replacement of an economy based on manual labour, to one dominated by industry and mechanized manufacturing [4,5]. This has also 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 or sedentary behaviours (e.g., motorized transport, desk work) [1]. A transition to lower levels of physical activity is thought to be one of the main contributors to the increasing burden of preventable NCDs in SSA [1,4,6–8]. Of great concern, are the long-term health consequences on children and youth, who are also influenced by this physical activity transition.

A large scale study of secular trends of children and adolescents between 1980 and 2000 using data from 11 mainly developed countries around the world revealed that aerobic fitness (measured by shuttle run tests) had rapidly declined, with the most marked decrease occurring in older age groups, and the rate of decline was similar for boys and girls [9]. This study provided supporting evidence for a decline in physical fitness, particularly aerobic fitness, among children and youth in developed countries.

Whereas physical activity and fitness transitions are well monitored and known to have taken place in high income countries such as Canada, the United States, or the United Kingdom; there is little information on possible physical activity and fitness transitions in SSA, particularly in the school-aged population. Indeed, SSA may be at the early stages of these transitions, and possibly amenable to early intervention strategies aimed at preserving healthy active behaviours. Therefore, the objective of this systematic review was to examine the evidence for a physical activity and fitness transition occurring among SSA's school-aged children and youth. Specifically, temporal trends and correlates of physical activity, sedentary behaviour, and physical fitness in SSA countries were examined. It is important to note that these terms are not interchangeable, particularly among children and youth, as described in Table 1.

Table 1. Outcome measures and their descriptions.

Outcome	Description
Physical Activity	Adequate participation in energy expending activities (e.g., walking, cycling, dancing) provides a wide spectrum of health benefits including reductions in risk for a variety of diseases, improvements in functional ability, and promotes psychological well-being [3,10,11]. Global physical activity guidelines recommend that children and youth, 5-17 years of age, should accumulate at least 60 min of moderate to vigorous intensity physical activity daily [12].
Sedentary Behaviours	These activities (e.g., prolonged sitting, seated screen time, motorized transportation) are characterized by sitting or reclined posture, little physical movement, and low energy expenditure (<1.5 metabolic equivalent tasks) [13]. Canadian sedentary behaviour guidelines developed by the Canadian Society for Exercise Physiology state that for health benefits, children aged 5–17 years should minimize the time they spend being sedentary each day by limiting recreational screen time to no more than 2 h per day, limiting motorized transport, extended sitting, and time spent indoors throughout the day [14].
Physical Fitness	Includes a set of health or skill related attributes that individuals possess in order to perform physical activity [15]. Health related components of physical fitness include cardiorespiratory endurance/aerobic (measured by cycle ergometer, shuttle run, distance run, Harvard step test *etc.*), musculoskeletal endurance & fitness (measured by pull ups, bent-arm hangs, sit ups *etc.*), muscular strength (measured by hand grip, trunk lift etc), body composition measures (measured by body mass index, body fat percentage, waist circumference *etc.*), flexibility (measured by sit-and-reach *etc.*), and anaerobic power (measured by dash/sprint runs, jumps *etc.*) [15].

2. Methods

2.1. Study Inclusion Criteria

All published, peer-reviewed studies were included if they reported using subjective or objective measures of physical activity, sedentary behaviour, or physical fitness in children and youth aged 5 to 17 years, with no chronic conditions, and living in SSA. The relevant outcome measures are described in Table 1.

2.2. Study Exclusion Criteria

In order to obtain information on a general population living under typical conditions, intervention studies were excluded unless they conducted baseline measurements. No date limits were imposed, but due to feasibility, studies in languages other than English or French were excluded. Studies were also excluded if they did not include one or more of the relevant health indicators.

2.3. Search Strategy

Studies were identified using the following electronic databases: Ovid MEDLINE (1948 to Week 4, May 2013), Ovid Embase (1974 to Week 21, 2013), Africa Index Medicus (database dates not available, searched on 3 June 2013), Global Health (1973 to 3 June 2013 through the CAB direct interface), Geobase (1884 to 3 June 2013 through the Engineering Village interface), and EPPI-Centre database of health promotion research (Bibliomap) (dates of coverage not available, searched 3 June 2013). The search strategy for this systematic review was completed in tandem with another publication examining the evidence for an overweight/obesity transition among school-aged children and youth in SSA [16]; hence, the inclusion of these terms in the search strategy. The search strategy was created and run by a research librarian. The complete search strategy used for MEDLINE is presented in Table 2. References were exported and de-duplicated using Reference Manager Software (Version 11, Thompson Reuters, San Francisco, CA, USA). Titles and abstracts of potentially relevant articles were screened by two independent reviewers, and full text articles were obtained for those meeting initial screening criteria. The full text articles were then screened in duplicate for inclusion in the review. This review is registered with the international prospective register of systematic reviews PROSPERO network (registration number: CRD42013004399) [17].

Table 2. MEDLINE search strategy; Ovid interface.

Order	Search Terms
1	exp "Africa South of the Sahara"/
2	(sub-sahar * or east afric * or south afric * or keny * or (south adj3 sahar *)).mp.
3	1 or 2
4	sedentar$.tw.
5	Sedentary Lifestyle/
6	((chair or sitting or car or automobile or auto or bus or indoor or in-door or screen or computer) adj time).tw.
7	low energy expenditure.tw.
8	(computer game * or video game * or ((television adj watch *) or tv watch *)).tw.
9	television/ or computers/ or video games/
10	(screen based entertainment or screen-based entertainment or screen time).tw.
11	physical inactivit *.tw.
12	bed rest.mp.
13	sitting.tw.
14	exp obesity/
15	(obesity * or obese).tw.
16	exp overweight/
17	(overweight or over weight).tw.

Table 2. *Cont.*

Order	Search Terms
18	exp Body Fat Distribution/
19	exp body composition/
20	Waist Circumference/
21	waist circumference.tw.
22	Skinfold Thickness/
23	(skin folds or skin fold *).tw.
24	(body composition * or BMI or body mass index).tw.
25	exp "body weights and measures"/
26	(bio-impedance analysis or BIA).tw.
27	Absorptiometry, Photon/
28	(absorptiometery or densitometry or photodensitometry or DXA or DEXA).tw.
29	Physical Fitness
30	(physical conditioning or physical fitness).tw.
31	musculoskeletal fitness.tw.
32	physical endurance/
33	cardiovascular fitness.tw.
34	motor activit$.tw.
35	physical exertion/
36	aerobic exercise.tw.
37	exp sports
38	play/
39	exp physical education/
40	musculoskeletal physiological processes/ or exercise/ or movement/ or locomotion/ or running/ or swimming/ or walking/ or motor activity/
41	or/4–40
42	(child * or adolescent * or youth * or pediatric * or paediatric *).tw.
43	3 and 41 and 42

Notes: The search strategy for this systematic review was completed in tandem with a sister publication examining the evidence for an overweight/obesity transition among school-age children and youth in Sub Saharan Africa [16]; hence, the inclusion of these terms in the search strategy.

2.4. Data Extraction, Synthesis and Quality Assessment

Data extraction was completed using a standardized data extraction template, and study quality was assessed using a modified Downs and Black instrument [18]. The Downs and Black checklist for measuring quality of evidence was selected for use due to its suitability for quality assessment of original research articles (beyond the typical gauges used for quality assessment of evidence from systematic reviews and meta-analyses) [18]. Due to limitations in study design, questions selected from the Downs and Black quality assessment instrument excluded any questions that referred to intervention and trial study methodology, leaving ten out of a possible 27 questions, as represented in Table 3.

Table 3. Modified Downs and Black checklist [18].

Reporting
Objective Clearly Stated—Question 1 from full checklist (Y = 1/N = 0)
Main Outcomes Clearly Described—Question 2 (Y = 1/N = 0)
Patient Characteristics Clearly Defined—Question 3 (Y = 1/N = 0)
Main Findings Clearly Defined—Question 6 (Y = 1/N = 0)
Random Variability in Estimates Provided—Question 7 (Y = 1/N = 0)
Actual Probability Values Reported—Question 10 (Y = 1/N = 0)
External Validity
Sample Targeted Representative of Population—Question 11 (Y = 1/N = 0)
Sample Recruited Representative of Population—Question 12 (Y = 1/N = 0)
Internal Validity/Bias
Statistical Tests Used Appropriately—Question 18 (Y = 1/N = 0)
Primary Outcomes Valid/Reliable—Question 20 (Y = 1/N = 0)

3. Results

Figure 1 shows the PRISMA flow diagram with numbers of included and excluded articles at each step of the review process, while Table 4 provides a summary of all studies included in this systematic review. A total of 2,657 records were identified through database searches and other sources. Following duplicate removal, 2,242 were screened for eligibility, and 663 were selected for a full-text review. Of these, a total of 71 articles met inclusion criteria, comprising a total sample of 77,515 participants from 17 SSA countries. Reasons for exclusion included: irrelevant population (e.g., studies that did not involve children 5–17 years of age with no pre-existing condition) (181 articles); population living in a country outside of SSA (10); irrelevant outcomes (334); and, excluded study design (67 articles).

Table 4. Descriptive characteristics of included studies.

First Author [reference]	Year	Study Design	Country	Age (Years)	Sample (n)	Outcome (Measures)	D&B Score
Sloan [19]	1967	Cross sectional	South Africa	15–17	393	PF (anaerobic fitness, musculoskeletal fitness)	7
Areskog [20]	1969	Cross sectional	Ethiopia	9–14	153	PF (aerobic fitness, musculoskeletal fitness)	7
Stephenson [21]	1985	Cross sectional	Kenya	7–15	12	PF (aerobic fitness)	7
Corlett [22]	1986	Cross sectional	Botswana	6–11	289	PF (musculoskeletal fitness)	6
Ndamba [23]	1986	Cross sectional	Zimbabwe	8–15	147	PF (aerobic fitness)	7
Corlett [24]	1988	Cross sectional	Botswana	7–12	612	PF (musculoskeletal fitness)	7
Benefice [25]	1992	Cross sectional	Senegal	9–14	100	PF (aerobic fitness, anaerobic fitness, musculoskeletal fitness)	7
Proctor [26]	1996	Cross sectional	Cameroon	9–14	119	PA (self-report)	7
Benefice [27]	1996	Cross sectional	Senegal	5–13	348	PF (aerobic fitness, anaerobic fitness, musculoskeletal fitness)	7

Table 4. *Cont.*

First Author [reference]	Year	Study Design	Country	Age (Years)	Sample (n)	Outcome (Measures)	D&B Score
Benefice [28]	1998	Cross sectional	Senegal	5–13	348	PF (aerobic fitness, anaerobic fitness, musculoskeletal fitness)	7
Prista [29]	1998	Cross sectional	Mozambique	8–15	593	PA (self-report) & PF (aerobic fitness, musculoskeletal fitness)	8
Benefice [30]	1999	Cross sectional	Senegal	12–13	221	PA (direct measures)	8
Benefice [31]	2001	Cross sectional	Senegal	13	40	PA (direct measures)	8
Benefice [32]	2001	Cross sectional	Senegal	13	40	PA (direct measures)	8
Garnier [33]	2001	Cross sectional	Senegal	13–15	80	PA (direct measures) & SB (direct measures)	8
Prista [34]	2003	Cross sectional	Mozambique	6–17	2,316	PA (self-report) & PF (musculoskeletal fitness)	8
McVeigh [35]	2004	Cross sectional	South Africa	9	386	PA (self-report) & SB (self-report)	7
McVeigh [36]	2004	Cross sectional	South Africa	10	386	PA (self-report)	7
Micklesfield [37]	2004	Cross sectional	South Africa	7–11	198	PA (self-report)	7
Larsen [38]	2004	Cross sectional	Kenya	15–17	11	PA (self-report)	7
Benefice [39]	2004	Cross sectional	Senegal	13–15	40	SB (direct measures)	7
Monyeki [40]	2004	Longitudinal	South Africa	7	85	PF (aerobic fitness, anaerobic fitness, musculoskeletal fitness, balance/flexibility)	8
Monyeki [41]	2005	Longitudinal	South Africa	7–14	855	PF (aerobic fitness, anaerobic fitness, musculoskeletal fitness)	8
Benefice [42]	2005	Cross sectional	Senegal	10–13	99	PA (direct)	8
Aandstad [43]	2006	Cross sectional	Tanzania	9–10	156	PA (self-report) & PF (aerobic fitness)	7
Garnier [44]	2006	Cross sectional	Senegal	13–15	80	SB (direct measures)	7
Djarova [45]	2006	Cross sectional	Zimbabwe	6–14	49	PA (self-report) & PF (musculoskeletal fitness)	6
Onyewadume [46]	2006	Cross sectional	Botswana	11–14	30	PF (musculoskeletal fitness)	8
Micklesfield [47]	2007	Cross sectional	South Africa	9	64	PA (self-report) & SB (self-report) & PF (musculoskeletal fitness)	7
Monyeki [48]	2007	Longitudinal	South Africa	7–14	702	PF (aerobic fitness, anaerobic fitness, musculoskeletal fitness)	8

Table 4. *Cont.*

First Author [reference]	Year	Study Design	Country	Age (Years)	Sample (n)	Outcome (Measures)	D&B Score
Bovet [49] [a,b,c]	2007	Cross sectional	Seychelles	12–15	4,343	PF (aerobic fitness, anaerobic fitness, musculoskeletal fitness)	9
Travill [50]	2007	Cross sectional	South Africa	8–17	720	PF (anaerobic fitness, musculoskeletal fitness, balance/flexibility)	7
Monyeki [51]	2008	Longitudinal	South Africa	7–13	1,817	PF (aerobic fitness, anaerobic fitness, musculoskeletal fitness, balance/flexibility)	7
Lennox [52]	2008	Cross sectional	South Africa	15	318	PA (self-report) & SB (self -report) & PF (musculoskeletal fitness, balance/flexibility)	8
Prista [53]	2009	Cross sectional	Mozambique	6–16	256	PA (direct measures)	8
Berntsen [54]	2009	Cross sectional	Tanzania	9–10	190	PF (aerobic fitness)	8
Peltzer [55]	2009	Secondary analysis	Namibia, Kenya, Uganda, Zimbabwe	13–15	12,740	PA (self-report) & SB (self- report)	9
Peltzer [56]	2010	Secondary analysis	Botswana, Kenya, Namibia, Senegal, Swaziland, Uganda, Zambia, and Zimbabwe	13–15	24,593	PA (self-report) & SB (self- report)	9
Harmse [57]	2010	Cross sectional	South Africa	13–17	221	PF (aerobic fitness)	7
Senbanjo [58]	2010	Cross sectional	Nigeria	5–14	392	PA (self-report)	8
Truter [59]	2010	Cross sectional	South Africa	9–13	280	PF (aerobic fitness)	7
Odunaiya [60]	2010	Cross sectional	Nigeria	14–16	608	PA (self-report)	7
Ansa [61]	2010	Cross sectional	Nigeria	10–17	964	PA (sel- report)	8
Adeniyi [62]	2011	Cross sectional	Nigeria	13–17	1,100	PA (self-report)	7
Peltzer [63] [c]	2011	Secondary analysis	Ghana & Uganda	13–15	5,613	PA (self-report) & SB (self- report)	9
Naude [64]	2011	Cross sectional	South Africa	12–16	162	PA (self-report) & SB (self -report)	5
Croteau [65]	2011	Cross sectional	Kenya	8–12	72	PA (direct measures)	8
Muller [66]	2011	Cross sectional	Côte d'Ivoire	7–15	17	PF (aerobic fitness)	7
Dapi [67]	2011	Cross sectional	Cameroon	12–16	227	PA (self-report)	8
Puckree [68]	2011	Cross sectional	South Africa	10–12	120	PA (self-report) & SB (self-report)	7

Table 4. *Cont.*

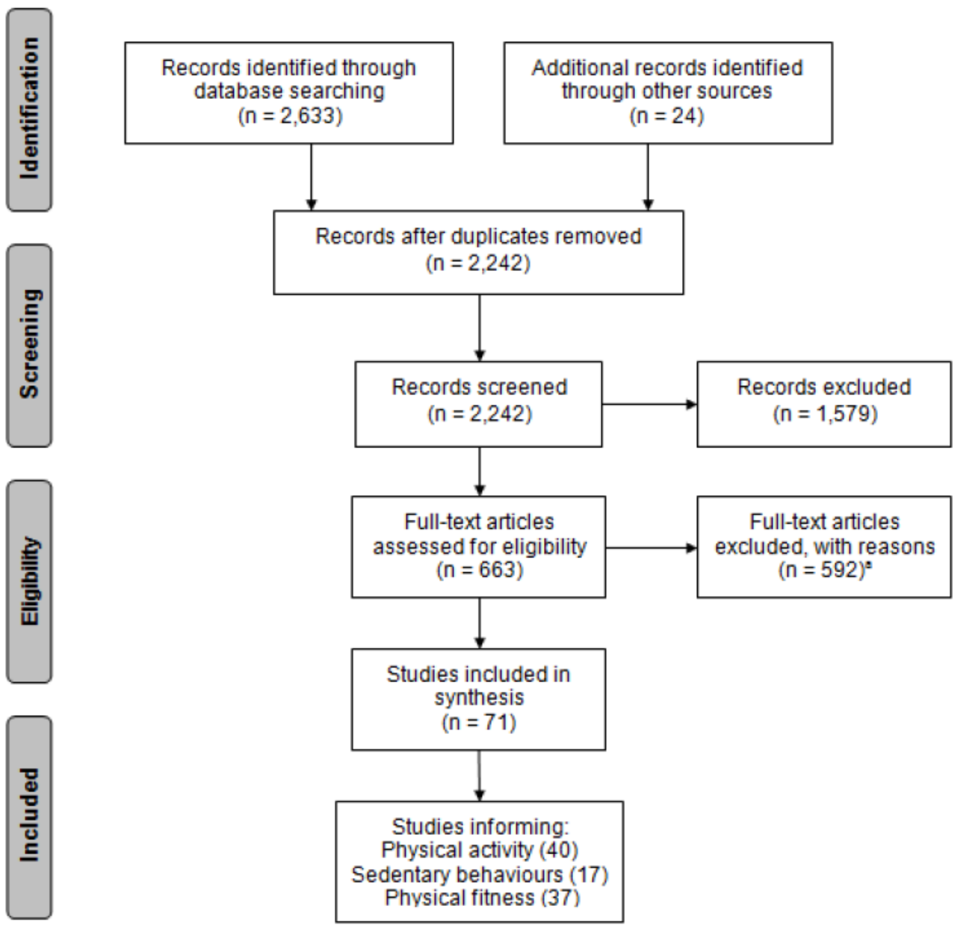
First Author [reference]	Year	Study Design	Country	Age (Years)	Sample (n)	Outcome (Measures)	D&B Score
Armstrong [69] [c]	2011	Cross sectional	South Africa	6–13	10,295	PF (aerobic fitness, anaerobic fitness, musculoskeletal fitness, balance/flexibility)	10
Adamo [70]	2011	Cross sectional	Kenya	9–13	179	PF (aerobic fitness, anaerobic fitness, musculoskeletal fitness)	7
Naidoo [71]	2012	Cross sectional	South Africa	7–10	170	PF (aerobic fitness)	7
Musa [72]	2012	Cross sectional	Nigeria	9–15	3,243	PF (aerobic fitness)	7
Monyeki [73]	2012	Longitudinal	South Africa	14	256	PF (anaerobic fitness, musculoskeletal fitness)	8
Onywera [74]	2012	Cross sectional	Kenya	9–12	169	PA (direct measures & self- report) & SB (self-report)	7
Ojiambo [75]	2012	Cross sectional	Kenya	12–16	200	PA (direct measures & self -report) & SB (direct measures & self-report)	7
Richards [76]	2012	Cross sectional	Uganda	11–14	31	PA (direct measures)	8
Micklesfield [77]	2012	Cross sectional	South Africa	11–15	381	PA (self-report) & SB (self -report)	6
Monyeki [78]	2012	Cross sectional	South Africa	14	256	PF (anaerobic fitness, musculoskeletal fitness)	8
Monyeki [79]	2012	Cross sectional	South Africa	14–15	153	PA (self-report) & PF (aerobic fitness)	8
Truter [80]	2012	Cross sectional	South Africa	9–13	280	PF (anaerobic fitness)	7
Bovet [81] [a,b]	2012	Cross sectional	Seychelles	9–16	8,462	PA (self-report)	9
Pienaar [82]	2012	Longitudinal	South Africa	13–17	87	PA (self-report)	8
Toriola [83]	2012	Longitudinal	South Africa	14	283	PA (self-report) & SB (self- report) & PF (aerobic fitness, anaerobic fitness, musculoskeletal fitness, balance/flexibility)	8
Craig [84]	2012	Secondary analysis	South Africa	7, 11, 15	89	PA (direct measures)	9
Ojiambo [85]	2012	Cross sectional	Kenya	13–16	200	PA (direct measures) & SB (direct measures)	7
Malete [86]	2013	Cross sectional	Botswana	13–16	756	PA (self-report) & SB (self-report)	7

Table 4. *Cont.*

First Author [reference]	Year	Study Design	Country	Age (Years)	Sample (n)	Outcome (Measures)	D&B Score
Onywera [87]	2013	Cross sectional	Kenya	9–13	179	PA (direct measures)	7
Heroux [88]	2013	Cross sectional	Kenya	9–13	179	PF (musculoskeletal fitness)	7
				Total (*n*)	77,515	Average D&B score	7.5

Notes: D & B score (Downs & Black score) [18]; PA = physical activity, SB = sedentary behaviour, PF = physical fitness. [a] = Article indicated targeting a sample size representative of the population of interest (2 articles). [b] = Article indicated recruiting a sample size representative of the population of interest (2 articles). [c] = Article indicated that the sample size was nationally representative (3 articles).

Figure 1. PRISMA flow chart of search strategy results.



Notes: PRISMA flow diagram [89]; [a] Reasons for exclusion included irrelevant population (181 studies), irrelevant geographic location/not Sub Saharan Africa (10 studies), irrelevant outcomes (334 studies), and irrelevant content/study design e.g. intervention programs or review articles (67 studies).

Data quality assessment revealed that the average score for all included studies was 7.5 out of a possible 10, pointing to a fairly high quality of evidence of the individual articles. The earliest relevant record captured was published in 1967, with two articles published between 1960 and 1969, none between 1970 and 1979, four articles between 1980 and 1989, six articles between 1990 and 1999, 26 articles between 2000 and 2009, and 33 articles published between 2010 and June 2013. This substantial increase in the publishing rate may be representative of a growing interest in this field of research. There was also good representation of the four regions of SSA with 20 (28.2%) articles from East African countries, 30 (42.3%) from South African countries, 16 (22.5%) from West African countries, two (2.8%) from Central African countries, and three (4.2%) that were combined.

3.1. Physical Activity

As shown in Table 5, 36 studies comprising 62,188 participants, presented in 40 articles, examined physical activity outcome(s). Of the 36 studies, 26 (72.2%) studies [26,29,34,35,37,38,43,45,47,52,55,56,58,60–64,67,68,77,79,81–83,86] used solely subjective measurements of physical activity (e.g., self-report or interviewer administered questionnaires), and 10 (27.8%) studies [30–33,42,53,65,74–76,84] used direct/objective measures (e.g., accelerometers, pedometers) or a combination of direct and subjective measures. Table 5 indicates the type the type of measure used and the main findings for each of the 36 studies. Despite the heterogeneity in the types of physical activity measures used in the included studies, some findings stood out from the data taken together.

Table 5. Findings from studies reporting on physical activity outcomes.

First Author [reference]	Year	Country	Age (years)	(n) Total	(n) Male	(n) Female	Main Finding(s) *
Subjective Measures (Self-report or interviewer administered questionnaires)							
Proctor [26]	1996	Cameroon	9–14	119	65	54	Physical activity among rural children was more than twice that of urban children, and was mostly work related and heavier intensity.
Prista [29]	1998	Mozambique	8–15	593	277	316	Underprivileged children had higher levels of physical activity due to survival activities (e.g., walking).
Prista [34]	2003	Mozambique	6–17	2,316	1,094	1,222	Low SES children and adolescents had higher levels of physical activity due to higher demands of survival activities and playing, but spent less time in formal sports than their more privileged peers.
McVeigh [35]	2004	South Africa	9	386	202	184	Inverted bell shape curve for association between percent physical activity levels and SES. The highest SES had the highest MVPA. Also discusses differences between different ethnicities.
Micklesfield [37]	2004	South Africa	7–11	198	0	198	Discussed differences between different ethnicities.

Table 5. *Cont.*

First Author [reference]	Year	Country	Age (years)	(n) Total	(n) Male	(n) Female	Main Finding(s) *
Subjective Measures (Self-report or interviewer administered questionnaires)							
Larsen [38]	2004	Kenya	15–17	11	11	0	Village boys were significantly more habitually active (e.g., running, field work) than town boys.
Aandstad [43]	2006	Tanzania	9–10	156	87	69	88% of rural children walked to school, 71% for more than 15 min, and 34% participated in outdoor games after school on most or all days.
Djarova [45]	2006	Zimbabwe	6–14	49			Mean duration of activities during the day (hours): Sleeping 8.2, walking 2.4, sitting 3.9, standing 2.0, running 1.0, sports 2.5, playing 4.0.
Micklesfield [47]	2007	South Africa	9	64	36	28	Mean hours of participation in school physical education 1.1, school sports 1.4, informal activities 7.7, and weekend activities 8.
Lennox [52]	2008	South Africa	15	318	137	181	Lower SES school had higher activity levels, particularly, walking to school.
Peltzer [55]	2009	Namibia, Kenya, Uganda, Zimbabwe	13–15	12,740	7,517	5,223	Physical activity on ≥3 days (for ≥ 60 min) ranged from 24.4% to 36.0%. Active transport on ≥5 days (for ≥60 min) ranged from 19.8% to 31.1%.
Peltzer [56]	2010	Botswana, Kenya, Namibia, Senegal, Swaziland, Uganda, Zambia, and Zimbabwe	13–15	24,593	10,575	14,018	A range of 9.0% to 17.7% of children reported being physically active on ≥5 days (for ≥60 min). The average was 14.2% in the total sample, 16.6% in males, and 12.0% in females. 18.9% of the total sample was physically active on ≥3 days (for ≥60 min).

Table 5. *Cont.*

First Author [reference]	Year	Country	Age (years)	(n) Total	(n) Male	(n) Female	Main Finding(s) *
Subjective Measures (Self-report or interviewer administered questionnaires)							
Senbanjo [58]	2010	Nigeria	5–14	392	202	190	Frequency of leisure time physical activity on ≥3 days in 5–9 year old males (3.2%), females (6.0%), in 10–14 year old males (20.1%), females (12.3%). Leisure time physical activity was higher in older children, in males, and in children of mothers with higher education level.
Odunaiya [60]	2010	Nigeria	14–16	608			64.1% of the total sample participated in moderate and high physical activity.
Ansa [61]	2010	Nigeria	10–17	964	472	492	75% of the total sample participated in outdoor sports. No SES effect found (not significant).
Adeniyi [62]	2011	Nigeria	13–17	1,100	538	562	Females had higher risk of low physical activity than boys.
Peltzer [63]	2011	Ghana & Uganda	13–15	5,613	2,738	2,875	78.5% of males and 84.9% of females were physically active for less than 60 min per day on at least 5 days per week.
Naude [64]	2011	South Africa	12–16	162			33% of the total sample participated in organized sports.
Dapi [67]	2011	Cameroon	12–16	227	108	119	Boys had significantly higher levels of physical activity than girls. No SES effect found (not significant).
Puckree [68]	2011	South Africa	10–12	120	48	72	92% of the total sample participated in extracurricular sporting activities.
Micklesfield [77]	2012	South Africa	11–15	381			Informal activity was significantly lower in older children. MVPA was significantly lower in girls than boys at all ages. Low SES was associated with higher walking for transport and lower MVPA in schools or clubs.
Monyeki [79]	2012	South Africa	14–15	153	0	153	26.8% of girls participated in moderate and high physical activity.
Bovet [81]	2012	Seychelles	9–16	8,462	4,239	4,223	There was higher leisure time physical activity in private compared to public schools, but higher active transport (walking) in public compared to private schools.

Table 5. *Cont.*

First Author [reference]	Year	Country	Age (years)	(n) Total	(n) Male	(n) Female	Main Finding(s) *
Subjective Measures (Self-report or interviewer administered questionnaires)							
Pienaar [82]	2012	South Africa	13–17	87	28	59	There was increased leisure time physical activity over time, higher house-chore related physical activity on weekends compared to weekdays, and higher exercise related activity on week days compared to weekends.
Toriola [83]	2012	South Africa	14	283	111	172	Boys had higher physical activity in the high/vigorous level compared to girls.
Malete [86]	2013	Botswana	13–16	756	464	292	Low SES and rural children had more minutes of physical activity than high SES or urban children.
Direct/Objective Measures							
Benefice [30]	1999	Senegal	13	221	0	221	Instrument: CSA accelerometer. Findings: Percentage of time spent during 12 hours of a day in MVPA (>940 counts/min corresponding to >6 METs) was 21.7% in the dry season, 29.3% in the rainy season, and 24.3% (corresponding to 2.9 h) in total.
Benefice [31]	2001	Senegal	13	120 (40 at each visit)			Instrument: CSA accelerometer. Findings: Time spent in moderate and vigorous activity was 29.12% (corresponding to 4.4 h) at the 1st visit in 1997, 25.71% (corresponding to 3.9 h) at the 2nd visit in 1998, and 25.54% (corresponding to 3.8 h) at the 3rd visit in 1999. Daily physical activity was expressed as a physical activity level unit (ratio of energy expenditure to BMR). Three units of BMR corresponded to 890 counts/min. MVPA was therefore a BMR corresponding to >1,890 counts/min and was calculated as a percent of 15 h or time between 7 a.m. and 10 p.m.
Garnier [33]	2001	Senegal	13–15	80	0	80	Instrument: CSA accelerometer. Findings: Migrants to the city spent more time engaged in moderate to heavy activity than did non-migrants in the rural area (9.3 h/24 h *vs.* 6.1 h/24 h). Intensity thresholds were defined according to Benefice & Cames, whereby MVPA was >610 counts/min or ≥3 METs [30].

Table 5. *Cont.*

First Author [reference]	Year	Country	Age (years)	(n) Total	(n) Male	(n) Female	Main Finding(s) *
Direct/Objective Measures							
Benefice [42]	2005	Senegal	10–13	99	46	53	Instrument: Cardio-frequencemeters. Findings: In adolescent girls, body composition was a significant predictor of activity levels.
Prista [53]	2009	Mozambique	6–16	256	139	117	Instrument(s): Actigraph accelerometer and self-report measures. Findings: Software converted actigraph counts into relative energy exposure using the regression equation developed by Freedson *et al.* for children 6–18 years of age [90]. The average minutes of time spent in MVPA (≥3 METs) in boys and girls 6–8 years of age was 232.2 and 235.5, in boys and girls 9–11 years of age was 202.0 and 210.3, and in boys and girls 12-16 years of age was 157.4 and 158.7. This corresponds to range of 2.6–3.9 hours for the total sample.
Croteau [65]	2011	Kenya	8–12	72	29	43	Instrument(s): Pedometers (step count data) and self-report measures. Findings: Daily steps in total sample 14,558 ± 3,993. Boys (16,262 ± 4,698) were significantly more active than girls (13,463 ± 3,051). No significant effect for age was found. Observed daily steps are higher than those observed in the USA and samples in other developed countries.
Onywera [74]	2012	Kenya	9–12	169	85	84	Instrument(s): Pedometers (step count data) and self-report measures. Findings: Rural children were more physically active than urban children. 87% rural children and 42% urban children used active transport to get to school.
Ojiambo [75]	2012	Kenya	12–16	200	99	101	Instrument: Actigraph accelerometer. Physical activity levels were assessed using cut-points developed by Puyau *et al.* whereby MVPA >3,200 counts/min [91]. The mean minutes of MVPA were 54 (corresponding to 0.9 h) in the total sample, 68 in rural males, 62 in rural females, 50 in urban males, and 37 in urban females.

Table 5. *Cont.*

First Author [reference]	Year	Country	Age (years)	(n) Total	(n) Male	(n) Female	Main Finding(s) *
Direct/Objective Measures							
Richards [76]	2012	Uganda	11–14	31	31	0	Instrument: Actigraph accelerometer. Findings: Mean minutes per day of MVPA were 114.09 (corresponding to 1.9 h), with only 4.32 minutes in the vigorous range. (MVPA cut-points not indicated).
Craig [84]	2013	South Africa	7–15	89	46	43	Instrument: Actigraph accelerometer. Findings: Total physical activity was generally high (mean accelerometer counts per minute ranged 485–1017), but MVPA was low with less than 1% of the total sample meeting the MVPA guidelines using the Puyau *et al.* cut points [91]. MVPA in boys comprised 1.7% of waking hours (12 min/day) at age 7, 1.3% (10 min/day) at age 11, and 0.6% (4 min/day) at age 15. MVPA in girls comprised 1.5% (11 min/day) at age 7, 0.9% (6 min/day) at age 11, and 0.2% (1 min/day) at age 15 years.

Notes: SES (socioeconomic status); MVPA (moderate-to-vigorous physical activity); Counts/min (counts per min); BMR (basal metabolic rate); METs (metabolic equivalents). Table excludes references [32,36,85,87] which used an identical study sample as used in another included manuscript. * Main finding(s) from the article as relates to physical activity outcomes.

3.1.1. Physical Activity Transition

Of the articles that used direct measures, seven studies [30,31,33,53,75,76,84] used accelerometry to measure physical activity. Only one study examined the changing trends over time. Benefice *et al.* found a decline in the amount of time spent in moderate-to-vigorous intensity physical activity (MVPA) from 29.12% (corresponding to 4.4 h) in 1997, to 25.71% (3.9 h) in 1998 and 25.54% (3.8 h) in 1999 [31]. Studies that used accelerometry used varying MVPA cut-points to categorise their samples making it impossible to comment on trends over time. As such, the general trend towards decreasing proportions of MVPA from earlier studies (1999–2009) with sample means of ≥2.6 h of MVPA [30,31,33,53] to later studies (2012) with sample means of ≤1.9 h of MVPA [75,76,84] as observed in Table 5, may be related to more stringent cut-points rather than decreasing levels of physical activity in these samples. In general, a lack of population-representative samples and heterogeneity of measurement protocols did not allow for a clear assessment of physical activity level trends over time.

One large scale, multi-country study using subjective measures with a sample of 24,593 participants reported that 14.2% (16.6% of males, 12.0% of females) of children were physically active on 5 days or more, for at least 60 min/day during leisure time [56]. The proportion was 18.9% of children on 3 days or more, for at least 60 min/day during leisure time [56]. Step count data determined that the observed average number of daily steps was higher than those of the United States and samples in other developed countries [65].

3.1.2. Socioeconomic (SES) and Urban/Rural Differences

Of the 14 studies using subjective measures to examine the association between physical activity and SES, 11 found that lower SES and rural children had higher levels of physical activity compared to higher SES and urban children, or children who had mothers with a higher educational level [26,29,34,38,43,52,58,74,77,81,86], while three found contradicting evidence or no SES differences [35,61,67]. Lower SES and rural children engaged in higher levels of active transportation (e.g., walking and running to school) [43,52,74,77,81], spent more time in activities of daily living (e.g., house chores, work related, habitual activity) [26,29,34,38], but, spent less time engaged in organized sports or formal activities compared to their higher SES and urban peers [77,81]. Directly measured physical activity (both accelerometry and pedometer data) also found that rural children were more physically active than urban children [74,75].

3.1.3. Sex Differences

Of the six studies using subjective data collection methods and that examined the differences in physical activity trends in boys and girls, five studies found higher levels of physical activity (e.g., informal activity, leisure time physical activity, MVPA) in boys compared to girls irrespective of age [56,63,67,77,83], while one study found that this was only true in the higher age-group (10–14 years), but not in lower age-group (5–9 years) [58]. Similarly, directly measured physical activity (both accelerometry and pedometer data) found that boys were significantly more active than girls [65,84].

3.2. Sedentary Behaviours

As shown in Table 6, a total of 17 studies examining sedentary behaviours, comprising 33,525 participants, were included in this review. Of these, the majority (12 studies) used self-report measures [35,47,52,55,56,63,64,68,74,77,83,86], and five studies used direct measurements [33,39,44,75,85]. Specific measurement tools varied across studies, but total weekday and/or weekend television viewing time was most often studied. All studies examining sedentary behaviour were published after 2000, with the majority published in the last three years (*i.e.*, since 2010).

Table 6. Findings from studies reporting on sedentary behaviour outcomes.

First Author [reference]	Year	Country	Age (Years)	(n) Total	(n) Male	(n) Female	Main Finding(s) *
Subjective Measures (Self-report or interviewer administered questionnaires)							
McVeigh [35]	2004	South Africa	9	386	202	184	Sedentary activity (h/day) among white girls 8.61 (±0.54), black girls 9.03 (±0.34), white boys 10.48 (±0.79), and black boys 10.63 (±0.33).

Table 6. *Cont.*

First Author [reference]	Year	Country	Age (Years)	(n) Total	(n) Male	(n) Female	Main Finding(s)*
Subjective Measures (Self-report or interviewer administered questionnaires)							
Micklesfield [47]	2007	South Africa	9	64	36	28	Average min per day spent on television watching was 123 ± 8.3.
Lennox [52]	2008	South Africa	15	318	137	181	TV h during the week in school 1 "(lower SES) & school 2 (higher SES) among boys 1.92 (1.43) & 2.24 (1.27), in school 1 & 2 among girls 1.76 (1.32) & 2.53 (1.38). TV hrs during the weekend in school 1 & 2 among boys 3.31 (2.10) & 3.62 (2.50), in school 1 & 2 among girls 2.74 (1.94) & 3.28 (2.38).
Peltzer [55]	2009	Namibia, Kenya, Uganda, Zimbabwe	13–15	12,740	7,517	5,223	Proportion of children reporting less than 3 h of sitting/day was 56.6% for Kenya, 64.3% for Namibia, 70.3% for Uganda, and 56.3% for Zimbabwe.
Peltzer [56]	2010	Botswana, Kenya, Namibia, Senegal, Swaziland, Uganda, Zambia, and Zimbabwe	13–15	24,593	10,575	14,018	Overall time spent sitting on a usual day for <1 h was 39.4%, 1–2 h was 32.7%, 3–4 h was 17.5%, ≥5 h was 11.2%.
Peltzer [63]	2011	Ghana and Uganda	13–15	5,613	2,738	2,875	Sedentary behavior (≥ 3h/day) in males was 27.1% (23.6–30.5), in females was 26.9% (24.3–29.6).
Naude [64]	2011	South Africa	12–16	162			Mean total weekly time (min) spent watching TV or playing on the computer was 1,001 (±570).
Puckree [68]	2011	South Africa	10–12	120	48	72	All sampled children reported watching >4 h of TV on weekdays and 6–8 h on weekends.
Onywera [74]	2012	Kenya	9–12	169	85	84	30% of rural children spent >2 h/week on screen time compared with 50% of urban children, and 62.5% of the rural children spent 0 h/week playing screen games compared with 13.1% of urban children.

Table 6. *Cont.*

First Author [reference]	Year	Country	Age (Years)	(n) Total	(n) Male	(n) Female	Main Finding(s)*
Subjective Measures (Self-report or interviewer administered questionnaires)							
Micklesfield [77]	2012	South Africa	11–15	381			Sedentary activity was significantly higher in older girls compared to younger counterparts ($p < 0.05$). Increasing pubertal status was associated with an increase in sedentary activity. Lower SES at the maternal, household, and community level was significantly associated with less sedentary activity.
Toriola [83]	2012	South Africa	14	283	111	172	Overall, 18%, 23%, and 40% watched TV for >3 h, 2–3 h, <1 h per day, respectively. More girls (19%) than boys (16%) watched TV for >3 h/day.
Malete [86]	2013	Botswana	13–16	756	464	292	Time spent sitting (min/week) was 2,612.38 (±910.87) or 6.2 h/day.
Direct/Objective Measures							
Garnier [33]	2001	Senegal	13–15	80	0	80	Instrument: CSA accelerometer. Findings: Sleeping and inactivity of migrants (who move for work) was 6 h and 42 min, and of non-migrants 8h and 29 min.
Benefice [39]	2004	Senegal	13–15	40 (in each year)	0	40 (in each year)	Instrument: CSA accelerometer. Findings: Resting time (min)—defined as the number of zero counts during the day—was 93 (±54) in the year 1997, 111 (±65) in 1998, and 103 (±51) in 1999.
Garnier [44]	2006	Senegal	13–15	80	40	40	Instrument: CSA accelerometer. Findings: Girls were more inactive (4 h and 23 min) than boys 2 h and 49 min).
Ojiambo [75]	2012	Kenya	12–16	200	99	101	Instrument: Actigraph accelerometer. Findings: Min (%) sedentary time in total sample was 584 ± 113 (72%); in rural males was 555 ± 67 (65%), in rural females was 539 ± 91 (66%), in urban males was 678 ± 95 (78%), and in urban females was 694 ± 81 (80%).
Ojiambo [85]	2012	Kenya	13–16	200	98	102	Instrument: Actigraph accelerometer. Findings: Daily mean sedentary time (min) was 619 ± 109, or approximately 78% of the monitored time.

Notes: SES (socioeconomic status); TV (television). * Main finding(s) from the article as relates to sedentary behaviour outcomes.

3.2.1. Sedentary Behaviour Transition

In South Africa, self-reported time spent watching television was inconsistent. Recent work by Puckree *et al.* showed that 100% of participants aged 10–12 years watched more than 4 h of television on weekdays, and 6–8 h of television on weekends [68]. Toriola and Monyeki reported that 40% of 14 year old participants watched less than 1 hour of television per day [83]. In other studies, the self-reported mean television viewing time was between 2 and 2.5 h per day for 9–16 year old children, with weekend television viewing slightly higher at 2.7 to 3.6 h, and television viewing generally higher in older children [47,52,64]. Data from Ghana and Uganda found that 27% of children aged 13–15 years spent more than 3 h per day in sedentary pursuits [63], while in Botswana, 14 year olds spent an average of 6.2 hours per day sitting [86]. Senegalese youth reported only 1.33 to 1.41 h of sedentary time per day [39].

One multi-country comparative study found that in children 13–15 years of age, the proportion reporting less than 3 h of sitting per day was 29.7% in Uganda, 25.7% in Namibia, 43.4% in Kenya, and 43.7% in Zimbabwe [55]. Another large scale multi-country study using data from eight African countries (Botswana, Kenya, Namibia, Senegal, Swaziland, Uganda, Zambia, and Zimbabwe) found that 39.4% of children aged 13–15 years spent less than one hour per day sitting, and an additional 32.7% spent 1–2 h per day sitting when not in school or doing homework [56].

Notably, the short time span within which the studies reporting on sedentary behaviour were published made it impossible to examine transitions over time, since temporal trends are often reasonably stable over short periods of time.

3.2.2. Sex Differences

Accelerometry measured sedentary time showed that Senegalese girls spent more time in sedentary behaviours than boys (4.23 h *vs.* 2.49 h) [44]. Investigation of self-reported television viewing also found that more girls (19%) than boys (16%) watched television for more than 3 hours daily [83]. Most studies however either found no significant difference or did not report on the difference in sedentary behaviours between boys and girls [35,52,63,75].

3.2.3. Age Differences

One included study examined age differences and found that sedentary activity was significantly higher in older girls compared to their younger counterparts [77]. This study also showed that increasing pubertal status, which is not a proxy for age, was associated with an increase in sedentary behaviours, but that the most significant determinant of sedentary behaviour was SES [77].

3.2.4. SES and Urban/Rural Differences

Higher SES and urban living children in Kenya were found to spend significantly more time in sedentary pursuits than their lower SES and rural counterparts, with approximately 50% of the urban children, and only 30% of the rural children reporting spending over 2 hours each week on screen time activities [74,75]. This is consistent with the findings of Lennox *et al.* showing that South African children in higher SES schools spent more time watching television than children in lower SES schools on both weekdays and weekends [52]. Additionally, Micklesfield *et al.* found that higher maternal, household, and community level SES were significantly associated with increased sedentary time [77]. In contrast, Malete *et al.*, found that public school students and those living in rural villages (lower SES) reported significantly more minutes of sitting than students in private schools or students from cities (higher SES); which is an unexpected finding given that the former group also reported more vigorous and total physical activity than the latter [86].

3.3. Physical Fitness

Thirty six included studies, presented in 37 papers, comprising 30,452 participants, examined physical fitness measures. The majority of these studies were published in the past three years, but studies were included from as early as 1967 [19]. Almost half (47.2%) of the 36 fitness related studies included South African participants. All studies used direct measures of physical fitness. Studies are presented based on whether they examined aerobic fitness, anaerobic fitness, musculoskeletal fitness and strength, or balance and flexibility, with many of the studies examining more than one aspect of physical fitness.

3.3.1. Aerobic Fitness

Twenty one studies presented data on aerobic fitness. Aerobic fitness was measured through shuttle run [29,41,43,48,49,51,52,57,66,69–72,79,83,88], maximal cycle ergometer test [20,54], maximal aerobic capacity [52,59], distance run [23,29,41,48,51], and the Harvard Step test [21]. Boys were found to have higher aerobic capacity and performed considerably better on measures of aerobic fitness than girls [23,41,49,54,59,66,72,83,88].

Two studies found that lower SES and rural children performed better on measures of aerobic fitness than higher SES and urban children [52,70]. In contrast, one study found the opposite to be true when comparing girls in the townships (lower SES) to girls in the towns (higher SES) [79]. It is noteworthy that in the latter study, township girls were also found to have significantly higher prevalence of underweight than the town girls. Aandstad *et al.* found that Tanzanian children had better aerobic fitness test results when compared to a Norwegian reference group [43].

Only one study examined changes over time in aerobic fitness tests. In their study of 702 rural South African children, Monyeki *et al.* found significant improvements in aerobic fitness results (shuttle run and 1,600 m run tests) from 2001 to 2002 though this was only across one year [48]. However, when data from studies using similar measures of aerobic fitness (*i.e.*, shuttle run [41,48,51,69] and 1,600 m run [41,48,51]) were examined, we found largely unaltered trends in aerobic fitness over time, with boys performing better than girls as shown in Table 7.

3.3.2. Anaerobic Fitness

Seventeen studies presented data on anaerobic fitness. This was measured though timed dashes/sprints [19,25,27,28,40,41,48–50,70] or long jumps [25,27,28,40,41,48–51,69,73,78,83]. Boys performed better in all measures of anaerobic fitness than girls [41,49,83]. Anaerobic test parameters in Senegalese children were found to be inferior to those of well-nourished Western children [25,28]. No temporal trend evidence was available.

Table 7. Findings from studies reporting on comparable physical fitness outcomes.

First Author [reference]	Year	Country	Age (Years)	(n) Boys	(n) Girls	(10 × 5m) Shuttle Run (sec)		Run 1,600 (m)		Grip Strength (kg)		Sit & Reach (cm)	
						B	G	B	G	B	G	B	G
Corlett [24]	1988	Botswana	7 (Urb)	18	17					11.9 (0.3)	11.6 (1.0)		
			7 (Rur)	19	31					7.4 (1.3)	6.3 (1.1)		
			8 (Urb)	26	29					12.4 (0.8)	11.6 (0.5)		
			8 (Rur)	25	24					9.2 (1.1)	7.8 (1.6)		
			9 (Urb)	18	30					13.4 (0.9)	12.7 (0.8)		
			9 (Rur)	32	37					9.8 (1.1)	8.4 (1.0)		
			10 (Urb)	28	20					15.6 (1.2)	14.0 (0.6)		
			10 (Rur)	43	25					12.4 (2.2)	10.0 (1.7)		
			11 (Urb)	24	18					17.4 (1.3)	15.1 (1.1)		
			11 (Rur)	30	38					13.7 (1.7)	12.8 (2.0)		
			12 (Urb)	17	16					20.2 (1.4)	16.8 (1.5)		
			12 (Rur)	36	32					16.5 (2.3)	15.2 (2.8)		
Monyeki [48] *	2001	South Africa	7–10	152	133	22.9 (2.1)	23.2 (1.9)	489.8 (42.0)	531.2 (62.9)				
	2002		7–10	228	189	21.9 (2.1)	21.8 (2.1)	475.3 (48.0)	514.6 (57.7)				
	2001		11–15	152	133	22.0 (1.8)	22.2 (1.7)	452.9 (40.5)	511.8 (59.8)				
	2002		11–15	228	189	21.2 (1.9)	21.5 (1.6)	460.7 (53.8)	529.3 (79.6)				
Monyeki [40]	2004	South Africa	7	47	38							14.1 (4.1)	15.0 (5.1)
Monyeki [41]	2005	South Africa	7	46	36	24.6 (2.3)	24.3 (3.1)	516 (36.5)	546 (42.8)			14.1 (4.2)	14.4 (5.1)
			8	58	54	22.8 (1.8)	23.3 (1.8)	486 (32.5)	528 (60.4)			15.5 (4.8)	16.5 (3.8)
			9	71	60	22.0 (1.5)	22.6 (1.7)	474 (43.1)	522 (65.1)			14.3 (5.1)	15.6 (4.6)

Table 7. *Cont.*

First Author [reference]	Year	Country	Age (Years)	(n) Boys	(n) Girls	(10 × 5m) Shuttle Run (sec)		Run 1,600 (m)		Grip Strength (kg)		Sit & Reach (cm)	
						B	G	B	G	B	G	B	G
			10	80	70	22.0 (2.2)	22.8 (1.9)	456 (39.6)	510 (53.0)			14.4 (5.1)	15.8 (4.6)
			11	69	74	21.8 (1.9)	22.1 (1.7)	450 (41.0)	498 (50.3)			15.7 (5.1)	16.9 (5.1)
			12	87	67	21.8 (1.6)	21.9 (1.5)	450 (40.4)	510 (44.1)			13.8 (4.8)	17.8 (5.0)
			13	35	21	21.3 (1.2)	21.6 (1.3)	438 (34.4)	504 (83.1)			12.8 (5.3)	17.6 (4.2)
			14	16	11	20.7 (1.2)	21.5 (1.1)	408 (56.7)	528 (89.9)			14.1 (5.2)	19.5 (6.2)
Onyewadume [46]	2006	Botswana	11–14	15	15					34.6 (7.3)	24.1 (5.1)		
Monyeki [51]	2008	South Africa	7	80	61	23.8 (2.6)	23.7 (2.9)	549.2 (94.6)	570.7 (69.0)				
			8	86	82	23.0 (2.3)	23.3 (2.6)	523.6 (76.3)	563.6 (87.2)				
			9	107	89	22.7 (2.2)	22.3 (2.0)	500.2 (78.9)	535.0 (80.9)				
			10	102	108	22.3 (1.8)	22.4 (1.7)	496.7 (84.0)	527.6 (67.6)				
			11	111	94	21.9 (2.1)	21.8 (1.8)	479.5 (64.3)	526.9 (74.2)				
			12	99	82	21.7 (1.7)	21.9 (1.9)	475.5 (83.1)	523.0 (82.2)				
			13	49	42	21.4 (1.4)	21.6 (1.3)	463.9 (96.9)	501.9 (128.6)				
Lennox [52]	2008	South Africa										School 1	
			15 (RR)	116	136							29.0	31.1
			15 (RL)	116	136							29.1	31.5
												School 2	
			15 (RR)	21	45							27.5	29.1
			15 (RL)	21	45							27.6	28.6
Armstrong [69]	2011	South Africa	6–13	5,611	4,684	22.8	23.8					21.4	23.7
Toriola [83]	2012	South Africa	14	111	172							42.2 (9.1)	48.5 (7.3)
Heroux [88]	2013	Kenya	9–13	86	93					34.7 (32.0, 37.3)	31.1 (28.7 , 3.5)		

Notes: B (boys); G (girls); Urb (urban); Rur (rural); RR (reach-right); RL (reach-left). Where reported, variance included in brackets as (standard deviation) or (confidence intervals). School 1 had lower socioeconomic status than school 2 [52]. (*) Study was published in 2007, but data was collected in the years indicated, *i.e.*, 2001 and 2002.

3.3.3. Musculoskeletal Fitness and Strength

Twenty five studies examined musculoskeletal fitness and strength. This was measured via bent arm hang [41,48,51,73,78,83], grip strength [20,24,25,27,29,45–47,50,52,68,70,88], timed push-ups [46,49], timed sit-ups [19,29,40,41,46,48,49,51,52,69,73,78,83], or throwing [19,25,27,28,49,69]. Boys performed better than girls in measures of bent arm, sit-ups, and push-ups [41,83].

As shown in Table 7, when data from studies using a similar measure of grip strength (kilograms) were examined, we found a trend towards increasing scores in both boys and girls over time [24,46,88]. It is however important to note that geographical differences between Botswana [24,46] and Kenya [88] may be clouding these findings. Further, even within the studies from Botswana, there was little overlap among the age groups, further complicating temporal trend analysis. From these data, it was also determined that boys performed better than girls in grip strength measurements [24,46,88]. Grip strength seemingly increased with age [50], and was found to be higher in higher SES and urban children compared to lower SES and rural children [24,70]. In general, measures of skeletal muscle fitness and strength were found to be lower in SSA children compared to various Western reference samples (e.g., United States, the Netherlands) [22,25,28,50].

3.3.4. Balance and Flexibility

Eight studies presented data on balance and flexibility. This was measured via flamingo balance [41,51] and sit-and-reach test [22,40,41,50,52,69,83]. Girls were more flexible and performed better in balance tests than boys [41,50,83]. As shown in Table 7, when data from studies examining sit and reach (cm) performance were assessed, we found a trend towards increasing measures of flexibility in both sexes, with girls performing consistently better than boys [40,41,52,69,83]. It is however important to note that these apparent increases may be a function of the way in which sit-and reach performance was scored, since we observe an approximate 3-fold increase in scores over an 8 year period among South African children [40,41,52,69,83].

4. Discussion

This is the first systematic review to comprehensively explore the evidence for a physical activity and fitness transition, and their correlates, among SSA's children and youth.

4.1. Physical Activity Transition

Subjective methods of assessing physical activity are commonly used to measure types, frequencies, durations, and levels of physical activity. This is likely due to low costs associated with measurement [92]. Previous work however has shown that there is little association between self-report and directly measured physical activity; largely as a result of poor recall in children [92–95]. A majority of the included studies examining physical activity used subjective methods of data collection. A smaller proportion of studies used direct methods to assess physical activity, thereby providing higher accuracy and validity [96]. The means of measured MVPA reported in studies that used accelerometry to monitor physical activity ranged from 1 min/day to 9.3 h/day [30,31,33,53,75,76,84]. The only included study that examined changes in reported time spent in MVPA found a decline in MVPA of 30 minutes per day from 1997 to 1999 [31]. Regrettably, those using direct methods also used vastly different measurement devices and cut-points, making it impossible to conduct legitimate quantitative analyses of the results.

Assessment of a physical activity time trend was challenging given that many of the subjective instruments used have yet to be properly validated and are fraught with various limitations, while the objective measures used were mainly cross-sectional and differed in methodology [97]. Owing to the vast heterogeneity of these results, little could be said definitively on whether there was indeed evidence of a physical activity transition over time. It is imperative that future work examine the duration and intensity of physical activity on population representative samples using common measurement techniques and sampling procedures.

Similarly, a clear transition to increasing time spent in sedentary behaviours was not apparent. The majority of studies reporting on sedentary behaviour outcomes were published after 2010, further complicating analysis of trends over time. The reported means of time spent in sedentary pursuits ranged from 1.3 hours to 6 hours on weekdays, and were as high as 8 h on weekends [39,47,52,64,68,86]. These means are problematic given that the Canadian sedentary behaviour guidelines (the first published evidence-based guidelines on sedentary behaviour) recommend that children 5–17 years should limit their recreational sedentary screen time to no more than 2 h per day [14]. The urbanization trend suggests an increase in sedentary behaviours over time as the data revealed higher television viewing times among urban and higher SES children than rural and lower SES children.

Quantitative and narrative analyses of studies examining physical fitness measures revealed a tendency towards increased fitness measures, particularly in grip strength and flexibility over time in SSA, though the inconsistencies in measures used and representativeness of the samples makes direct comparisons across studies tenuous. It has been postulated that body composition indices should be interpreted differently in undernourished populations, that is, higher body mass index measures could be seen as a measure of muscle mass instead of a measure of fatness [41,48]. With this in mind, whereas previously the prevalence of underweight in SSA's school-aged children was high, these numbers are falling, giving rise to higher proportions of well-nourished children who may have greater muscle mass and perform better in various fitness measures. Improvements in fitness parameters in SSA's school-aged children may also be as a result of an increase in the proportion of children participating in formal/organized sports or activities, which has enabled these children to improve certain physical fitness skills that may not be learned through informal activities, random play, and self-directed activities engaged in more by the rural living and lower SES children. Despite these apparent improvements, when compared to Western reference groups, SSA children performed better in aerobic fitness measures but worse in anaerobic fitness tests or measures of musculoskeletal fitness and strength [22,25,28,43].

4.2. SES Differences

This systematic review found that lower SES and rural living children had higher levels of physical activity compared to higher SES and urban living children. Higher activity levels in lower SES children are associated with higher demands of informal/survival activities such as household chores and walking from place to place (active transport), rather than the formal/organized sporting activities engaged in by their more privileged peers. Higher SES and urban living children were also found to spend more time in sedentary pursuits than lower SES and rural living children; consistent with the finding that lower SES children were more active. This finding is likely due to lower access to motorized transport and higher need for their contribution to household and other tasks in lower SES settings. Lastly, lower SES children were also found to perform better in aerobic fitness measures compared to their higher SES peers. Superior aerobic fitness performance in lower SES and rural children may indeed be as a direct result of their higher participation in habitual active transport (e.g., walking, running), when compared to higher SES and urban children. In the one study where lower SES girls performed worse than their higher SES peers, this may be explained by the high prevalence of underweight that was also found in the low SES group, resulting in lower muscle mass as previously described; hence, poor performance in aerobic fitness tests [41,48,79]. The same may be said about the finding that higher SES children perform better in grip strength measures than lower SES children.

4.3. Sex Differences

This review found significantly higher levels of physical activity in boys compared to girls irrespective of age. Similarly, boys engaged in less sedentary behaviours (e.g., television viewing) than girls. Boys were also found to have considerably better aerobic, anaerobic, musculoskeletal fitness, and strength measures than girls; however, girls performed better on balance and flexibility measures of fitness. Besides biology and socio-cultural roles, this superior physical and functional ability of boys may be explained by their higher motivation to participate in physical activities.

The use of high quality methodology to capture and synthesize the studies in this review offers strength to the findings and conclusions in this manuscript. Additionally, decisions were made *a priori* to limit possible bias, and review processes were conducted in duplicate to ensure a higher level of accuracy. However, this review had several limitations including the vast heterogeneity in study sampling and methodology, which complicated quantitative analysis and direct comparison. Further, any trends observed over time may be reflective of the growth or differences in the ages of participants rather than group differences. It is also unclear if any material relevant for this review may have been published in un-indexed journals and hence not captured by the literature search.

5. Concluding Remarks

Owing to the vast heterogeneity in measurement devices, methodologies, and cut-points used by studies included in this review, little could be said definitively on the evidence for a physical activity and fitness transition over time. More generally however, the data revealed that urbanization was associated with a developing trend towards decreasing physical activity, increasing sedentary behaviours, and decreasing fitness measures (particularly aerobic fitness) over time. This was shown by engagement in lower amounts and levels of physical activity, higher television viewing and other sedentary pursuits, and lower aerobic fitness levels among urban and higher SES children compared to their rural and lower SES peers. As such, proactive strategies to prevent decreased physical activity and fitness and increased sedentary behaviours in the context of a probable physical activity transition in children from SSA appears warranted.

This systematic review also revealed a critical lack of representative, temporally sequenced data on physical activity, sedentary behaviours, and physical fitness measures in SSA's school-aged children and youth, which is a largely understudied and vulnerable group [98]. It is our recommendation that future work entail concerted efforts in carrying out nationally representative surveys, using comparable or common measurement techniques, sampling procedures, and cut-points, in order to effectively monitor physical activity transitions over time in this region. Further, considering that costs and ease of accelerometry use have improved over the last decade, we recommend that objective monitoring of physical activity and sedentary time be used in future studies. For instance, multi-country surveys would best strengthen the knowledge base in this field of research.

Acknowledgements

The authors are grateful to Alison McFarlane for her contributions towards manuscript formatting.

Author Contributions

Stella Muthuri, Mark Tremblay, Margaret Sampson, Lucy-Joy Wachira, Allana Leblanc, and Vincent Onywera developed the systematic review research question and objectives. Margaret Sampson created the search strategy and provided guidance on review methodology. Stella Muthuri, Claire Francis, Lucy-Joy Wachira, and Allana Leblanc screened and extracted the evidence. Stella Muthuri and Mark Tremblay led data analysis, synthesis, and writing of the manuscript. All authors contributed to interpretation of the results, edited, reviewed, and approved the final manuscript.

Conflicts of Interest

The authors declare that they have no competing interests.

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CHAPTER 4

Correlates of Objectively Measured Overweight/Obesity and Physical Activity in Kenyan School Children: Results from ISCOLE-Kenya

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Formatted for submission to: BMC Public Health in August 2013 [**Current Status:** Published].

The objective(s): While no temporal trends of a physical activity and fitness transition were immediately evident among children and youth in SSA, higher socioeconomic status, urban residence, and being female were associated with lower levels of physical activity, higher sedentary behavior, and lower aerobic fitness performance. These findings were supportive of the overweight/obesity transition manuscript results, which revealed that higher socioeconomic status, urban residence, and being female were associated with higher body composition measures. Having provided some context in the broader SSA region, this next manuscript aimed to investigate the prevalence and correlates of overweight/obesity, physical activity, and sedentary behavior in Kenyan children recruited from the urban city of Nairobi.

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BMC Public Health 2014, **14**:436 doi:10.1186/1471-2458-14-436

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ISSN	1471-2458
Article type	Research article
Submission date	20 August 2013
Acceptance date	30 April 2014
Publication date	9 May 2014
Article URL	http://www.biomedcentral.com/1471-2458/14/436

Abstract

Background

Childhood overweight/obesity and inadequate physical activity burden Western countries, and now, pose a growing threat to the health of children in low and middle income countries. Behavioural transitions toward more sedentary lifestyles coupled with increased consumption of high calorie foods has resulted in rising proportions of overweight/obesity and decreasing levels of physical activity in school-aged children. The objective of this study was to determine the prevalence and to investigate factors associated with overweight/obesity and physical activity in Kenyan children aged 9 to 11 years.

Methods

Body composition and physical activity measures of participating children were accomplished by anthropometric assessment, accelerometry, and administration of questionnaires related to diet and lifestyle, and the school and neighbourhood environments. Data collection was conducted in the city of Nairobi as part of a larger International Study of Childhood Obesity, Lifestyle and Environment.

Results

A total of 563 participants (46.5% boys, 53.5% girls) were included in the analyses. Of these, 3.7% were underweight, 14.4% were overweight, and 6.4% were obese based on WHO cut-points. Mean daily sedentary time was 398 minutes, time spent in light physical activity was 463 minutes, and time spent in moderate-to-vigorous physical activity was 36 minutes based on activity cut-points developed by Treuth *et al*. Only 12.6% of participating children were meeting the recommendation of ≥ 60 minutes of daily moderate-to-vigorous physical activity, and 45.7% of participants used active transportation to/from school. Increasing parental education level, total annual household income, and attending a private rather than public school were associated positively with being overweight/obese and negatively with meeting physical activity guidelines.

Conclusions

This study provided the evidence for an existing prevalence of childhood overweight/obesity in Nairobi. Children were spending a considerable amount of time in sedentary and light intensity physical activity, with few meeting physical activity guidelines. Higher socioeconomic status and parental education attainment were associated with a higher likelihood of children being overweight/obese and a lower likelihood of children meeting the physical activity recommendations. Interventions and strategies should be attentive to the potential health consequences of lifestyle transitions resulting from urbanisation and economic prosperity.

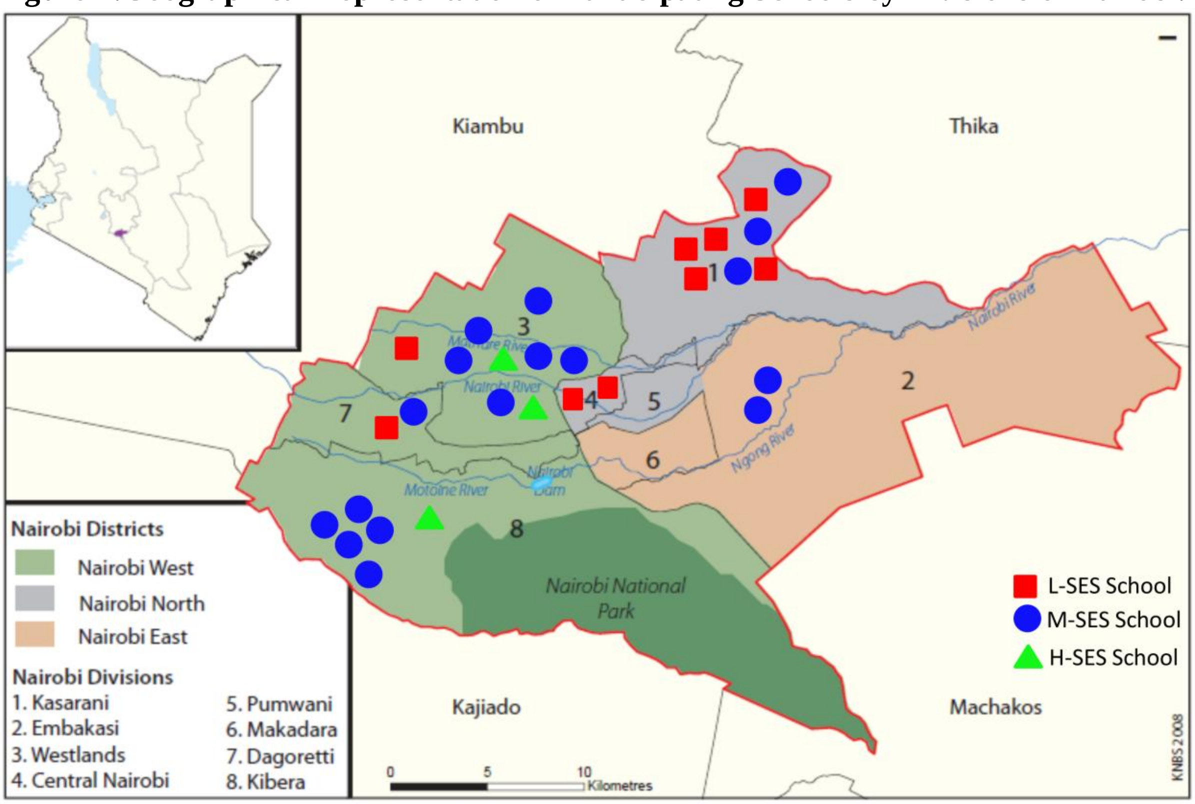
Keywords

Overweight, Obesity, Physical activity, School children, Kenya

Background

Physical activity and nutritional transitions around the world have resulted in a shift towards more sedentary lifestyles, increased consumption of high calorie foods, and rising proportions of overweight and obesity (overweight/obesity). These transitions have led to increases in the occurrence of modifiable non-communicable diseases such as diabetes, hypertension, heart disease, and some forms of cancer [1]. Physical inactivity and overweight/obesity are classified as the fourth and fifth leading causes of global mortality, and two of the greatest health challenges and determinants for various chronic diseases [1–4]. Of major concern is the potential for lifelong health consequences in children and youth, who have not been spared from the effects of these behavioural transitions. Childhood overweight/obesity is significantly associated with increased risk of obesity, physical morbidity, and premature mortality in adulthood [5–8]. However, children who attain a healthy weight by adolescence have better cardiovascular disease risk factor profiles compared to those remaining overweight [6].

Figure 1:Geographical Representation of Participating Schools by Divisions of Nairobi.



Global physical activity guidelines recommend that children and youth 5–17 years of age should accumulate an average of at least 60 minutes of daily moderate-to-vigorous physical activity (MVPA) in order to improve or maintain a healthy cardiorespiratory, fitness, and body composition profile [9].

Unfortunately, childhood overweight/obesity and inadequate physical activity remain a challenge in high income countries, and now pose a growing public health threat to children in low and middle income countries, particularly in urbanised areas [10,11]. While the health benefits of maintaining healthy active lifestyles are well established, in many Sub-Saharan African countries including Kenya, declines in habitual physical activity (e.g. traditional practices of walking long distances, manual labour) and subsequent increases in sedentary behaviour (e.g. motorised transport, desk jobs) have been observed [10–13]. Whereas physical activity and nutritional transitions have been well documented in high income countries, in Kenya, there is a lack of nationally representative data on the prevalence of childhood overweight/obesity and levels of physical activity among school-aged children. Even fewer studies have examined correlates or other factors associated with childhood overweight/obesity and physical activity. However, a growing number of research studies that are not nationally representative have shown emerging evidence of an overweight/obesity and inadequate physical activity problem in school-aged children in Kenya, predominantly in urban living children [14–20].

The primary objective of this study was to determine the prevalence of and investigate factors associated with overweight/obesity and physical activity in children aged 9 to 11 years, recruited from public and private schools in Nairobi. Data analysis sought to investigate the relationships between overweight/obesity or physical activity and factors at the individual, parental, household, neighbourhood, and school environment levels. Examination of these factors was guided by the socioecological model for creating active living communities proposed by Sallis *et al.*, which identifies potential environmental and policy influences on four broad domains of active living: household activities (e.g. household environment and facilities), active recreation (e.g. neighbourhood environment and facilities), active transport (e.g. neighbourhood walkability and safety), and occupational activities (e.g. the schools environment and policies) [21]. It was hypothesised that the results of this study would show further evidence of an emerging overweight/obesity and inadequate physical activity threat in school-aged children in Kenya, while also providing novel evidence of correlates of these outcomes in this African context.

Methods

Body composition and physical activity measures of the participating children were completed by direct anthropometric assessment and questionnaires related to diet and lifestyle, and the school and neighbourhood environments. Data collection was conducted as part of the International Study of Childhood Obesity, Lifestyle and Environment (ISCOLE) [22].

The ISCOLE project

The primary aim of ISCOLE was to investigate the influence of behavioural settings and the physical, social, and policy environments on the observed relationship between lifestyle characteristics and weight status in approximately 500 children from each of the included 12 countries (representing the major regions of the world) [22]. Given that much of the knowledge available on the influence of lifestyle behaviours on overweight/obesity and physical activity is informed by studies conducted in North America and Europe [23,24], there is a pressing need to determine the robustness of these relationships across all global regions [22]. Details of the ISCOLE study protocol are provided elsewhere [22]. Data collection was conducted in the urban city of Nairobi, for ISCOLE-Kenya's assessments following ethical approval from Kenyatta University, the Nairobi City Council, and the National Council for Science and Technology.

Study design and population

Recruitment targeted a sex-balanced sample of 500 children between the ages of 9 and 11 years. The primary sampling frame was a convenience sample of non-boarding public and private schools in Nairobi as shown in Figure 1. Schools were recruited proportional to the distribution of public and private school attendance. Non-compliant schools were replaced with the next randomly selected school. Type of school, public verses private, was an indicator of lower and higher socioeconomic status (SES) respectively. The secondary sampling frame was classrooms in the recruited schools that best yielded a final sample with minimal variability around 10 years of age. Children included in this study were typically in classes 4 or 5. Depending on the size of the classroom, 30 to 50 children were approached to participate in the study and were sent home with an introduction letter and consent form for their parents or guardians to review and give consent. Children were thereafter asked to provide assent to participate in the study. As per the study protocol, data collection was conducted for a full school year (2012, excluding the month long school holiday breaks in April, August, and December) in order to allow for examination of any seasonal differences [22].

Direct measures (anthropometry)

Extensively trained research staff measured standing and sitting height of participating children using the Seca 213 portable stadiometer (Birmingham, United Kingdom), with the participant as erect as possible and head positioned in the Frankfort horizontal plane [22]. The participant's weight, body fat percentage, and bioelectrical impedance were measured using a portable Tanita Body Composition Analyser (SC-240, Illinois, USA), after all outer clothing, heavy pocket items, shoes, and socks were removed [22]. Waist circumference measurements were made on exposed skin at the end of a normal expiration using a non-elastic anthropometric tape midway between the lower rib margin and the iliac crest [22]. Mid-upper-arm circumference of the right arm was measured at the midpoint distance between the bare acromion and olecranon, with the arm relaxed at the participant's side [22]. All measurements were done in duplicate. Body mass index (BMI) was derived from weight and height (kg/m^2), and thereafter BMI z-scores calculated based on growth reference algorithms developed by the World Health Organisation (WHO) for children and youth [25]. Definitions used to categorise children into underweight, healthy weight, overweight, and obese are shown in Table 1.

Table 1 Descriptions of cut-points used for outcomes of interest

Physical Activity [26]	
Sedentary	< 100 CPM
Light	100 to 2999 CPM
Moderate	3000 to 5200 CPM
Vigorous	> 5200 CPM
WHO BMI-for-age [25]	
Underweight	< −2 SD
Healthy/normal	0.99 SD to −1.99 SD
Overweight	> +1 SD
Obese	> +2 SD

Acronyms: CPM (counts per minute); WHO (World Health Organization); SD (standard deviation); BMI (body mass index).
Note: The z-score system expresses the anthropometric value as a number of standard deviations or z-scores below or above the reference mean or median value.

Direct measures (accelerometry)

Objective monitoring of physical activity, sedentary time, and sleep duration was achieved by use of ActiGraph GT3X + accelerometers at a one second epoch setting. Accelerometers were firmly attached to belts and distributed to the children who were then instructed to wear the instruments on the right side of their waists at all times except when bathing or swimming (including when sleeping). The research team demonstrated appropriate wearing of the accelerometers to ensure proper use. Participants were required to wear the devices for at least 7 consecutive days, plus an initial familiarisation day, in order to maximise the number of children providing a minimum of 4 days of wear of up to 10 hours, with at least one valid weekend day [22]. Non-wear time within a day was considered 60 consecutive minutes of '0' counts. Reminder telephone calls and reminders from class teachers were helpful in ensuring compliance with the protocol and return of the accelerometers. Once accelerometers were returned, data were downloaded from the device to a computer, and the log reviewed for completeness [22]. Accelerometry data reduction was completed using cut-points developed by Treuth *et al.*, which are validated in children and youth [26], and the relationships found confirmed using an alternate set of cut-points (Evenson et al. – data not reported) [27]. Time spent in sedentary, light, moderate, or vigorous physical activity was categorised as shown in Table 1.

Questionnaires

A *diet and lifestyle questionnaire* related to dietary intake, physical activity, sedentary behaviours, and sleep duration was completed by participating children in the presence of research staff during school visits. A *demographic and family health questionnaire* captured information about the health history of the child, parental education, parent weight and height, and household income and facilities. A *neighbourhood questionnaire* was used to capture information on parental perceptions of the social environment, the neighbourhood built, food, and physical activity environment. A *tracing questionnaire* was used to collect detailed contact information for ease of follow-up. The three latter questionnaires were completed by the parents of participating children and sent back to the research team. A *school environment questionnaire* captured information on school characteristics, policies, and practices that may influence healthy eating and activity behaviours of the children. This questionnaire was completed by a school administrator or teacher in each of the participating schools. Lastly, one *school audit questionnaire* was completed for each participating school by the research study team. This questionnaire recorded directly observed information on the school's built and food environments [22]. Full details of the questionnaires are proved elsewhere [22].

Recruitment rates

A total of 1278 introduction letters and consent forms were distributed to children to take home to their parents or guardians. Of these, 634 (49.6%) participants were consented, and 563 (44.1%) participants completed all primary anthropometric assessments and questionnaires. Only 555 (43.4%) participants also had adequate accelerometry wear time. Participating children were 9.0 to 11.9 years of age, and were recruited from 16 public and 13 private schools throughout Nairobi.

Statistical analysis

Descriptive statistics included means and standard deviation or frequencies. Univariable analysis was used to assess the associations between overweight/obesity or meeting the physical activity guidelines, with variables of interest selected *a priori* based on previous research findings and the socioecological model by Sallis *et al.* [14–20, 22]. Statistically significant associations from univariable analyses were then used in multivariable analyses (logistic regression) to investigate the odds of being overweight/obese or meeting the physical activity guidelines in multi-predictor models. Hosmer-Lemeshow and c-statistic tests were used to ascertain that these multivariable models had good calibration and acceptable to excellent discrimination. All statistical analyses were computed using SAS version 9.3 (SAS Institute, Cary, North Carolina, USA).

Results

Participant and parent characteristics

Characteristics of participating children and their parents are summarised in Table 2. Of the 563 participants, 46.5% were boys and 53.5% were girls. Waist and mid-upper arm circumference data were presented in three tertiles with ranges and means for each in order to offer additional body composition descriptions of the sample. Based on WHO's BMI z-score categorisation, we found that 3.7% of children were underweight, 75.5% were healthy weight, 14.4% were overweight, and 6.4% were obese (20.8% overweight/obese). The proportion of overweight/obesity was lower - 15.8% and 14.9% - when categorised based on Centers for Disease Control and Prevention (CDC) and International Obesity Task Force (IOTF) cut-points respectively [28, 29]. Two hundred and forty five (45.7%) participants reported that they used active transportation (e.g. walking) to or from school. The mean daily, weekday, and weekend time spent in various activity intensity levels are also reported in Table 2. Notably, mean daily sedentary time was 398 minutes; mean daily time spent in light physical activity was 463 minutes; mean daily time spent in moderate physical activity was 32 minutes; and mean daily time spent in vigorous physical activity was a mere 4 minutes. Only 12.6% of participating children met the recommendation of ≥ 60 minutes of daily MVPA. The mean sleep duration was found to be 516 minutes (8.6 hours) for this sample of children.

Table 2 Descriptive characteristics of participating children

	Mean (SD) or *n* (%)
Individual Factors	
Sex	
Boys	262 (46.5%)
Girls	301 (53.5%)
Waist Circumference (cm)	
1st tertile (range: 47.85 – 58.30)	55.5 (1.9)
2nd tertile (range: 58.35 – 62.95)	60.5 (1.4)
3rd tertile (range: 63.00 – 108.10)	70.8 (7.9)
Mid Upper Arm Circumference (cm)	
1st tertile (range: 14.65 – 18.80)	17.4 (0.9)
2nd tertile (range: 18.85 – 21.20)	19.9 (0.7)
3rd tertile (range: 21.25 – 36.15)	24.5 (3.1)
BMI Categories (WHO Cut-Points)	
Underweight	21 (3.7%)
Healthy weight	425 (75.5%)
Overweight	81 (14.4%)
Obese	36 (6.4%)
Transport to School	
Active (Walking, bicycle, roller blade, skate board)	245 (45.7%)
Motorised (Bus, van, car)	291 (54.3%)
Mean (minutes) in Various Activity Intensities	
Daily minutes of Sedentary	397.8 (71.5)
Weekday minutes of Sedentary	419.5 (82.7)
Weekend day minutes of Sedentary	349.4 (94.9)
Daily minutes of Light	463.1 (69.8)
Daily minutes of Moderate	31.5 (20.2)
Daily minutes of Vigorous	4.0 (4.3)
Daily minutes of MVPA	35.4 (23.2)
Weekday minutes of MVPA	36.1 (24.2)
Weekend day minutes of MVPA	34.2 (28.7)
Met MVPA Guidelines *(Mean of ≥ 60 minutes of daily MVPA)*	71 (12.6%)
Mean (minutes) of Sleep Duration	516.4 (55.0)
Parental Factors	
Maternal Education Level	
Primary or less	91 (16.3%)
High school or less	163 (29.2%)
Diploma/Higher Diploma/Degree	237 (42.5%)
Graduate/Professional Degree	67 (12.0%)
Paternal Education Level	
Primary or less	43 (8.4%)

High school or less	159 (31.1%)
Diploma/Higher Diploma/Degree	197 (38.6%)
Graduate/Professional Degree	112 (21.9%)
Maternal BMI (kg/m^2)	
Underweight (<18.50)	157 (27.9%)
Healthy weight (18.50 – 24.99)	128 (22.7%)
Overweight (25.00 – 29.99)	135 (24.0%)
Obese (≥30.0)	143 (25.4%)
Paternal BMI (kg/m^2)	
Underweight (<18.50)	206 (36.6%)
Healthy weight (18.50 – 24.99)	142 (25.2%)
Overweight (25.00 – 29.99)	149 (26.5%)
Obese (≥30.0)	66 (11.7%)
Household Environment Factors	
Total Annual Household Income (Kshs)	
Low SES (<466,728)	264 (48.6%)
Mid SES (466,728 - 1,799,999)	177 (32.6%)
High SES (>1,800,000)	102 (18.8%)
Neighbourhood Environment Factors	
Trust (P*eople in my neighbourhood can be trusted*) -% that somewhat agree/strongly agree	301 (54.5%)
Getting Around (*There are shops/stores/markets and place to buy things that I need within easy walking distance*) -% that somewhat agree/strongly agree	467 (85.2%)
High crime rate -% that somewhat agree/strongly agree	232 (42.5%)
School Environment Factors	
Participation by Type of School	
Public	295 (52.4%)
Private	268 (47.6%)
Participants in schools with written policies (*underdevelopment or existing*) or practices on Physical Activity	529 (94.0%)
Participants in schools with written policies (*underdevelopment or existing*) or practices on Healthy Eating	475 (84.4%)

Acronyms: WHO (World Health Organisation); MVPA (moderate-to-vigorous physical activity); BMI (body mass index); SES (socioeconomic status); Kshs (Kenya shillings).

A higher proportion of fathers (21.9%) than mothers (12.0%) reported having attained a graduate or professional degree. More mothers (49.4%) than fathers (38.2%) were found to be overweight/obese based on WHO BMI categories as derived from self-reported height and weight variables [30]. Over half of parents (54.5%) agreed that they believed people in their neighbourhoods can be trusted. A large percentage (85.2%) reported that there were shops, stores, markets and places to buy the things that they required within easy walking distance. Less than half (42.5%) reported that there was a high crime rate in their neighbourhoods.

From the Government of Kenya tax brackets and through a consultative process, total annual household income was categorised into low, medium, and high SES. As expected, a majority of households (48.6%) fell in the low SES category, while 32.6% and 18.8% were medium and high SES respectively. Of the 563 participants, 52.4% attended public schools, while 47.6% were enrolled in private schools. A large proportion of children - 94.0% and 84.4% - attended schools with written policies or practices on physical activity and healthy eating respectively.

Factors associated with overweight/obesity

As shown in Table 3, univariable analysis revealed that active transport, maternal education level, paternal education level, maternal BMI, paternal BMI, total annual household income, and type of school were all associated with being overweight/obese. A higher proportion of children using motorised transport (25.8%) were overweight/obese compared to those using active transport (14.7%) to get to/from school. As presented in Table 3, there was a progressive increase in the number of children who were overweight/obese with increasing maternal and paternal education attainment. Proportions of childhood overweight/obesity also increased with increasing household SES. Similarly, a higher percentage of children in private schools (33.6%) were overweight/obese compared to those in public schools (9.2%). Paternal BMI and type of school remained significant predictors of overweight/obesity in multivariable analyses as shown in Table 4. A one unit increase in paternal BMI was associated with a 17.2% increased odds of the child being overweight/obese. Attending a private rather than public school was associated with a 4.2 times higher odds of being overweight/obese.

Table 3 Univariable model for factors associated with childhood overweight/obesity and physical activity

	Overweight/Obese (%)	p-value	Met Daily MVPA Guidelines (%)	p-value
Individual Factors				
Sex				
Boys	54 (20.6%)	NS	46 (17.6%)	0.0013
Girls	63 (20.9%)		25 (8.3%)	
Transport to School				
Active	36 (14.7%)	0.0019	55 (22.4%)	< 0.0001
Motorised	75 (25.8%)		16 (5.5%)	
BMI Categories				
Overweight/Obese			3 (2.6%)	< 0.0001
Underweight/Healthy weight			68 (15.3%)	
Parental Factors				
Maternal Education Level				
Primary or less	3 (3.3%)	< 0.0001	34 (37.4%)	< 0.0001
High school or less	24 (14.7%)		23 (14.1%)	
Diploma/Higher diploma/Degree	69 (29.1%)		12 (5.1%)	
Graduate/Profession degree	21 (31.3%)		2 (3.0%)	
Paternal Education Level				
Primary or less	1 (2.3%)	< 0.0001	13 (30.2%)	< 0.0001
High school or less	14 (8.8%)		31 (19.5%)	
Diploma/Higher diploma/Degree	54 (27.4%)		9 (4.6%)	
Graduate/Profession degree	41 (36.6%)		7 (6.3%)	
Maternal BMI (kg/m^2); *as continuous variable*	0.11 (r-value)	0.0297		NS
Paternal BMI (kg/m^2); *as continuous variable*	0.27 (r-value)	< 0.0001		NS
Household Environment Factors				
Total Annual Household Income (Kshs)				
Low SES (<466,728)	27 (10.2%)	< 0.0001	59 (22.4%)	< 0.0001
Mid SES (466,728 - 1,799,999)	47 (26.6%)		10 (5.7%)	
High SES (>1,800,000)	35 (34.3%)		2 (2.0%)	
School Environment Factors				

Participation by Type of School				
Public	27 (9.2%)	< 0.0001	69 (23.4%)	< 0.0001
Private	90 (33.6%)		2 (0.8%)	

Acronyms: NS (not significant); BMI (body mass index); SES (socioeconomic status); Kshs (Kenya shillings).
Note: Spearman correlation coefficients presented for continuous variables.

Table 4 Multivariable model for factors associated with childhood overweight/obesity and physical activity

	OR (Confidence Limits)	p-value
	Overweight/Obese	
Paternal BMI (kg/m^2); *as continuous variable*	1.17 (1.09 - 1.26)	< 0.0001
Participation by Type of School *(Private vs. Public)*	4.18 (2.26 - 7.72)	< 0.0001
	Met Daily MVPA Guidelines	
Sex (Boys vs. *Girls*)	2.63 (1.49 – 4.64)	0.0009
Maternal Education Level		
High school or less vs. Primary or less	0.35 (0.19 - 0.67)	0.0014
Diploma/Higher Diploma/Degree vs. Primary or less	0.25 (0.12 – 0.54)	0.0008
Graduate/Professional Degree vs. Primary or less		NS
Participation by Type of School *(Private vs. Public)*	0.04 (0.01 – 0.17)	< 0.0001

Acronyms: BMI (body mass index).
Note: All variables that were significant in the univariable analyses (from Table 3) were included in the initial multivariable model, and a backward elimination approach used to reduce the model to only those that remained significant as reported in this table.

Factors associated with meeting daily MVPA guidelines

As shown in Table 3, univariable analysis revealed that sex, active transport, child BMI category, maternal education level, paternal education level, total annual household income, and type of school were all associated with meeting physical activity guidelines. A higher percentage of boys (17.6%) than girls (8.3%) met the recommended daily minutes of MVPA. More children that used active transport (22.4%) met the physical activity guidelines compared to those that used motorised transport (5.5%). A higher proportion of underweight and healthy weight children (15.3%) met the guidelines compared to those in the overweight/obese category (2.6%). As presented in Table 3, there was a decreasing trend in the number of children who met the guidelines with increasing maternal and paternal education attainment. Proportions of children meeting the physical activity guidelines also decreased with increasing household SES. A considerably higher percentage of children in public schools (23.4%) met the guidelines compared to those in private schools (0.8%). Sex, maternal education level, and type of school remained significant predictors of meeting physical activity guidelines in multivariable analyses shown in Table 4. Boys were 2.6 times more likely to meet physical activity guidelines than girls. Mothers attaining a high school or lower education level (compared to a primary school or lower education level) was associated with a 64.8% decreased odds of their child meeting the guidelines, while mothers having a diploma, higher diploma, or degree (compared to a primary school or lower education level) was associated with a 75.1% decreased odds of their child meeting the physical activity guidelines. Children attending private schools were 96.4% less likely to meet physical activity guidelines than children attending public schools.

Discussion

The objective of this study was to determine the prevalence of, and investigate factors associated with overweight/obesity and physical activity in school-aged children from Nairobi. The findings of this study were suggestive of the potentially negative impact of higher socioeconomic status and urbanisation on body weights and physical activity patterns of school aged children in this setting. These urban living children were found to have substantial proportions of overweight/obesity, high amounts of sedentary time, high volumes of light intensity physical activity, and considerably low amounts of time spent in MVPA.

Individual level factors

Child under-nutrition – which includes underweight (low weight-for-age), stunting (low height-for-age), wasting (low weight-for-height), and deficiencies of essential vitamins and minerals [31] – remain some of Sub-Saharan Africa's most fundamental challenges for improved human development [32–34]. This is a particular concern when considering the school-aged child population since malnutrition is associated with lower schooling attainment and educational performance, as well as shorter adult height and reduced adult income or economic productivity [31, 32]. It has been suggested that when conducting studies on the prevalence of overweight/obesity in low and middle income countries, that stunting also be considered, since BMI works poorly when there is a high percentage of stunting [35, 36]. The relationship between stunting and obesity is highly debatable, with some studies showing no relationship between the two [37, 38], while others finding an existing relationship between the two [39, 40]. For instance, even among child populations with high levels of stunting, stunting did not alter the relationship between BMI and other measures of body composition [38]. BMI was found to be the strongest predictor of all adiposity indicators, suggesting that BMI can be used in stunted populations in the same way as it is used in non-stunted populations [38]. While stunting refers to retarded linear growth as a result of chronic under-nutrition, wasting results from inadequate nutrition over a shorter period, and underweight encompasses both stunting and wasting [41]. Further, the high correlation between stunting and underweight suggests that the prevalence of underweight aptly describes the magnitude of the problem of growth faltering in children [41]. Consequently, it is probable that underweight was a reasonable indicator of child linear growth, particularly in this urban population where underweight was found to be low. Indeed, the criteria used to assess the nutritional status of children in SSA are important in estimating the prevalence of a nutritional double burden, defined as the coexistence of under-and-over nutrition in the same population [42]. This was indeed evident from the finding that even in the urban city of Nairobi, 3.7% of children were underweight. While under-nutrition continues to be an issue of critical importance in this region, the purpose of the present study was to examine the emergence of the other end of the spectrum – overweight/obesity – and the possible emergence of a nutritional double burden of public health challenges, as this may begin to place more strain on the limited healthcare resources in Kenya.

Data analysis revealed substantial proportions of childhood overweight/obesity for this age group. While these figures are lower than values in developed countries such as in the USA and Canada, which have childhood overweight/obesity prevalences of 33% and 29%

respectively [43–45], these findings are indicative of an existing threat of childhood overweight/obesity among Kenya's urban school-aged children. A recent systematic review examining the evidence for an overweight/obesity transition among school-aged children and youth in Sub-Saharan Africa found that weighted averages of overweight/obesity and obesity for the entire time period captured in the review were 10.6% and 2.5% respectively [46]. In light of the findings of this systematic review, these proportions of childhood overweight/obesity in Nairobi are indeed concerning. It is, however, noteworthy that the age range of the sample of children included in this study was 9 to 11 years, whereas those of the references cited were between 5 and 19 years. As such, there may be age differences in the prevalence of overweight/obesity not accounted for in these simplified comparisons.

Objectively measured mean daily sedentary time was 6.6 hours, with children spending more time in sedentary behaviours while at school than on weekends. This difference may be explained by the amount of time they were required to be seated in classrooms during the school week. Children also spent a considerable amount of time in light physical activity (7.7 hours). Objectively measured physical activity data in South African children 7 to 15 years of age similarly showed that they participated in a high volume of physical activity at low intensity [47]. Future studies should focus on investigating the potential health consequences of relatively large volumes of light intensity physical activity in this age group. The mean daily time spent in MVPA was 36 minutes, with only 12.6% of participating children meeting the recommendation of ≥ 60 minutes of daily MVPA. These findings are comparable to those of Ojiambo *et al.*, who found that the mean daily time spent in MVPA by urban children from Eldoret town in Kenya (of somewhat lower socioeconomic status than Nairobi) was 44 minutes, with 16.5% of children meeting physical activity guidelines [18]. The proportion of urban children meeting the physical activity guidelines in Kenya is not much higher than some Western countries such as Canada, where objective measures revealed that only 7% of children and youth accumulated the recommended ≥ 60 minutes of daily MVPA [48]. A relatively high number of Kenyan children reported using active transport means to and from school. Active transport was associated with a lower likelihood of being overweight/obese, and a higher likelihood of meeting the physical activity guidelines. Unfortunately, numbers of children using active transport may be declining due to increased automobile availability and use, as well as declining road safety, which make active transportation difficult and dangerous for school children in many areas of Nairobi. Despite the cost effectiveness of active transportation, an increasing number of parents prefer that their children use school buses or personal cars for transport. It is important to note that active transportation may be an important strategy in maintaining or increasing physical activity levels in children from lower income countries, and this issue requires the attention of key stakeholders in order to inform future planning and policy development [49].

A significantly higher percentage of boys than girls met the recommended daily minutes of MVPA , and boys were more likely to meet physical activity guidelines than girls. Higher activity in boys has also been observed in the Canadian setting [48]. It was suggested that differences in gender roles (e.g. boys participating in higher energy expending roles or activities), and a higher motivation inherent in boys to participate in physical activity, may explain this sex difference [46].

Parental factors

Higher paternal BMI was associated with increased odds of children being overweight/obese, and increasing maternal education level was associated with decreased odds of children meeting the physical activity guidelines. A study by Micklesfield *et al.* in South African children 11 to 15 years of age also showed that higher maternal socioeconomic status and education were associated with decreased childhood physical activity and increased sedentary time [50]. The results of this study therefore serve to provide further evidence of these relationships. However, it is important to note that there are various limitations associated with self-report of body height and weight by adults [51].

Household and Socioeconomic Factors

Total annual household income and type of school (private vs. public) were markers of SES. Proportions of childhood overweight/obesity increased with increasing household SES and attending a private school (higher SES) rather than a public school (lower SES). Proportions of children meeting the physical activity guidelines decreased with increasing household SES and attending a private school rather than a public school.

Taken together, the findings of this study showed that higher SES was associated with higher body composition measures, pointing to a positive SES relationship with overweight/obesity. Higher SES was also associated with decreased time spent in MVPA, pointing to a negative SES relationship with physical activity. Higher parental education achievement, greater use of motorised transport, and attending private schools - all of which are more prevalent among and accessible to those in higher SES - were associated with a higher likelihood of children being overweight/obese and a lower likelihood of children meeting the physical activity recommendations. These findings are supportive of studies conducted in Kenya and other Sub-Saharan African countries showing similar deleterious associations between urbanisation and healthy active lifestyles and body weights in school-aged children [14–20, 46, 52, 53]. Interestingly, they are the inverse of the relationship observed in many high income countries where studies have consistently shown that lower SES is associated with lower levels of physical activity, more time spent in sedentary behaviours, and higher risk for unhealthier lifestyles compared to higher SES children [54, 55].

This research study had several limitations including a cross-sectional design, not being nationally representative, and the realisation that accelerometry does not directly measure habitual physical activity or sedentary behaviour; rather, estimates these categories based on movement counts and arbitrary intensity thresholds [56]. Nevertheless, this study provides robust objective measures of several healthy active living variables and related correlates among a large group of Kenyan school children and represents the first study of this kind in Kenya.

Conclusions

The findings of this study were suggestive of the potential negative impact of higher socioeconomic status and urbanisation on body composition and physical activity patterns in school aged children in this setting. In order to tackle the growing concern of childhood overweight/obesity and inadequate physical activity in Kenya, we must first improve surveillance of these health risk factors. Herein lies the importance of conducting comprehensive research studies such as the ISCOLE study at a nationally representative level. While not nationally representative, it is envisaged that this ISCOLE-Kenya study may serve as a model for a nation-wide survey. Further, and strategies to address these growing threats should focus on higher SES and urban populations, with greater attention placed on girls, to ensure that children are attaining healthy active lifestyles.

Abbreviations

MVPA, Moderate-to-vigorous physical activity; BMI, Body Mass Index; CDC, Centers for Disease Control and Prevention; IOTF, International Obesity Task Force; ISCOLE, International Study of Childhood Obesity, Lifestyle and Environment; SES, Socioeconomic Status; WHO, World Health Organisation.

Competing interests

The authors declare that they have no competing interests. ISCOLE is funded by the Coca-Cola Company. The funder had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

Authors' contributions

SKM, LMW, VOO, and MST contributed to preparations prior to implementing the study protocol in Kenya. SKM and LMW participated in data collection. SKM and MST analysed the data and interpreted the results. SKM led the writing of the manuscript. All authors contributed to the writing, editing, and approved this manuscript.

Acknowledgements

The authors are grateful to all the school children, families, and school administrators who participated in the ISCOLE-Kenya study, and the research assistants who helped with data collection. We thank biostatistician Kathryn Williams for her guidance with statistical analysis for this manuscript. In addition, we would like to thank the ISCOLE Coordinating Center staff at the Pennington Biomedical Research Center for study coordination and data management (Peter T. Katzmarzyk PhD and Timothy S. Church MD, principal investigators, and Denise Lambert, project manager). We would also like to recognize principal investigators from the 12 participating countries who played a role in developing the research study design and protocol.

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CHAPTER 5

Direct and Self-Reported Measures of Physical Activity and Sedentary Behaviours by Weight Status in School-Aged Children: Results from ISCOLE-Kenya

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Formatted for submission to: Annals of Human Biology in October 2013 [**Current Status**: Under Review]

The objective(s): Studies from various high income countries have revealed little association between self-report and directly measured physical activity in the pediatric population. Previous work has also shown differences in the extent of response bias associated with self-report assessment of physical activity between children of healthy weight and those that are overweight/obese. The aim of this manuscript was to investigate the relationships between direct and self-report measures of physical activity and sedentary behavior by weight status, that is, under/healthy weight versus overweight/obese children, thereby examining whether similar response biases exist in pediatric samples of lower income countries like Kenya.

ABSTRACT

Background: Previous work has shown little association between self-report and directly measured physical activity. The objective of this study was to investigate the relationships between self-reported and directly assessed measures of physical activity and sedentary time by weight status in Kenyan children.

Methods: Direct assessment of body weight, physical activity, and sedentary time of 563 children was collected through anthropometry and accelerometry, while self-reported assessment was achieved by administering a questionnaire.

Results: Under/healthy weight children had significantly higher directly measured mean daily minutes of moderate-to-vigorous physical activity (MVPA) compared to overweight/obese children (39 verses 20 minutes); had lower mean weekend-day minutes of sedentary time (346 verses 365 minutes); had a higher proportion who met accepted physical activity guidelines (15.3% versus 2.6%); and a higher number reported using active transportation to/from school (49.2% versus 32.4%). Self-reported time spent outside before and after school, and active transport to/from school were significantly associated with mean weekday minutes of MVPA (r-value range: 0.12 to 0.36), but only for the under/healthy weight children.

Conclusions: The results of this study found a number of differences in the accumulation of MVPA and sedentary time by weight status, and weak to moderate correlations between self-report and direct measures of weekday and weekend-day physical activity among the under/healthy weight children.

Key words: Physical activity, sedentary behaviours, direct-measures, self-report, children.

BACKGROUND

Measurement of physical activity using self-report methods (e.g., questionnaires, interviews) is commonly used to collect information on the types, frequency, intensity, and duration of activities in various populations and ages of participants (Adamo et al., 2009; Dishman et al., 2001; Gorber et al., 2007; Kowalski et al., 2012). Activity-specific energy expenditure values may then be used to estimate the total energy expenditure from all activities reported (Dishman et al., 2001). Such reporting methods of data collection are preferable due to their low cost, speed, and ease of implementation, especially in larger sample sizes (Adamo et al., 2009; Gorber et al., 2007). However, self-report measures are fraught with various challenges associated with recall and response biases (e.g., inaccurate recall, misunderstanding questions, or a tendency to report desirably) (Gorber et al., 2007; Singleton et al., 1993). Self-report is particularly problematic in children and youth since they are less attentive to the construct of time, may participate in physical activity in intermittent bouts, and may also be more inclined to respond in a socially desirable manner (Armstrong & Bray, 1991; Bailey et al., 1995).

Despite the associated higher costs, challenging data management, and higher participant burden, direct measurement of physical activity (e.g., pedometers, accelerometers) offers a higher level of accuracy and validity (Adamo et al., 2009; LeBlanc & Janssen, 2010; Prince et al., 2008; Shephard, 2003). Regrettably, direct measures of physical activity are also problematic owing to the lack of standardized measurement devices and intensity level cut-points, making comparability across studies difficult (Adamo et al., 2009; Dishman et al., 2001). The World Health Organization (WHO) recommends that children and youth 5-17 years of age accumulate at least 60 minutes per day of moderate-to-vigorous intensity physical activity (MVPA) for positive health outcomes (WHO, 2010). Further, given that sedentary behaviours (low-energy expenditure activities) are independently associated with adverse health outcomes (Tremblay et al., 2010), the Canadian sedentary behaviour guidelines recommend that children of this age group should limit their recreational sedentary screen time to no more than 2 hours per day (Canadian Society for Exercise Physiology, 2011).

Previous work has shown little association between self-report and directly measured physical activity (Armstrong & Bray, 1991; Bailey et al., 1995; LeBlanc & Janssen, 2010; Shephard, 2003). A systematic review of reported versus direct measures for assessing physical activity in the pediatric population found the range of correlations were low-to-moderate and wide ranging (r= -0.56 to 0.89), and a majority (72%) of the reported measures over-estimated the directly measured values (Adamo et al., 2009). These findings were supported by the work of Foley *et al*., who determined that self-report use-of-time tools had moderate reliability and validity for the assessment of physical activity in youth, compared with objective methods (Foley et al., 2012). Further, various studies have shown that questionnaire-based assessment of physical activity levels may under-estimate the differences in MVPA and vigorous physical activity (VPA) between healthy weight and overweight/obese individuals; with a lower accuracy in self-report of physical activity found among those that are overweight/obese (Buchowski et al., 1999; McMurray et al., 2008; Slootmaker et al., 2009; Warner et al., 2013). However, these reviews and findings were largely informed by studies conducted in high income countries, so whether a similar reporting bias exists in developing countries remains unclear.

Comparison of *proxy* (parental)-report verses direct measures of physical activity and sedentary behaviours in children has revealed parents over-estimated time their children were engaging in MVPA, and under-estimated the time their children were participating in sedentary pursuits (Colley et al., 2012). While it may be intuitive that similar observations would be found in the association between self-report and directly measured sedentary behaviours, further investigation is necessary, especially in developing countries where such research is lacking.

To help address these research gaps, the objective of this study was to investigate the relationships between self-reported (questionnaire-based) and directly assessed (accelerometry) measures of physical activity and sedentary behaviours, by weight status, in school-aged children recruited from the city of Nairobi in Kenya. These findings would serve to indicate whether similar discrepancies or reporting biases exist in developing (low to middle income) countries, as found to be the case in high income countries (as described above). The findings may further inform appropriate data collection methodologies for low to middle income countries.

METHODS

Data were collected as part of the International Study of Childhood Obesity, Lifestyle and Environment (ISCOLE), whose primary aim was to investigate the influence of behavioural settings and the physical, social, and policy environments on the observed relationship between lifestyle characteristics and weight status in 10 year-old children from 12 countries in different regions of the world (Katzmarzyk et al., 2013). Direct measures of body composition, physical activity, and sedentary time of the participating children were assessed by anthropometry and accelerometry. Self-reported physical activity and sedentary behaviours were collected by administering a lifestyle questionnaire to the children. Full details of the ISCOLE study protocol, measurements, and questionnaires are provided elsewhere (Katzmarzyk et al., 2013).

Study design: Recruitment targeted a convenience sex-balanced sample of 500 children 9 to 11 years of age, attending non-boarding public and private schools in Nairobi, Kenya. Typically, children in classes 4 and 5 best yielded a final sample with minimal variability around 10 years of age. Depending on the classroom size, 30 to 50 children were approached to participate in the study and were sent home with an introduction letter and consent form for their parents or guardians to review and if interested, provide consent. Children were thereafter asked to provide assent to participate in the study. Data were collected across a full school year (January to November) in 2012, following ethical approval from the Kenyatta University Ethics Review Board (the local organizing institution), and authorization to conduct research by the Nairobi City Council and the Kenyan National Council for Science, Technology, and Innovation.

Anthropometry: Trained research staff measured standing height of participating children using the Seca 213 portable stadiometer (Birmingham, United Kingdom), with the participant as erect as possible and head positioned in the Frankfort horizontal plane (Katzmarzyk et al., 2013). The participant's weight was measured using a portable Tanita Body Composition Analyser (SC-240, Illinois, USA), after all outer clothing, heavy pocket items, shoes, and socks were removed (Katzmarzyk et al., 2013). Measurements were done in duplicate and the average calculated. Body mass index (BMI) was derived from weight and height (kg/m^2), and thereafter BMI z-scores calculated based on growth reference algorithms developed by WHO for children and youth (de Onis et al., 2007). Briefly, underweight is (< -2 SD), healthy weight (0.99 SD to -1.99 SD), overweight (> +1 SD), and obese (> +2 SD).

Accelerometry: Direct monitoring of physical activity and sedentary time was achieved by use of the ActiGraph GT3X+ accelerometer at a one second epoch setting. Accelerometers were firmly attached to belts and distributed to participants who were then instructed to wear the monitors fitting snugly on the right side of their waist at all times except when bathing or swimming. The research team demonstrated appropriate wearing of the accelerometers to ensure proper use. Participants were required to wear the devices for at least 7 consecutive days, plus an initial familiarisation day, in order to maximise the number of children providing a minimum of 4 days of wear with at least 10 hours per day, including at least one valid weekend day (Katzmarzyk et al., 2013). Non-wear time within a day was considered 60 consecutive minutes of '0' counts. Reminder telephone calls and reminders from class teachers were helpful in ensuring compliance with the protocol and return of the accelerometers. Once accelerometers were returned, data were downloaded to a computer, and the log reviewed for completeness (Katzmarzyk et al., 2013). Accelerometry data reduction was completed using cut-points developed by Treuth *et al*., which are validated in children and youth, whereby sedentary behavior is (< 100 counts per minute (CPM)), light physical activity (100 to 2999 CPM), moderate physical activity (3000 to 5200 CPM), and vigorous physical activity (> 5200 CPM) (Treuth et al., 2004).

Questionnaires: A diet and lifestyle questionnaire capturing information related to physical activity and sedentary behaviours (as well as other factors not included in these analyses), was completed by participating children in the presence of research staff during school visits (Katzmarzyk et al., 2013). The aim of this questionnaire was to collect data at the individual level; hence, key questions about lifestyle behaviours were designed to explore multi-level relationships and obesogenic environments on a global stage (including several countries of high and low to middle income status) (Katzmarzyk et al., 2013). The questionnaire was a compilation of validated items obtained from several different existing questionnaires or sources, and new questions designed by ISCOLE investigators in the case that no suitable alternatives were found (Katzmarzyk et al., 2013). Questions regarding obtaining adequate amounts of physical activity, and the amount of time spent watching television or playing video games on school days and weekend days, were adopted from the United States (U.S.) Youth Risk Behavior Surveillance System (U.S. Centers for Disease Control and Prevention, 2012). Questions related to active transport to school were adapted from the Canadian component of the 2009-10 Health Behaviour in School-aged Children (HBSC) Study (Gropp, Janssen & Pickett, 2013). Questions probing opportunities for physical activity, such as the amount of time the children spent outside before school, after school, and on the weekend days, were developed by the ISCOLE investigators. The list of questions used for these analyses are listed in *table I*.

< Insert table I here >

Statistical analysis: All statistical analyses presented in this manuscript were computed using SAS version 9.3 (SAS Institute, Cary, North Carolina, USA). Characteristics of participating children were analysed by weight status, that is, under/healthy-weight and overweight/obese categories. Significant associations between self-report measures of physical activity or sedentary behaviours, and comparable direct measures of MVPA and sedentary time were investigated by use of Spearman correlation coefficients. The data were tested for normality, thereby informing the choice of analyses conducted.

RESULTS

Of the 563 included participants (53.5% girls) between 9.0 to 11.9 years of age, 555 children met the minimum requirements for adequate accelerometry wear (minimum of 4 days of wear with at least 10 hours per day, including at least one valid weekend day). As such, non-response bias was not a problem. The children were recruited from 16 public and 13 private schools throughout Nairobi, purposely stratified by socioeconomic status, whereby type of school – public and private – were markers of lower and higher and socioeconomic status respectively.

< Insert table II here >

Physical Activity Measures

Differences by weight status: Characteristics of participating children are summarised in *table II* by weight status. Children in the under/healthy weight category had significantly higher directly measured mean ***daily*** minutes of MVPA (39 minutes) compared to those in the overweight/obese category (20 minutes). A significantly higher proportion (15.3%) of those in the under/healthy weight category met accepted physical activity guidelines compared to 2.6% in the overweight/obese category. Over half of the children in both weight categories self-reported spending 2 days or less being physically active for more than 60 minutes; however, there was no significant difference found between the two weight groups.

Children in the under/healthy weight category also had significantly higher mean ***weekday*** minutes of directly measured MVPA (40 minutes) compared to those in the overweight/obese category (20 minutes). A majority of children in both weight categories (over 70%) self-reported spending one hour or less outside before school; however, there was no significant difference found between the weight groups. On the contrary, there was a significant difference in self-reported time spent outside after school before bedtime between the weight groups. A higher proportion of children in the under/healthy weight category spent two hours or more outside after school (51.3% versus 42.2%). A significantly higher proportion of children in the under/healthy weight category reported using active transport to/from school (49.2%) compared to those in the overweight/obese category (32.4%).

Children in the under/healthy weight category had significantly higher directly measured mean ***weekend-day*** minutes of MVPA (38 minutes) compared to those in the overweight/obese category (20 minutes). There was no significant difference in self-reported time spent outside on a weekend-day between the two weight groups.

< Insert table III here >

Relationships between self-reported and directly assessed measures by weight status: As shown in *table III*, there was no significant association between self-reported number of days the child was physically active for more than 60 minutes, and directly measured mean ***daily*** minutes of MVPA for either weight group. There was also no significant association found between those meeting accepted physical activity guidelines (WHO, 2010) from direct assessment and self-report measures. Self-reported time spent outside before school, time spent outside after school before bedtime, and active transport to/from school were all significantly associated with mean ***weekday*** minutes of directly measured MVPA, with Spearman's correlation coefficients of 0.12, 0.20, and 0.36 respectively, but only in the case of the under/healthy weight children. None of these comparisons were significant in the case of the overweight/obese children. Self-reported time spent outside on a weekend-day was also significantly associated with mean directly measured ***weekend-day*** minutes of MVPA among under/healthy weight children, with a Spearman's correlation coefficient of 0.10.

Sedentary Behaviour Measures

Differences by weight status: Directly measured mean daily time spent in sedentary activities was approximately 10 times higher than the mean time spent in MVPA for this sample of children. As presented in *table II*, there was no significant difference in the mean ***daily*** or ***weekday*** minutes of directly measured sedentary time between the weight categories. However, there was a statistically significant difference in self-reported time spent watching television on weekdays between the weight categories. A higher proportion of children in the under/healthy weight group spent ≤ 2 hours watching television on schools days compared to their overweight/obese peers (84.8% versus 74.4%). There was no significant difference in self-reported time spent on video/computer games or use on weekdays between the weight categories.

Children in the under/healthy weight category had significantly lower mean directly measured ***weekend-day*** minutes of sedentary time (346 minutes) compared to those in the overweight/obese category (365 minutes). However, there was no significant difference in self-reported number of hours spent watching television and on video/computer games on weekend-days between the weight categories.

Relationships between self-reported and directly assessed measures by weight status: As shown in *table III*, there were no significant associations between self-reported screen time on weekdays or weekend-days (i.e., time spent watching television or using video/computer games), and directly measured mean ***weekday*** or ***weekend-day*** minutes of sedentary time in either weight category.

DISCUSSION

The results from this study revealed significant differences in the accumulation of MVPA by weight status – particularly when assessed with direct methods, but less so for sedentary behaviour. Analysis also showed largely no associations between direct and self-report measures of physical activity and sedentary behaviour in this sample of Kenyan school-aged children, with the only significant associations and weak to moderate correlations found between direct and self-report measures of weekday and weekend-day physical activity among the under/healthy weight children.

Physical Activity Measures

Differences by weight status: Using direct measures, children in the overweight/obese category had significantly lower mean daily, weekday, and weekend-day minutes of MVPA, and a lower proportion met accepted physical activity guidelines compared to children in the under/healthy weight category. The self-reported measures indicated a significant difference in reported time spent outside after school and active transportation to/from school between the two weight categories. Taken together, direct measures of physical activity consistently revealed a significant difference between the weight categories, while a significant difference between the groups was less evident from the self-reported physical activity data. More generally, the findings of this study are consistent with previous work showing low to moderate relationships between self-report assessment of physical activity in the pediatric population, compared with direct methods (Adamo et al., 2009; Armstrong & Bray, 1991; Bailey et al., 1995; Foley et al., 2012; LeBlanc & Janssen, 2010; Shephard, 2003). Specifically, the finding that self-report measures of physical activity infrequently captured a significant difference between the weight groups points to differential accuracy of physical activity self-report by weight status, compared to direct measures, as has been reported (Buchowski et al., 1999; McMurray et al., 2008; Slootmaker et al., 2009; Warner et al., 2013). It has been suggested that the finding of lower accuracy of self-report physical activity measures, particularly among overweight/obese individuals, may be related to the phrasing of questions requiring that the participant gauge their “physical effort” in relation to intensity of physical activity (Maffeis et al., 1993; Marinov et al., 2002; Warner et al., 2013). Consequently, the indicators of “physical effort” may be more evident in overweight/obese than under/healthy weight children, resulting in misclassification of the intensity of physical activity (Maffeis et al., 1993; Marinov et al., 2002; Warner et al., 2013).

Relationships between self-reported and directly assessed measures by weight status: Analysis of the relationships between self-reported measures of physical activity and comparable directly measured MVPA revealed several low associations and weak to moderate correlations (range: 0.10 to 0.36) among the under/healthy weight children only. Time reportedly spent outside before school, after school, and active transport to/from school were significantly associated with directly measured mean weekday minutes of MVPA, while time spent outside on a weekend-day was significantly associated with mean weekend-day minutes of MVPA in this weight category. Similar findings of low to moderate correlations between direct and self-report of physical activity in the pediatric population have been previously determined in higher income countries (Adamo et al., 2009: Foley et al., 2012).

Notably, significant associations were most commonly found to exist in measures of weekday activities such as active transport to/from school, and time spent outside before and after school. It has been previously proposed that self-report is problematic in children and youth since they are less attentive to the construct of time, may participate in physical activity in intermittent bouts, and may be more likely to respond in a socially desirable manner (Armstrong & Bray, 1991; Bailey et al., 1995). However, it is probable that among these under/healthy weight children, timing in different activities, particularly during the school day, was more accurately reported due to the constraints of school-day scheduling, and as such, allowing for closer correlation to comparable directly measured variables.

Further, Kenyan under/healthy children may report more accurately than children from higher income countries, where the importance of regular physical activity is more publicized, possibly leading to greater social desirability bias to respond in a particular manner, much unlike the situation in Kenya (Bailey et al., 1995). Children and youth spend a significant proportion of their waking hours in the school environment; hence, it provides an important opportunity to positively influence their healthy active living behaviours (Story et al., 2009; Strong et al., 2005).

Sedentary Behaviour Measures

Differences by weight status: Using direct measures, children in the overweight/obese category had significantly higher mean weekend-day minutes of sedentary time compared to children in the under/healthy weight category, with no significant differences in the mean daily and weekday minutes of sedentary time. Self-reported measures indicated that a significantly higher proportion of children in the under/healthy weight group reported spending ≤ 2 hours watching television on schools days, thereby meeting the Canadian sedentary behaviour guidelines (CSEP, 2011), compared to their overweight/obese peers. There were no differences in time spent on video/computer games on weekdays and weekend-days, or time spent watching television on weekend-days. Collectively, both direct and self-report measures of sedentary time seldom showed a significant difference between the two weight groups. A systematic review examining the validity and reliability of sedentary behaviour measures in children and youth from some higher income countries concluded that self-report measures provided reliable estimates of screen time; however, their validity remains largely unexamined (Lubans et al., 2011). If we supposed that self-report measures also provided reliable estimates of screen time among Kenyan children, then perhaps both weight categories were accumulating similar levels of sedentary behaviour. Nevertheless, these findings warrant further investigation.

Relationships between self-reported and directly assessed measures by weight status: There were no associations found between self-report and direct measures of sedentary behaviour. Recent findings have found that self-reported screen time is only weakly correlated with objectively measured sedentary behaviour in adults (Clark et al., 2011), and while less effort has been placed on the comparison of self-report and direct measures of sedentary behaviour in the pediatric population, parental (proxy)-report under-estimated the time that children were spending in sedentary pursuits (Colley et al., 2012). The lack of correlation between direct and self-report measures of sedentary behaviour among Kenyan children may be as a result of the novelty of discussing time spent in sedentary pursuits in this region, or a general lack of attentiveness to the time they spend being sedentary. However, it is important to acknowledge that the self-report measures of sedentary behaviour as discussed in this manuscript only comprise a portion of total directly measured sedentary time – in other words, the two measures (reported screen time versus total measured sedentary behaviour) are fundamentally different. Further investigation of the relationship between self-report and direct measures of sedentary behaviour is necessary, especially in developing countries like Kenya, where screen time exposure opportunities are changing rapidly.

More generally, the main limitation of this study arises from the use of comparable variables rather than an exact comparison of self-report and direct assessment of movement. For instance, in our analyses, we examine the correlation of self-reported time spent outside before and after school, and active transport to/from school, to mean weekday minutes of MVPA rather than an actual movement profile at these times of the day. Nevertheless, the correlation analyses between self-reported and direct measurements of physical activity and sedentary time presented in this manuscript reveal some key findings on the extent of agreement or disagreement between the two.

It is important to note that habitual physical activity is often not measured directly (e.g., by accelerometry), but rather it is estimated from arbitrary intensity thresholds for moderate and vigorous intensity physical activity, after which a determination of the number of children accumulating at least 60 minutes of daily MVPA is made (Corder et al., 2008). Similarly, intensity thresholds for sedentary behaviour are also variable (Corder et al., 2008), and indeed, a lot more work needs to be done on validation of measurement tools for sedentary behaviour. Physical activity and sedentary behaviour are a function of the type, intensity, duration, and frequency of movement and therefore different measurement tools capture different properties (Adamo et al., 2009). For instance, while accelerometers can accurately classify behaviour as sedentary, they cannot indicate the type of sedentary behaviour or provide information about context (Story et al., 2009) as may be captured using self- report methods. As such, care must be taken when attempting to use varying measurement tools reciprocally.

CONCLUSION

The results of this study identified considerable differences in both self-report and direct measures of physical activity by weight status among Kenyan children, but less so for sedentary behaviour. Children in the overweight/obese category spent half the time in MVPA than their under/healthy weight peers, a substantially lower proportion met accepted physical activity guidelines, and they accumulated more sedentary time on weekends. Overweight/obese children also reported less time spent outside after school, and a lower proportion reportedly met the sedentary behaviour guidelines or reported using active transport to/from school. Taken together, these findings suggest that questionnaire-based assessment of physical activity in Kenyan children of different weight status may quite accurately capture differences between weight categories, that is, the magnitude of the bias among Kenyan children may be slightly muted, compared to previous findings in several higher income countries (Buchowski et al., 1999; McMurray et al., 2008; Slootmaker et al., 2009; Warner et al., 2013).

In the contrary, similar to findings from some higher income countries, direct and self-report measures were largely not associated, with significant associations only found in weekday and weekend-day measures of physical activity among the under/healthy weight children. This is indicative that the strength of association between direct and self-report measures of physical activity in particular, vary according to weight status, favourably so for the under/healthy weight children.

However, it is important to highlight the potential discrepancies of using self-report and direct measures interchangeably as described herein, since they may potentially misinform public health interventions. Researchers should be aware of the strengths and limitations of either self-report or direct measures of physical activity and sedentary behaviour prior to selecting a particular method in order to effectively address their research questions and thereby adequately inform policy and practise.

FUNDING

ISCOLE is funded by the Coca-Cola Company. The funder had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

DECLARATION OF INTEREST

The authors declare that they have no competing interests.

AUTHOR'S CONTRIBUTIONS

SKM, LMW, VOO, and MST contributed to preparations prior to implementing the study protocol in Kenya. SKM and LMW participated in data collection and entry. SKM and MST analysed the data and interpreted the results. SKM led the writing of the manuscript. All authors contributed to the writing, editing, and approved this manuscript.

ACKNOWLEDGEMENTS

The authors are grateful to all participants of the ISCOLE-Kenya study, and the research assistants who helped with data collection. We thank biostatistician Kathryn Williams for her guidance with statistical analysis for this manuscript. In addition, we would like to thank the ISCOLE Coordinating Center staff at the Pennington Biomedical Research Center for study coordination and data management (Peter T. Katzmarzyk PhD and Timothy S. Church MD, principal investigators, and Denise Lambert RN, project manager).

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TABLES

Table I: Self-report questions and the list of possible answers.

PHYSICAL ACTIVITY
Weekly Activities
During the past week (7 days), on how many days were you physically active for a total of at least 60 minutes per day? (all the time you spent in activities that increased your heart rate and made you breathe hard) ☐ 0 days ☐ 1 day ☐ 2 days ☐ 3 days ☐ 4 days ☐ 5 days ☐ 6 days ☐ 7 days
Weekday Activities
On a school day how much time did you spend outside **before** school? ☐ < 1 hour ☐ 1 hour ☐ 2 hours ☐ 3 hours ☐ 4 hours ☐ 5 or more hours On a school day how much time did you spend outside **after** school before bedtime? ☐ < 1 hour ☐ 1 hour ☐ 2 hours ☐ 3 hours ☐ 4 hours ☐ 5 or more hours In the last week you were in school, the **MAIN** part of your journey to school was by: ☐ walking ☐ bicycle, roller-blade, skateboard or scooter ☐ bus, train, tram, underground or boat ☐ car, motorcycle or moped ☐ other
Weekend Activities
On a weekend day, how much time did you spend outside? ☐ < 1 hour ☐ 1 hour ☐ 2 hours ☐ 3 hours ☐ 4 hours ☐ 5 or more hours
SEDENTARY TIME
Weekday Activities
On a school day, how many hours did you watch TV? ☐ I did not watch TV on school days ☐ < 1 hour ☐ 1 hour ☐ 2 hours ☐ 3 hours ☐ 4 hours ☐ 5 or more hours On a school day, how many hours did you play video or computer games or use a computer for something that was not school work? ☐ I did not play video/computer games or use a computer other than for school work on school days ☐ < 1 hour ☐ 1 hour ☐ 2 hours ☐ 3 hours ☐ 4 hours ☐ 5 or more hours
Weekend Activities
On a weekend day, how many hours did you watch TV? ☐ I did not watch TV on weekend days ☐ < 1 hour ☐ 1 hour ☐ 2 hours ☐ 3 hours ☐ 4 hours ☐ 5 or more hours

On a weekend day, how many hours did you play video or computer games or use a computer for something that was not school work?

☐ I did not play video/computer games or use a computer other than for school work on the weekend ☐ < 1 hour ☐ 1 hour ☐ 2 hours ☐ 3 hours ☐ 4 hours ☐ 5 or more hours

Table II: Directly measured and self-report descriptive characteristics of participating children by weight status.

	Mean (SD) or *n* (%)		
	Under/Healthy Weight (*n* = 446)	**Overweight/ Obese (*n* = 117)**	p-value
PHYSICAL ACTIVITY			
Weekly Activities			
Directly Measured			
Mean daily minutes of MVPA	39.2 (23.5)	20.1 (13.9)	< 0.0001
Met MVPA guidelines *(≥ 60 minutes of daily MVPA)*	68 (15.3 %)	3 (2.6 %)	< 0.0001
Self Report			
Days child was physically active for > 60 minutes			
0 - 2 days	249 (55.8 %)	60 (51.3 %)	NS
3 - 5 days	147 (33.0 %)	43 (36.7 %)	
6 - 7 days	50 (11.2 %)	14 (12.0 %)	
Weekday Activities			
Directly Measured			
Mean weekday minutes of MVPA	39.9 (24.3)	20.2 (16.1)	< 0.0001
Self Report			
Time spent outside before school			
≤ 1 hour	319 (71.5 %)	95 (81.2 %)	NS
2 - 3 hours	99 (22.2 %)	18 (15.4 %)	
≥ 4 hours	28 (6.3 %)	4 (3.4 %)	
Time spent outside after school before bedtime			
≤ 1 hour	217 (48.7 %)	67 (57.8 %)	0.0075
2 - 3 hours	158 (35.4 %)	24 (20.7 %)	
≥ 4 hours	71 (15.9 %)	25 (21.5 %)	
Transport to school			
Active *(Walking, bicycle, roller blade, skate board)*	209 (49.2 %)	36 (32.4 %)	0.0019
Motorized *(Bus, van, car)*	216 (50.8 %)	75 (67.6 %)	
Weekend Activities			
Directly Measured			
Mean weekend day minutes of MVPA	37.7 (30.0)	19.5 (15.4)	< 0.0001
Self Report			
Time spent outside			
≤ 1 hour	109 (24.4 %)	29 (24.8 %)	NS
2 - 3 hours	155 (34.8 %)	44 (37.6 %)	
≥ 4 hours	182 (40.8 %)	44 (37.6 %)	
SEDENTARY TIME			
Weekly Activities			
Directly Measured			

Mean daily minutes of Sedentary	396.6 (72.1)	402.8 (68.9)	NS
Weekday Activities			
Directly Measured			
Mean weekday minutes of Sedentary	419.4 (82.8)	420.3 (82.8)	NS
Self Report			
Time spent watching television			
Did not watch on school days	149 (33.4 %)	35 (29.9 %)	0.0376
≤ 2 hours	229 (51.4 %)	52 (44.5 %)	
≥ 3 hours	68 (15.2 %)	30 (25.6 %)	
Time spent playing video/computer games/use			
Did not play screen games on school days	268 (60.1 %)	76 (65.0 %)	NS
≤ 2 hours	148 (33.2 %)	35 (29.9 %)	
≥ 3 hours	30 (6.7 %)	6 (5.1 %)	
Weekend Activities			
Directly Measured			
Mean weekend day minutes of Sedentary	345.6 (95.8)	365.1 (90.3)	0.0181
Self Report			
Time spent watching television			
Did not watch on weekend days	35 (7.9 %)	6 (5.1 %)	NS
≤ 2 hours	163 (36.6 %)	32 (27.4 %)	
≥ 3 hours	247 (55.5 %)	79 (67.5 %)	
Time spent playing video/computer games/use			
Did not play screen games on weekend days	177 (39.7 %)	45 (38.5 %)	NS
≤ 2 hours	172 (38.6 %)	49 (41.9 %)	
≥ 3 hours	97 (21.7 %)	23 (19.6 %)	

Acronyms: MVPA (moderate-to-vigorous physical activity); NS (No statistical significant difference).

Table III: Associations between comparable self-reported and directly measured variables by weight status.

	Mean (SD) or *n* (%)	r-value	p-value	Mean (SD) or *n* (%)	r-value	p-value
	Under/Healthy Weight			**Overweight/Obese**		
PHYSICAL ACTIVITY						
Weekly Activities						
	DM: Mean daily minutes of MVPA					
SR: Days child was physically active for > 60 minutes						
0 - 2 days	38.6 (23.7)			20.2 (15.6)		
3 - 5 days	38.9 (24.1)	0.04	NS	18.2 (8.6)	0.08	NS
6 - 7 days	43.0 (21.1)			25.5 (17.9)		
	DM: % that met MVPA guidelines					
SR: Days child was physically active for > 60 minutes						
0 - 2 days	33 (13.3 %)			2 (3.3 %)		
3 - 5 days	25 (17.0 %)	0.07	NS	0 (0 %)	- 0.01	NS
6 - 7 days	10 (20.0 %)			1 (7.1 %)		
Weekday Activities						
	DM: Mean weekday minutes of MVPA					
SR: Time spent outside before school						
≤ 1 hour	38.5 (24.0)			19.6 (14.5)		
2 - 3 hours	40.7 (24.1)	0.12	0.0143	18.3 (9.0)	0.08	NS
≥ 4 hours	55.5 (24.8)			103.2 (0)		
SR: Time spent outside after school before bedtime						
≤ 1 hour	35.5 (23.4)			21.8 (18.9)		
2 - 3 hours	42.7 (22.8)	0.20	< 0.0001	16.9 (8.7)	- 0.06	NS
≥ 4 hours	48.0 (28.1)			18.5 (12.4)		
SR: Transport to school						
Active	49.4 (25.9)	0.36	< 0.0001	23.4 (20.1)	0.17	NS
Motorized	31.9 (19.5)			18.2 (13.5)		
Weekend Activities						
	DM: Mean weekend day minutes of MVPA					
SR: Time spent outside						
≤ 1 hour	35.0 (29.5)			19.2 (19.6)		
2 - 3 hours	36.4 (31.0)	0.10	0.0392	17.9 (15.9)	0.19	NS (0.0548)

≥ 4 hours	40.3 (29.5)			21.2 (11.4)		
SEDENTARY TIME						
Weekday Activities						
	DM: Mean weekday minutes of Sedentary					
SR: Time spent watching television						
Did not watch on school days	410.4 (77.5)			401.2 (85.5)		
≤ 2 hours	429.6 (85.7)	0.03	NS	422.8 (86.5)	0.15	NS
≥ 3 hours	405.8 (81.6)			435.2 (72.3)		
SR: Time spent playing video/computer games/use						
Did not play screen games on school days	418.8 (81.4)			422.8 (80.4)		
≤ 2 hours	425.6 (84.6)	0.01	NS	416.1 (90.7)	- 0.09	NS
≥ 3 hours	393.1 (84.7)			402.8 (52.7)		
Weekend Activities						
	DM: Mean weekend day minutes of Sedentary					
SR: Time spent watching television						
Did not watch on weekend days	339.9 (133.4)			347.6 (61.8)		
≤ 2 hours	345.2 (93.2)	0.03	NS	368.8 (87.7)	- 0.07	NS
≥ 3 hours	346.6 (91.4)			364.5 (93.7)		
SR: Time spent playing video/computer games/use						
Did not play screen games on weekend days	331.6 (87.6)			364.3 (89.5)	0.01	NS
≤ 2 hours	359.8 (100.9)	0.09	NS	372.2 (95.5)		
≥ 3 hours	345.5 (97.9)			351.2 (82.5)		

Acronyms: SR (self-report); DM (directly measured); NS (No statistical significant difference).

Note: Spearman correlation coefficients reported.

CHAPTER 6

Comparative Study of Physical Activity Patterns among School Children in Kenya and Canada: Results from the ISCOLE Project

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Running Title: Childhood Activity Patterns.

Formatted for submission to: African Journal for Physical Health Education, Recreation and Dance in January 2014 [**Current Status:** Under Review].

The objective(s): This last manuscript aimed to compare activity patterns, including moderate-to-vigorous physical activity, light physical activity, and sedentary time, between Kenyan and Canadian children. By comparing the activity profile of Kenyan children – a country deemed to be at the early stages of a physical activity transition – to the situation in Canada, which is further along this transition, changing cultural norms and context contributing to this behavioural transition may start to emerge.

Abstract

Examination of the timing and patterns of daily activity are crucial in understanding when children accumulate the highest levels of physical activity. The objectives of this study were to examine moderate-to-vigorous physical activity (MVPA) patterns accrued by time of day among Kenyan children, and compare activity patterns in Kenya to those of Canadian children. Physical activity and body weights of participating children were measured by accelerometry and anthropometry, while supplementary self-report data were captured by questionnaires. Data were collected as part of a larger International Study of Childhood Obesity, Lifestyle and Environment (ISCOLE) in Nairobi for ISCOLE-Kenya and in the Ottawa Region for ISCOLE-Canada. A total of 555 Kenyan and 541 Canadian children 9 to 11 years were included in the analyses. In Kenya, boys, under/healthy weight, and children attending public (lower socioeconomic status (SES)) schools were found to have significantly higher MVPA levels compared to girls, overweight/obese, and children attending private (higher SES) schools respectively. MVPA on weekdays was higher than on weekend-days. Activity profiles among Kenyan and Canadian children were very similar; however, Kenyan children had significantly higher MVPA and lower sedentary time on weekend-days. MVPA patterns among urban Kenyan children were largely similar to those of urban Canadian children when assessed by sex, BMI category, and weekday/weekend days. However, in the Kenyan sample, unlike in many higher income countries, lower SES was associated with higher MVPA.

Key Words: Accelerometry, physical activity patterns, school children, Kenya, Canada.

Introduction

Physical activity guidelines developed by the World Health Organization (WHO) recommend that children and youth (5 – 17 years) should accumulate at least 60 minutes of daily moderate-to-vigorous physical activity (MVPA) for positive health outcomes (WHO, 2010). Canadian sedentary behaviour guidelines further recommend that children of this age group should limit their recreational sedentary screen time to no more than 2 hours per day (Canadian Society for Exercise Physiology, 2011), since sedentary behaviours are independently associated with adverse health outcomes (Tremblay, Colley, Saunders, Healy, & Owen, 2010). Investigation of the timing and patterns of daily physical activity, including MVPA, light physical activity, and sedentary time, are crucial in understanding how, when, or where children accumulate the highest levels of physical activity (Cairney, Veldhuizen, Kwan, Hay, & Faught, 2013; Colley et al., 2011; Garriguet & Colley, 2012; Laguna et al., 2013; Ramirez-Rico, Hilland, Foweather, Fernández-Garcia, & Fairclough, 2013; Sigmund, Sigmundová, Snoblová, & Gecková, 2013), thereby providing the evidence for informed interventions and strategies to promote physical activity and prevent sedentary behaviours in this population.

Objectively measured physical activity in Canada showed that only 7% of children and youth accumulated the recommended ≥ 60 minutes of daily MVPA, with those that were overweight/obese accumulating even less (Colley et al., 2011). A higher proportion of boys (9%) than girls (4%) met these recommendations (Colley et al., 2011). This study also revealed that children were spending an average of two thirds of their waking hours - 8.6 hours - in sedentary activities daily (Colley et al., 2011). Garriguet and Colley (2012) found that among Canadian children and youth (6 -19 years), boys on average accumulated more MVPA than girls, and that children and youth spent more time in MVPA on weekdays than on weekend-days. Similar findings of lower MVPA among girls, among overweight/obese children, and on weekend-days compared to weekdays have been reported in other higher income countries (Cairney et al., 2013; Ekelund et al., 2002; Laguna et al., 2013; Mota, Santos, Guerra, Ribeiro, & Duarte, 2003; Nilsson et al., 2009; Page et al., 2005; Ramirez-Rico et al., 2013; Sigmund et al., 2013). Further, various studies have shown that lower socioeconomic status (SES) is associated with lower levels of physical activity, more time spent in sedentary behaviours, and higher risk for unhealthy lifestyles compared to higher SES children (Drenowatz et al., 2010; Jimenez Pavon et al., 2010). Given that much of the knowledge available on these emerging patterns of physical activity is informed by studies conducted in higher income countries (Haug et al., 2009; Janssen et al., 2005; Katzmarzyk et al., 2013), it is important that we examine whether these findings and relationships are maintained across other regions of the world, including lower income countries such as Kenya. While there is lack of nationally representative data on physical activity and sedentary behaviour in Kenya, data from a recently study (International Study of Childhood Obesity, Lifestyle and Environment, ISCOLE-Kenya) revealed that mean daily sedentary time in a sample of urban living children from Nairobi was 6.6 hours (Muthuri, Wachira, Onywera, & Tremblay, 2014a). Mean daily time spent in MVPA was 36 minutes, with only 12.6% of participating children meeting the WHO recommendation of ≥ 60 minutes of daily MVPA (Muthuri et al., 2014a).

The primary objective of this study was to examine the levels of MVPA accrued by time of day among Kenyan children, by sex, BMI (WHO) category, type of school (an indicator of SES), and on weekdays compared to weekend-days. The secondary objective of this study was to compare activity patterns in the Kenyan setting, to activity patterns in the Canadian setting, in order to gain insight into the similarities or differences in accumulation of moderate-to-vigorous, light physical activity, and sedentary time among school-aged children, by time of day and on weekdays/weekend-days.

Materials and Methods

Physical activity and body weight measures of the participating children were obtained by accelerometry and anthropometric assessment. Supplementary self-report information was captured by the use of questionnaires related to lifestyle and the environment. Data collection was conducted as part of the ISCOLE project (Katzmarzyk et al., 2013).

The ISCOLE Project

The primary aim of ISCOLE was to investigate the influence of behavioural settings and the physical, social, and policy environments on the observed relationship between lifestyle characteristics and weight status in approximately 500 children from each of 12 countries from the major regions of the world (Katzmarzyk et al., 2013). Data collection was conducted in the urban city of Nairobi, for ISCOLE-Kenya's assessments, and in the Ottawa Region for the ISCOLE-Canada's assessments, following ethical approval from the local coordinating centers – Kenyatta University in Nairobi, and the Children's Hospital of Eastern Ontario in Ottawa. Extensive details of the ISCOLE study protocol are provided elsewhere (Katzmarzyk et al., 2013), and a brief overview provided here.

Study Design and Population

A sex-balanced sample of approximately 500 children between the ages of 9 and 11 years was recruited for each of the sites (Nairobi and Ottawa). In Nairobi, the primary sampling frame was a convenience sample of non-boarding public and private schools, whereby type of school, public verses private, was an indicator of lower and higher SES respectively. The secondary sampling frame was classrooms in the recruited schools that best yielded a final sample with minimal variability around 10 years of age. In the Ottawa Region, schools were stratified into four groups with proportional representation (English Public, French Public, English Catholic, and French Catholic). At both sites, schools within each stratum (type of school) were invited to participate (proportional to attendance by school children), and thereafter parental consent and child assent sought prior to inclusion in the study. Further details on the sampling strategy are provided elsewhere (Katzmarzyk et al., 2013).

Questionnaires

A diet and lifestyle questionnaire was completed by participating children and captured information about their individual level factors including sex, while a school environment questionnaire completed by a school administrator captured information on school characteristics such as the type of school. Full details of the questionnaires are provided elsewhere (Katzmarzyk et al., 2013).

Anthropometry

Trained research staff measured standing height of participating children using the Seca 213 portable stadiometer (Birmingham, United Kingdom), with the participant as erect as possible and head positioned in the Frankfort horizontal plane (Katzmarzyk et al., 2013). The weight of each participant was measured using a portable Tanita Body Composition Analyser (SC-240, Illinois, USA), after all outer clothing, heavy pocket items, shoes, and socks were removed (Katzmarzyk et al., 2013). Body mass index (BMI) was derived from weight and height (kg/m^2), and BMI z-scores calculated based on growth reference algorithms developed by the WHO for children and youth (de Onis et al., 2007). Children were thereafter grouped into underweight/healthy weight and overweight/obese categories.

Accelerometry

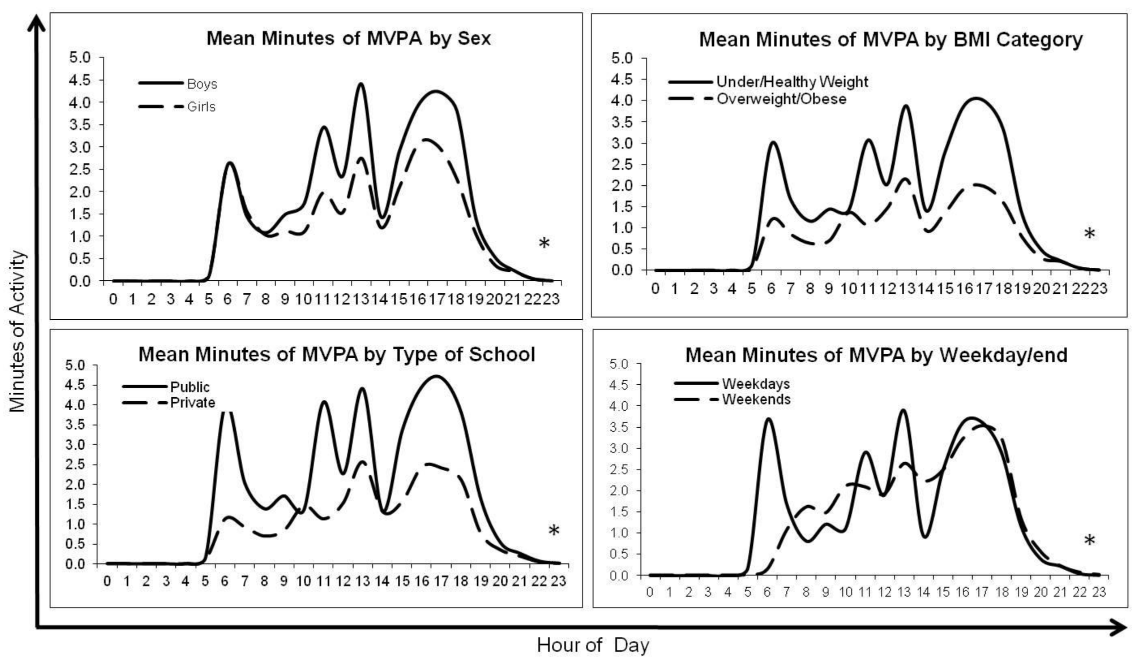
Direct monitoring of physical activity and sedentary time was achieved by use of ActiGraph GT3X+ accelerometers at a one second epoch setting. Accelerometers were firmly attached to belts and distributed to the children who were instructed on appropriate wearing of the instruments; on the right side of their waists at all times except when bathing or swimming (including when sleeping). Participants were required to wear the devices for at least 7 consecutive days, plus an initial familiarisation day, in order to maximise the number of children providing a minimum of 4 days of wear of at least 10 hours per day, with at least one valid weekend-day (Katzmarzyk et al., 2013). Non-wear time within a day was considered 60 consecutive minutes of '0' counts. Reminder telephone calls and reminders from class teachers were helpful in ensuring compliance with the protocol. Accelerometry data were downloaded, the logs reviewed for completeness, and data reduction completed using cut-points developed by Treuth et al., which are validated in children and youth (Treuth et al., 2004). Time spent in sedentary, light, and MVPA were then determined.

Statistical Analysis

All statistical analyses presented in this manuscript were computed using SAS version 9.3 (SAS Institute, Cary, North Carolina, USA). Minute-by-minute data downloaded from the accelerometers were summarized into one record per person, thereby allowing for the extraction of mean minute and hourly level sample data. Significant differences in the distribution of two sets of data of moderate-to-vigorous, light physical activity, and sedentary time, were investigated using the two-sample Kolmogorov-Smirnov test, a non-parametric test that compares the empirical distribution functions (EDFs) of two data sets (Kirkman, 1996). The Kolmogorov-Smirnov test is one of the more useful and general methods for comparing the distribution between two samples, and it makes no assumption about the distribution of data (Kirkman, 1996). It was selected for use in these analyses due to its sensitivity to differences in location and shape of cumulative distribution functions, and because it is fairly robust to outliers. With a null hypothesis that both data sets are from populations with identical distributions, this test searches for any violation of that null hypothesis, that is, different medians, variances, or distributions (Kirkman, 1996). The Kolmogorov-Smirnov test seeks to determine how far apart the relative frequency distributions of the two data sets are – at the point where they are furthest apart – that is, it computes the maximum vertical deviation (supremum) between the two cumulative distributions, and then calculates a p-value based on this difference, while accounting for the sample sizes of the data sets (Kirkman, 1996).

Results

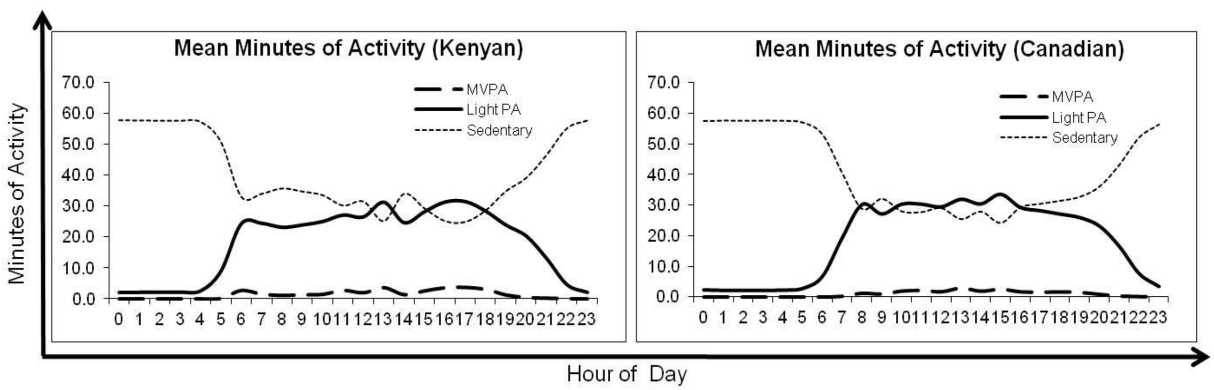
Figure 1: Mean daily minutes of moderate-to-vigorous physical activity patterns by time of day among Kenyan children.



Legend: * Significant difference in the levels of moderate-to-vigorous physical activity by sex [p<0.0001], by BMI (WHO) category [p<0.0001], by type of school [p<0.0001], and by weekdays/weekend-days [p<0.0001]

Participating children were 9.0 to 11.9 years of age at the time of recruitment. A total of 555 Kenyan participants (46.4% boys, 53.6% girls) recruited from 29 schools in Nairobi, completed the required anthropometric assessments and had valid accelerometry wear data. Of these, 79.8% were underweight/healthy weight while 20.2% were overweight/obese, and 52.2% were attending public schools while 47.8% were attending private schools in Nairobi. An age matched sample of 541 children (41.9% boys, 58.1% girls) was recruited from 26 schools in the Ottawa Region of Canada. Of these, 69.2% were underweight/healthy weight while 30.8% were overweight/obese.

Figure 2: Mean daily minutes of moderate-to-vigorous, light physical activity, and sedentary time among Kenyan and Canadian children.

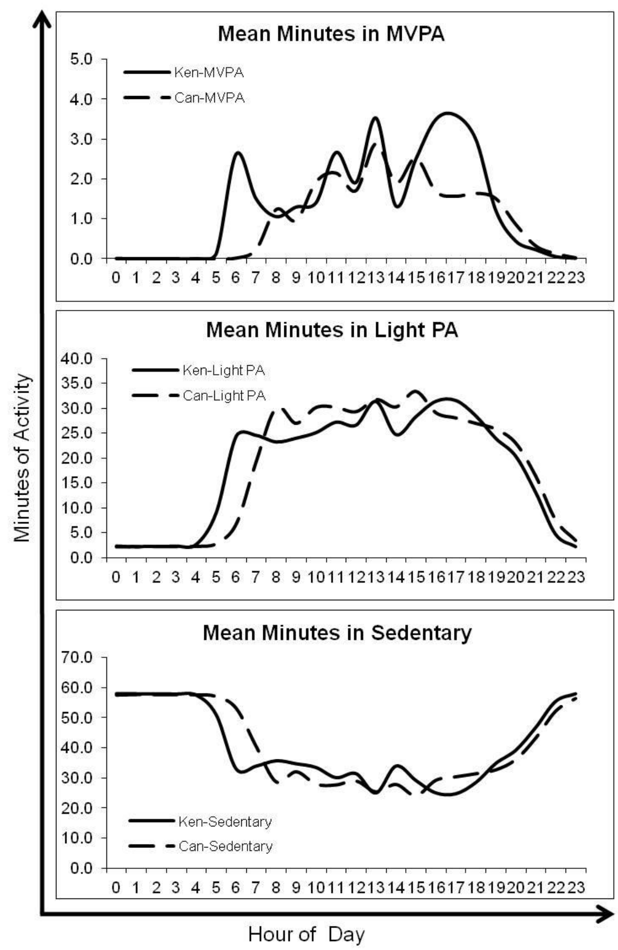


Activity Patterns among Kenyan Children

The MVPA patterns among Kenyan children are presented in *Figure 1*. Boys, under/healthy weight children, and public school attending children were found to have significantly higher mean daily MVPA levels, compared to girls, overweight/obese children and private school attending children respectively (p<0.0001). MVPA distinctly peaked at around 6:30 am and 11:30 am in the morning, 1:30 pm in the afternoon, and 5:30 pm in the evening.

Mean daily MVPA levels on weekdays was significantly higher than on weekend-days ($p<0.0001$). On weekdays, MVPA levels were highest between 6:00 – 7:00 am, 11:00 – 12:00 noon, 1:00 – 2:00 pm, and 4:00 – 6:00 pm. On weekend-days, MVPA levels gradually increased throughout the day starting at 9:00 am, and were highest between 4:30 – 6:30 pm.

Figure 3: Kenyan-Canadian comparison of mean daily minutes of moderate-to-vigorous, light physical activity, and sedentary time.

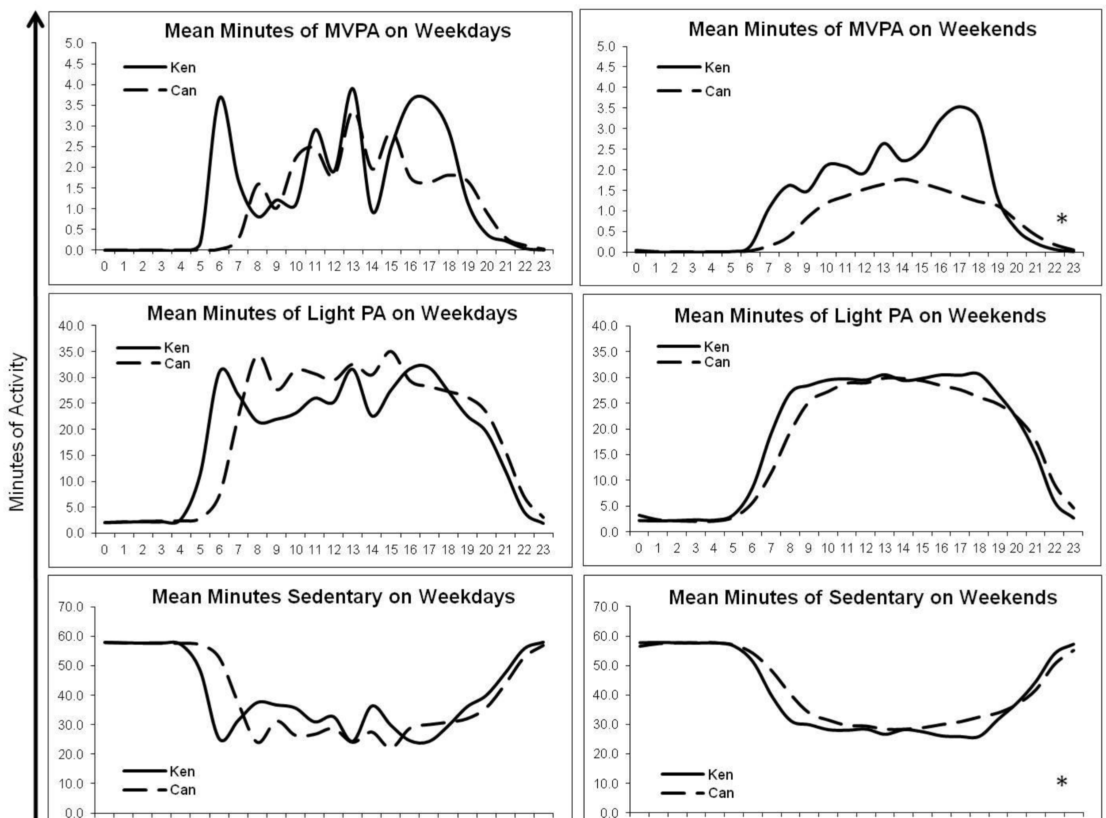


Legend: No significant difference in the levels of moderate-to-vigorous, light physical activity, and sedentary time between Kenyan and Canadian children.

Activity Pattern Comparisons between Kenyan and Canadian Children

As shown in *Figure 2*, an examination of the activity profiles among Kenyan and Canadian children revealed considerable similarities in the trends. Comparative analysis of mean daily minutes of MVPA, light physical activity, and sedentary time between Kenyan and Canadian children revealed no significant differences at the different intensity levels, as represented in *Figure 3*. There were no significant differences found even when boys and girls were assessed separately; however, there was a trend towards higher mean MVPA levels in Kenyan verses Canadian children, particularly when boys and girls were assessed separately. More generally, most MVPA was found to occur between 5:30 am and 8:30 pm for Kenyan children and between 7:30 am and 9:30 pm for Canadian children.

Figure 4: Kenyan-Canadian comparison of mean daily minutes of moderate-to-vigorous, light physical activity, and sedentary time on weekdays and weekend-days.



Legend: * Significant difference in the levels of moderate-to-vigorous physical activity [p=0.019] and sedentary time [p=0.043] between Kenyan and Canadian children on weekend-days. No significant difference in the levels of light physical activity on weekend-days, or in either activity level on weekdays.

As shown in *Figure 4*, comparative analysis of mean daily minutes of MVPA, light physical activity, and sedentary time on weekdays and weekend-days revealed that there was a significant difference between Kenyan and Canadian children in their accumulation of MVPA and sedentary time on weekend-days ($p<0.0001$). However, there were no significant differences in the levels of light physical activity on weekend-days, or in the levels of MVPA, light physical activity, and sedentary time on weekdays.

Discussion

Activity Patterns among Kenyan Children

Kenyan boys were found to have higher mean daily MVPA levels throughout the day compared to girls. This sex difference in the accumulation of physical activity has also been observed in various other low and high income countries (Cairney et al., 2013; Colley et al., 2011; Garriguet & Colley, 2012; Mota et al., 2003; Muthuri et al., 2014b; Page et al., 2005; Sigmund et al., 2013). Differences in gender roles (e.g. participation in different tasks or chores) and a higher motivation inherent in boys to participate in physical activity may explain this sex difference.

Overweight/obese children in this setting were also found to engage in lower levels of MVPA than their peers. Similarly, overweight/obese children in other global regions and settings have been found to be generally less physically active than their non-overweight/obese counterparts, particularly in girls (Colley et al., 2011, Laguna et al., 2013, Page et al., 2005, Sigmund et al., 2013). It has been suggested that this difference in physical activity may not be necessarily equal to a difference in energy expenditure (Ekelund et al., 2002), but that lower physical activity may be related to engagement in other behaviours such as consumption of energy dense foods, sedentary behaviours, and activities undertaken by overweight/obese children (Page et al., 2005).

The study also revealed that public school attending (lower SES) children were found to have significantly higher mean daily MVPA levels compared to private school attending (higher SES) children. This inverse relationship between SES and physical activity is the opposite of findings reported in many higher income countries (Drenowatz et al., 2010, Jimenez Pavon et al., 2010); however, these findings are commensurate with studies conducted in Kenya showing similar associations between higher SES and urbanization, with decreased time spent in physical activity (Larsen, Christensen, Nolan, & Sondergaard, 2004; Ojiambo et al., 2012; Onywera et al., 2012).

Time spent in MVPA in this sample of children was higher on weekdays than on weekend-days, much like reports from various studies conducted in higher income countries (Garriguet & Colley, 2012; Laguna et al., 2013; Nilsson et al., 2009; Ramirez Rico et al., 2013). Further, similar to findings in the USA and Canada, the period before-school, the mid-morning break, lunch-time, and the period after school, were all consistent with the distinctly higher levels of MVPA observed on weekdays (Garriguet & Colley, 2012; Tudor-Locke, Lee, Morgan, Beighle, & Pangrazi, 2006). These are all times when children are released from their classrooms. On weekend-days, there was a gradual increase in MVPA levels observed throughout the day, culminating in the highest levels right before dinner-time. Overall, weekday physical activity may represent the most important source of MVPA; however, weekend-days represent an important point of intervention for promoting physical activity in this age of children, and a possible means of establishing self-directed healthy active living habits.

Activity Pattern Comparisons between Kenyan and Canadian Children

Activity profiles among Kenyan and Canadian children were very similar, with no significant differences observed in levels of MVPA, light physical activity, and sedentary time accrued by time of day. These similarities may indeed be reflective of a deeper concern, since lower income countries like Kenya may be adopting behavioural patterns that could lead to a growing problem of physical inactivity, comparable to observations in higher income countries. More broadly, while the health benefits of maintaining healthy active lifestyles are well known, in many Sub-Saharan African countries, declines in habitual physical activity (e.g. manual labour and the practice of walking long distances) and increases in sedentary behaviour (e.g. desk work and motorised transport) have been reported (Onywera, 2010; Steyn & Damasceno, 2006; Unwin et al., 2001). In Kenya specifically, a number of studies have shown emerging evidence of a physical inactivity problem in school-aged children in Kenya, particularly urban living children, in contrast to their rural living peers (Croteau, Schofield, Towle, & Suresh, 2011; Larsen et al., 2004; Ojiambo et al., 2012, Onywera et al., 2012).

Kenyan children were found to start their day earlier (5:30 am verses 7:30 am), and end their day earlier (8:30 pm verses 9:30 pm), compared to Canadian children. This may be indicative that Kenyan children were awake for approximately an hour longer than their Canadian peers, or that the Canadian children were much more sedentary in the early morning, and requires further exploration. An examination of the ISCOLE-Kenya school start times revealed that sampled schools in Nairobi started their day between 6:30 am and 8:20 am, and had school end times that fell between 2:45 pm and 5:00 pm, while ISCOLE-Canada school start times ranged from 7:55 am to 9:15 am, and end times ranged from 2:25 pm to 3:45 pm. These differences in school start and end time ranges may explain why Kenyan children were found to seemingly start their day earlier and have more minutes of movement during the day compared to their Canadian peers.

Comparative analysis revealed that Kenyan children had higher MVPA levels and lower sedentary time than their Canadian counterparts on weekend-days. This may indeed account for the seeming – but non-significant - trend towards higher overall MVPA levels in Kenyan verses Canadian children, particularly when boys and girls were assessed separately. Children in the Kenyan setting may be spending less time in sedentary pursuits than their Canadian peers on weekend-days, as a consequence of reduced penetration of screen-based options for children and youth, even in the urban city of Nairobi. These children may therefore be engaging in more active play or other activities that account for higher MVPA levels on weekend-days compared to Canadian children.

While this study is limited by its cross-sectional design and by not being nationally representative, its strength lies in the standardized, objective measures collected. Further, the findings clearly reveal differences and similarities in the accumulation of MVPA, light physical activity, and sedentary time, between Kenyan and Canadian children.

Conclusions

In the Kenyan sample, girls, overweight/obese, and private school attending (higher SES) children had significantly lower mean daily MVPA levels compared to boys, under/healthy weight, and public school attending (lower SES) children. MVPA on weekdays was significantly higher than on weekend-days. These results are similar to patterns observed in Canada and other higher income countries. However, the inverse relationship between SES and MVPA in the Kenyan sample is unlike that observed in many higher income countries. Activity profiles among Kenyan and Canadian children were very similar; however, there were significant differences between Kenyan and Canadian children in their accumulation of MVPA and sedentary time on weekend-days. Generally, the findings of this study will serve to further promote collaboration in surveillance and dissemination efforts among researchers as they attempt to address the potential population health concerns caused by childhood physical inactivity, by highlighting similarities and differences in activity patterns among school children from different global regions.

Acknowledgements

The authors are grateful to all participants of the ISCOLE-Kenya and ISCOLE-Canada studies, and the research assistants who helped with data collection. We thank biostatistician Kathryn Williams for her guidance with statistical analysis for this manuscript. In addition, we would like to thank the ISCOLE Coordinating Center staff at the Pennington Biomedical Research Center for study coordination and data management (Peter T. Katzmarzyk PhD and Timothy S. Church MD, principal investigators, and Denise Lambert RN, project manager).

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CHAPTER 7

General Discussion

The overall objectives of this thesis were to investigate the evidence for an overweight/obesity, physical activity, and fitness transition in SSA, thereby contextualising Kenyan findings with respect to the growing concern of childhood overweight/obesity and physical inactivity in the region. Thereafter, proportions of overweight/obesity, time spent in sedentary, light, moderate, and vigorous physical activity levels, and relationships between self-reported and directly assessed measures of physical activity and sedentary behaviours among school-aged children in Kenya were examined.

7.1 Bridging the Manuscripts

7.1.1 Overweight/Obesity Transition

Examination of the systematic review evidence revealed a transition to increasing proportions of overweight/obesity among school-aged children in SSA, and a less prominent trend towards increasing proportions of obesity over time. The weighted averages of the proportions of overweight/obesity and obesity alone for the entire period captured by the review were 7.6% and 2.0% in boys, and 15.4% and 3.9% in girls, while the weighted averages of overweight/obesity and obesity alone for the total population were 10.6% and 2.5%. While the increasing trend in proportions of overweight/obesity over time was observed for both boys and girls, body composition measures were proportionally higher in girls than in boys. Higher body composition measures were also found in the urban compared to the rural populations, and in higher SES compared to lower SES children, pointing to a positive SES relationship with overweight/obesity in the region. The review also provided the evidence for a persisting underweight trend among SSA's children and youth over time.

An examination of the prevalence and correlates of overweight/obesity among school-aged children from Nairobi in Kenya revealed that a concerning 14.4% were overweight, and 6.4% were obese (20.8% overweight/obese) based on WHO BMI cut-points for this age group (1). Use of active transportation was negatively associated with being overweight/obese. Further, there was an increase in the number of children who were overweight/obese with increasing maternal and paternal education attainment and increasing household SES. Higher paternal BMI and attending a private (higher SES) rather than a public (lower SES) school was associated with increased odds of children being overweight/obese. Similar to the systematic review findings on the situation in SSA, these results also pointed to a positive SES relationship with overweight/obesity. An existing persistence of underweight was evident from the finding that even in the urban city of Nairobi, 3.7% of children were underweight.

While the weighted averages of overweight/obesity are lower than proportions in various high income countries, the transition to higher proportions of overweight/obesity over time observed in SSA is similar to trends observed in developed countries (2-5). These results are indicative that there is an impending threat of sustained increases in levels of childhood overweight/obesity in SSA and that preventative measures are required to mitigate associated health concerns in this population, before the situation worsens.

While proportions of overweight/obesity were generally higher in girls than in boys in SSA, in North America, various studies have shown that obesity is more common in boys than in girls, particularly among younger children (4, 5). We postulate that this sex difference – higher proportions of overweight/obesity in SSA girls – may be related to differences in gender roles particularly those requiring higher physical exertion among boys than girls, in addition to a cultural desirability, whereby being plump is an admired trait and seen as a sign of wealth and prestige predominantly in girls (6).

The United Nations Population Fund indicates that urban cities offer a more favourable setting for social and environmental development compared to rural areas, owing to the generation of jobs and income, better governance, education, health care, and other services. However, poverty is also growing in urban areas, particularly in urban slums, which are overcrowded, polluted, and lack basic services such as clean water and sanitation (7). Nevertheless, while urbanization increasingly concentrates poverty, it also provides possibilities for escaping it (7). Urban residence and higher SES may be positively associated with overweight/obesity in Kenya and the larger SSA region owing to improved access to amenities such as health care, education, and employment, coupled with increased availability of packaged foods high in saturated fats and sugars, and increased sedentary behavior (e.g., motorized transport and desk jobs), all of which are more accessible to and/or affordable to those of higher SES or individuals living in urban areas. These findings are suggestive of the negative impact of higher SES and urbanisation on body weights of school-aged children in this region. These conclusions are further supported by the finding that the prevalence of overweight/obesity among school-aged children in the urban city of Nairobi was 20.8%, double the weighted average of overweight/obesity for the entire period captured by the review at 10.6%.

Undeniably, child under-nutrition is a critical challenge for improved human development in SSA, particularly among school-aged children, owing to the potential for diminished success in later years (8-10). This persistence of underweight, coupled with an overweight/obesity transition, may place undue strain on the limited public health and healthcare resources in SSA and Kenya specifically. Interventions to improve the nutritional status of SSA children will have to account for this double burden.

7.1.2 Physical Activity and Fitness Transition

Vast heterogeneity in the methodology of studies examining temporal trends of physical activity, sedentary behaviour, and physical fitness among school-aged children and youth in SSA, complicated quantitative analyses; as such, a physical activity and fitness transition over time was not immediately discernible. However, quantitative and narrative analyses of studies examining physical fitness measures revealed a tendency towards increased fitness measures, particularly in grip strength and flexibility over time in SSA. Improvements in these fitness parameters in SSA's school-aged children may be directly related to increasing proportions of well nourished children with greater muscle mass and increased participation in organized sports or activities, thus improving their physical fitness skills.

More generally however, the findings of the systematic review were suggestive of the negative impact of higher SES and urbanisation on physical activity and fitness levels of school-aged children. Higher activity levels in lower SES and rural living children may be associated with a higher requirement for their involvement in survival activities such as household chores and walking from place to place (active transportation). In contrast, higher SES and urban living children may be spending more time in sedentary pursuits due to increased access and use of motorized transport and screen facilities (e.g. televisions, computers). The superior aerobic fitness performance observed among lower SES and rural living children may be directly associated with their higher participation in habitual active transport (e.g. walking, running), when compared to their higher SES and urban living children. In addition, boys were found to engage in significantly higher levels of physical activity, lower levels of sedentary behaviour, and have considerably better aerobic, anaerobic, musculoskeletal fitness, and strength measures than girls. Biology and socio-cultural roles may explain the superior physical ability of boys and their higher level of participation in physical activity.

Analysis of ISCOLE-Kenya data revealed concerning amounts of sedentary time and considerably low amounts of time spent in MVPA. The mean daily time spent in MVPA was 36 minutes (0.6 hours), while mean daily sedentary time was 398 minutes (6.6 hours). Only 12.6% of participating children met the recommendation of ≥ 60 minutes of daily MVPA as per the WHO physical activity guidelines (11). A higher percentage of boys than girls met the recommended daily minutes of MVPA. Children that used active transportation, and that attended public (lower SES) schools, were more likely to meet the physical activity guidelines compared to those that used motorised transport or that attended private (higher SES) schools. There was a decreasing trend in the number of children who met the guidelines with increasing maternal and paternal education attainment and increasing household SES. These results also pointed to a negative relationship between higher SES and urbanization and physical activity, characterised by a developing trend towards decreasing physical activity, increasing sedentary behaviours, and decreasing fitness measures (particularly aerobic fitness) over time.

Taken together, the most unexpected finding was that urban residence and higher SES may be positively associated with overweight/obesity and negatively associated with physical activity in Kenya and the larger SSA region. The inverse has been observed in many high income countries where studies have shown that lower SES is associated with lower levels of physical activity, more time spent in sedentary behaviours, and higher risk for unhealthy lifestyles compared to higher SES children (12, 13).

7.1.3 Additional Activity Behaviour Descriptive

Comparison of direct versus self-reported measures for assessing physical activity and sedentary behaviour revealed that while direct measures of physical activity consistently showed significant differences between the under/healthy weight and overweight/obese weight categories in their accumulation of MVPA, these differences were less evident from self-reported physical activity data. In addition, self-reported measures of physical activity were weakly associated with directly measured MVPA. These findings were consistent with previous studies from higher income countries showing low to moderate relationships between self-reported assessment of physical activity in the pediatric population, compared with direct methods (14-19). Analyses of the differences between self-reported and direct measures of sedentary behaviour were however more difficult to tease out.

Examination of activity patterns among school-aged children in Kenya showed that boys had higher mean daily MVPA levels compared to girls, a sex difference also observed in various other higher income countries (20-25), and probably explained by the differences in gender roles and a higher motivation inherent in boys to participate in physical activity. Overweight/obese children were also found to engage in lower levels of MVPA than their peers, similar to the findings from other global regions (21, 24-26). ISCOLE-Kenya study data analysis also showed that public (lower SES) school attending children had higher mean daily MVPA levels compared to private school attending (higher SES) children. This inverse relationship between SES and physical activity is the opposite of findings reported in many higher income countries (12, 13); however, these findings are commensurate with studies conducted in Kenya and other SSA countries as previously described. Lastly, much like reports from various studies conducted in higher income countries (22, 26-28), urban Kenyan children had higher MVPA on weekdays than on weekend-days. More generally, activity profiles among urban Kenyan and urban Canadian children were very similar; however, there were significant differences between Kenyan and Canadian children in their accumulation of MVPA and sedentary time on weekend-days. These vast similarities may be indicative of a growing concern, since lower income countries like Kenya may be adopting behavioural patterns that could lead to a more pronounced problem of physical inactivity, comparable to observations in higher income countries.

7.2 General Strengths and Limitations

The main strength of systematic review methodology – as employed in chapters 2 and 3 of this thesis – lies in its reliance on explicit procedures to locate, evaluate, and synthesise available data (29). Further, diversity among the subjects across the various included studies allows for more generalizable and global conclusions to be made; as such, the findings of the reviews included herein are more credible than other comprehensive, though non-systematic reviews. The main limitation lies in the vast heterogeneity in study methodology, which may affect review results (29). In addition, even with a well conducted literature search, it may be difficult to locate all relevant articles owing to the presence of un-indexed journals and the existence of other key grey literature that may not be easily accessible. To get around this issue, several open access un-indexed journals relevant to SSA were identified, and those journal web sites searched for additional relevant papers.

The systematic reviews also revealed a critical lack of nationally representative, temporally sequenced data on overweight/obesity, physical activity, sedentary behaviours, and physical fitness measures in SSA's school-aged children and youth, which further complicated time trend analyses attempted within this thesis.

The ISCOLE-Kenya research study – as analysed in chapters 4, 5, and 6 of this thesis – had several limitations including its cross-sectional design and not being nationally representative. The main limitation of cross sectional study designs is that while associations may be determined, there is generally no evidence of the temporal relationships being examined (causality is often unclear) (30). Additionally, cross sectional studies are prone to selection and measurement bias. However, despite these limitations, this study provided robust objective measures of several key variables (anthropometry and accelerometry), supplemented with validated questionnaires for collection of subjective measures, on a large group of Kenyan school-aged children. It represents the first comprehensive and multi-level study of this kind in Kenya, with data collected at the individual, home and neighbourhood, and school levels.

7.3 Population and Public Health Implications

In order to adequately tackle the growing concern of childhood overweight/obesity and physical inactivity in Kenya and the larger SSA, we must first strengthen surveillance of these health risks. Comprehensive research studies ought to be implemented at a nationally representative level. Given that the ISCOLE study is based on a socioecological model – a framework which incorporates people's interactions with their physical and socio-cultural surroundings, and includes environmental and policy variables (31) – the ISCOLE study may be scaled up to the national level, and modelled in other SSA countries. Further, it is important that future studies seek to use consistent cut-points for distinguishing weight status and physical activity levels, thus allowing for improved comparability and time trend analyses in SSA. Multi-country surveys using common measurement techniques and sampling procedures would be most desirable.

Lastly, it is crucial that interventions and strategies developed to address these growing threats focus on higher SES and urban populations, with greater attention placed on girls, to ensure that children are attaining or maintaining healthy active lifestyles. Indeed, overweight/obesity and physical inactivity are a particular threat to the child and youth population due to the potential for long-term health concerns, and an increased risk of incident severe obesity, physical morbidity, and premature mortality in adulthood (32-34). Given that many lifelong diseases start in childhood, it is a crucial phase when basic life skills can be gained for their life course, including proper nutrition and how to accumulate sufficient levels of activity (35). Children are a vulnerable population, making it a foremost responsibility to act to preserve healthy active living behaviours for their well being, particularly the right to enjoy regular physical activity and proper nutrition for the maintenance of health body weights (36).

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CHAPTER 8

DISEEMINATION EFFORTS

8.1 Kenya's 2011 Report Card on the Physical Activity and Body Weight of Children and Youth (May 2011)

The first of its kind, *Kenya's 2011 Report Card on the Physical Activity and Body Weight of Children and Youth*, modelled after the *Active Healthy Kids Canada Report Card* provided a baseline assessment of the state of affairs on the physical activity patterns and body weights of Kenyan children and youth. The goal was to highlight the areas where Kenya was succeeding as a nation and emphasise areas where more action was needed, in order to realize healthy active living goals for children and youth. This report, prepared and produced in both long and shoft form, is accessible from the Healthy Active Kids Kenya (HAKK) weisbite (http://www.hakkenya.org/).

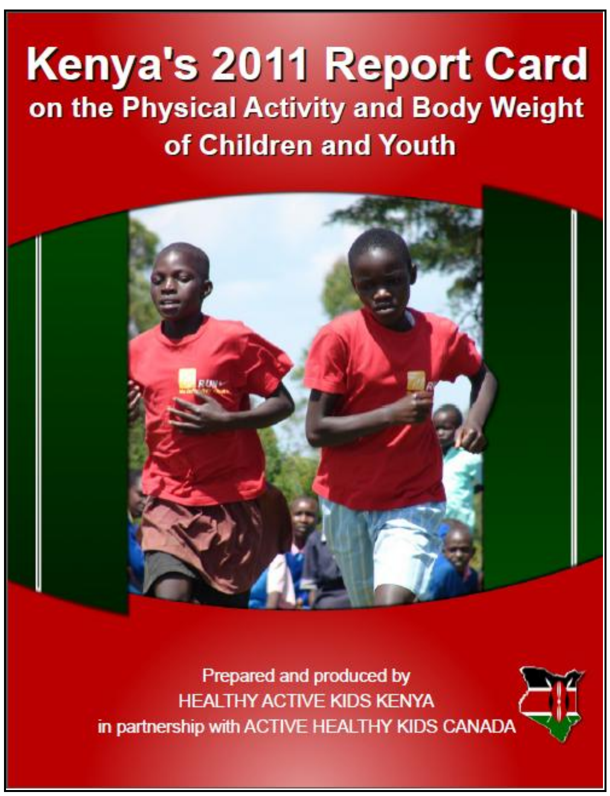


Figure 8.1: Kenya's 2011 Report Card

8.2 ISCOLE-Kenya Report to Schools (March 2013)

This report was compiled and distributed to schools around Nairobi, particularly schools that had participated in the ISCOLE-Kenya study. It provided preliminary analyses on major outcomes, such as proportions of overweight/obesity by type of school and SES, self-reported participation in physical activity and screen-based activities, and proportions of schools with policies on healthy eating and physical activity.

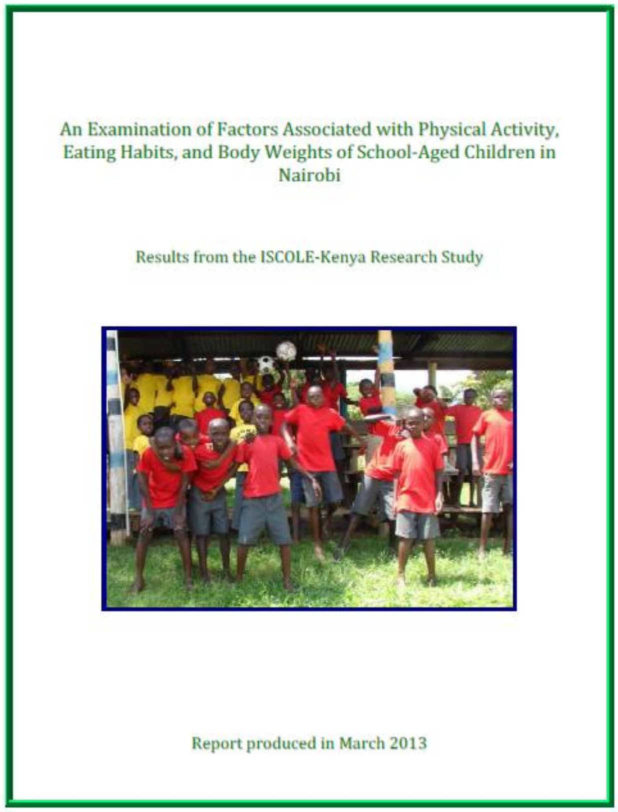


Figure 8.2: ISCOLE-Kenya School Report

8.3 Kenya's 2014 Report Card on the Physical Activity and Body Weights of Children and Youth (December 2013)

Kenya's 2014 Report Card was the second report card completed in Kenya after the first ever *Kenya's 2011 Report Card on the Physical Activity and Body Weights of Children and Youth.* The aim was to synthesize the best available evidence and provide increased awareness on issues surrounding physical activity of children and youth. Development of this report also culminated in a manuscript – "Wachira LM, Muthuri SK, Tremblay MS, Onywera VO. Results from Kenya's 2014 Report Card on the Physical Activity and Body Weight of Children and Youth" – submitted to the Journal of Physical Activity and Health, as part of a special issue on the Global Summit on the Physical Activity of Children, and attached in *Appendix G*. This report, prepared and produced in both long and shoft form, is accessible from the Healthy Active Kids Kenya (HAKK) weisbite (http://www.hakkenya.org/).

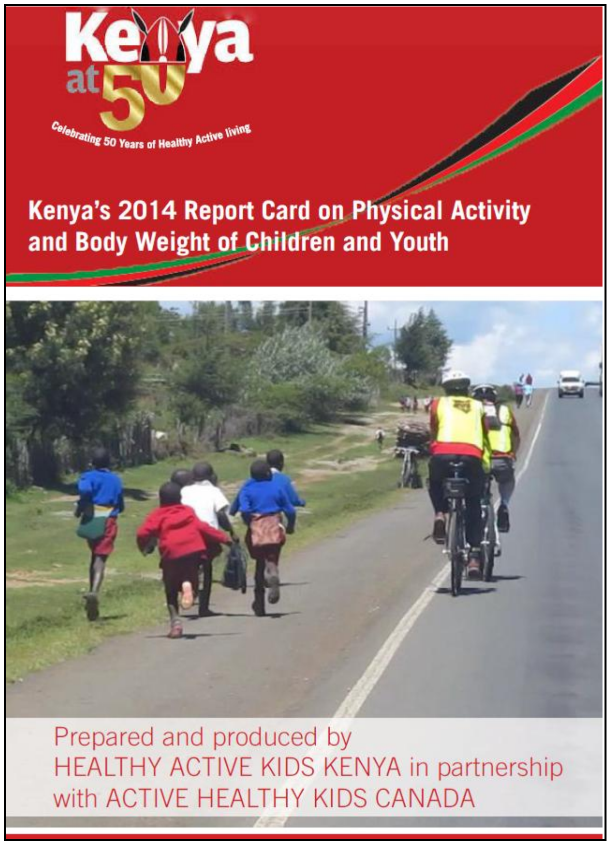


Figure 8.3: Kenya's 2014 Report Card

8.4 Abstract Submitted to the PASHDA Conference, Maputo, Mozambique (March 2014)

Overweight/Obesity Transitions over Time in Sub Saharan Africa's School Children: Results from a Systematic Review.

Stella K. Muthuri[1,2], Lucy-Joy M. Wachira[3], Vincent O. Onywera[1,3], and Mark S. Tremblay [1,2,3]

Affiliations: [1] Children's Hospital of Eastern Ontario Research Institute, Ottawa, Ontario, Canada. [2] University of Ottawa, Ottawa, Ontario, Canada. [3] Kenyatta University, Nairobi, Kenya.

Background: While the benefits of maintaining healthy body weights and an active lifestyle are well established, declines in habitual physical activity, increases in sedentary behaviour, and consumption of high calorie foods have been on the rise across developing nations, particularly in urban areas. These changes have in turn lead to an increase in the occurrence of non communicable diseases in Sub Saharan Africa, and children and youth have not been spared from these deleterious consequences. We sought to examine time trends in the proportions of overweight/obesity in school-aged children and youth in Sub Saharan Africa.

Methods: Systematic review methodology was adopted in identifying studies that used subjective or objective measures to assess body weight status in apparently healthy school children aged 5 to 17 years living in Sub Saharan Africa. The MEDLINE, Embase, Africa Index Medicus, Global Health, Geobase, and EPPI-Centre electronic databases were searched for relevant studies.

Results: Two hundred and eighty three studies met the inclusion criteria. Data synthesis revealed an increasing trend over time in proportions of overweight/obesity in school-aged children in Sub Saharan Africa, with the weighted average of overweight/obesity for the entire time period captured found to be 10.6%. Generally, there were higher proportions of overweight/obesity in girls than boys, and in higher socioeconomic status or urban living children compared to their lower socioeconomic status or rural living peers.

Conclusions: This review provides evidence for an overweight/obesity transition over time in Sub Saharan Africa, especially among girls, those with higher socioeconomic status, and those living in urban settings. These findings can inform interventions and strategies to address the potential health risks associated with rising proportions of overweight/obesity in school-aged children living in Sub Saharan Africa.

Key words: Overweight, obesity, transition, school children, Sub Saharan Africa.

8.5 Abstract Submitted to the Global Summit on the Physical Activity of Children, Toronto, Canada (May 2014)

Socioeconomic Differences in Objectively Measured Overweight/Obesity and Physical Activity in Kenyan School Children: Results from ISCOLE-Kenya

Stella K. Muthuri[1,2], Lucy-Joy M. Wachira[3], Vincent O. Onywera[1,3], and Mark S. Tremblay [1,2,3]

Affiliations: [1] Children's Hospital of Eastern Ontario Research Institute, Ottawa, Ontario, Canada. [2] University of Ottawa, Ottawa, Ontario, Canada. [3] Kenyatta University, Nairobi, Kenya.

Background: As childhood overweight/obesity increases and physical activity levels decrease, worldwide child and youth populations are facing a rise in chronic diseases. To adequately inform public health efforts, it is imperative that we explore the correlates of overweight/obesity and physical activity, particularly in lower income countries, where this information may be less available. The objective of this study was to investigate socioeconomic factors associated with overweight/obesity and physical activity in Kenyan children (9 - 11 years).

Methods: Data collection was conducted in Nairobi as part of a larger International Study of Childhood Obesity, Lifestyle and the Environment. Body weights and physical activity of participating children were objectively measured using anthropometry and accelerometry, while information on indicators of socioeconomic status obtained via questionnaires.

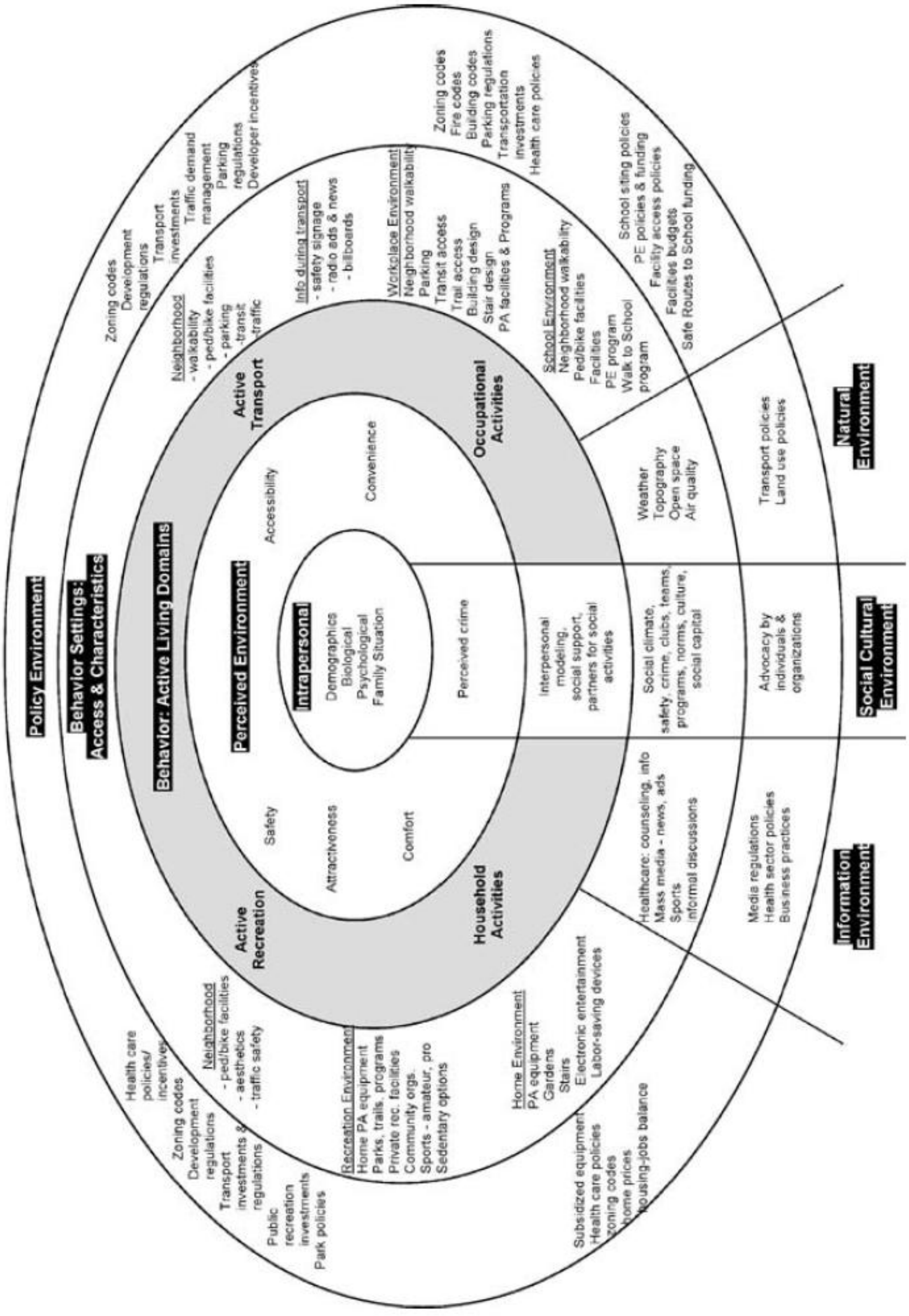
Results: Of the 563 participants, 14.4% were overweight, and 6.4% were obese based on WHO cut-points. Mean daily time spent in moderate-to-vigorous physical activity was 36 minutes based on cut-points developed by Treuth *et al*., and only 12.6% of participating children were meeting global physical activity guidelines. Proportions of overweight/obesity increased, while number of children meeting physical activity guidelines decreased, with increasing maternal and paternal education attainment, and increasing household socioeconomic status. More children attending private schools were overweight/obese and less met the physical activity guidelines compared to those in public schools.

Conclusions: The findings of this study revealed a positive socioeconomic status relationship with overweight/obesity and a negative relationship with physical activity. Strategies to address the growing threats of obesity and inactivity should therefore focus on higher socioeconomic status populations.

Key words: Overweight, obesity, physical activity, socioeconomic status, school children, Kenya.

APPENDICES

A. Ecological Model of Four Domains of Active Living (Sallis et al., 2006)



B. Kenyatta University Ethics Approval (page 1 of 2)

KENYATTA UNIVERSITY
ETHICS REVIEW COMMITTEE

Our Ref: KU/R/COMM/51/15 Date: March 8th, 2011

Dr. Vincent Onywera,
Dpt. of Recreation Management & Exercise,
Kenyatta University.

Dear Dr. Onywera,

APPLICATION NUMBER PKU005/I04 OF 2011 - 'INTERNATIONAL STUDY OF CHILDHOOD OBESITY, LIFESTYLE AND THE ENVIRONMENT (ISCOLE)'.

1. IDENTIFICATION OF PROTOCOL

The application before the committee is with a research topic 'INTERNATIONAL STUDY OF CHILDHOOD OBESITY, LIFESTYLE AND THE ENVIRONMENT (ISCOLE)' dated 24th January 2011.

2. APPLICANT

Dr. Vincent Onywera
Dpt. of Recreation Management & Exercise,
Kenyatta University

3. SITE

KENYA

4. DECISION REACHED.

The committee has considered the research protocol in accordance with the Kenyatta University Research Policy (section 7.2.1.3) and the Kenyatta University Ethics Review Committee Guidelines, and is of the view that against the following elements of review,

i. Scientific design and conduct of study,

ii. Recruitment of research participant,

iii. Care and protection of research participants,

iv. Protection of research participant's confidentiality,

v. Informed consent process,

vi. Community considerations.

B. Kenyatta University Ethics Approval (page 2 of 2)

APPROVED that the research proceeds for a period of ONE year.

The approval is for the period 8th March 2011 to 8th March 2012.

5. ADVICE

   i. Progress reports are submitted to the KU-ERC every six months and a full report is submitted at the end of the study,

   ii. Serious and unexpected adverse events related to the conduct of the study are reported to this board immediately they occur,

   iii. Notify the Kenyatta University Ethics Committee of any amendments to the protocol.

Please sign in the space provided below and return to KU-ERC a copy of the letter.

NICHOLAS K. GIKONYO, PhD.
CHAIRMAN ETHICS REVIEW COMMITTEE

I ...Dr. Vincent Onywera... accept the advice given and will fulfill the conditions therein.

Signature... .... Dated this day of ...March 8th...... 2011.

cc. Vice-Chancellor
Director: Institute for Research Science and Technology

AT/

C. Nairobi City Council Ethics Approval

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CITY EDUCATION DEPARTMENT

GL/NC/141VOL IV/162

7th October, 2011

HEADTEACHERS
PRIMARY SCHOOLS
NAIROBI.

RE: **RESEARCH AUTHORIZATION**

This is to certify that **VINCENT OCHIENG ONYERA**, a lecturer in Kenyatta University has been granted authority to conduct research in your school from January 2012 to July 2012.

The title of his research is ***"International Study of Childhood Obesity, Lifestyle and Environment (ISCOLE)."***

You are therefore requested to accord him necessary assistance as may be required in this exercise. Upon completion of the study, a copy of the research report should be submitted to this office.

CATHERINE W. GICHUBA
ASST. CHIEF ADVISOR TO SCHOOLS
FOR: DIRECTOR CITY EDUCATION

Cc **Education Officers**

D. National Council for Science and Technology Ethics Approval

REPUBLIC OF KENYA

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Date: **5th July, 2011**

Vincent Ochieng Onywera
Kenyatta University
P. O. Box 43844
NAIROBI

RE: RESEARCH AUTHORIZATION

Following your application for authority to carry out research on **"International study of childhood obesity, lifestyle and environment (ISCOLE)"** I am pleased to inform you that you have been authorized to undertake research **in Nairobi Province** for a period ending ***30th June, 2014.***

You are advised to report to **the Provincial Commissioner & the Provincial Director of Education, Nairobi Province** before embarking on the research project.

On completion of the research, you are expected to submit **two hard copies and three soft copies** of the research report/thesis to our office.

SAID HUSSEIN
FOR: SECRETARY/CEO

Copy to:

The Provincial Commissioner
Nairobi Province

The Provincial Director of Education
Nairobi Province

E. University of Ottawa Ethics Approval

Université d'Ottawa University of Ottawa
Bureau d'éthique et d'intégrité de la recherche Office of Research Ethics and Integrity

January 24, 2012

Mark Tremblay Stella Muthuri

Co-researcher: Vincent Onywera, Kenyatta University, Nairobi

Re: U of O Ethics file no. A 01-12-01 – "A Comparative Study of Physical Activity and Overweight / Obesity in School-Aged Children in Kenya and Canada"

Dear Dr. Tremblay and Ms. Muthuri,

Thank you for the protocol documents and the Certificates of Approval from the CHEO REB (# 11/23E), Kenyatta University Ethics Review Committee, and the Republic of Kenya National Council for Science and Technology for your project named above.

This is to confirm that, an administrative review of the project has been conducted at the University of Ottawa and in accordance with the agreement between the University of Ottawa and CHEO the University of Ottawa has authorized this board to act as Board of Record for the review and oversight of this research project which involves human participants and is conducted at or through the hospital.

We remind you of your obligation to:

- Follow all procedures of the CHEO REB including reporting and renewal procedures;
- Submit to the authority of the CHEO REB and that you are subject to CHEO REB requirements, including, without limitation, the requirement to modify or stop the research on demand of the CHEO REB.
- Provide the University of Ottawa with a copy of any progress reports and final report submitted to CHEO.

If you have any questions, please contact our ethics office at 562-5387.

Sincerely yours,

Catherine Paquet
Director, Office of Research Ethics and Integrity

F. CHEO Ethics Approval

Children's Hospital of Eastern Ontario
Centre hospitalier pour enfants de l'est de l'Ontario

2011 FINAL APPROVAL LETTER

CHEO Site Investigator:	Dr. Mark Tremblay
Department/PSU	HALO Research Group
Protocol Title:	International Study of Childhood Obesity, Lifestyle and the Environment (ISCOLE) – Kenya
REB #:	11/23E
Other Study #:	
c.c.:	Stella Mathuri, CHEO RI Administration
Protocol Date	September 28, 2011
Protocol Version	Version 2.0
Date of Health Canada Non-Objection Letter, and Control #	Not applicable
Investigators Brochure/Drug Monograph Version and Date	Not applicable
Date of Final Approval	December 08, 2011
Valid until	November 15, 2012
Date of REB Meeting (Initial Review)	November 02, 2011
Date Submission for Annual Renewal Due	October 15, 2012
Consent Form Version and Date	December 1, 2011
Assent Form Version and Date	December 1, 2011
Recruitment Poster Version and Date	Not applicable
Recruitment Pamphlet Version and Date	Not applicable
SITE Specific Restrictions	
Other Study Documentation Received by REB	

This protocol was approved at a meeting of the CHEO Research Ethics Board in which the quorum rules were met and only those REB members who were independent of the investigator(s) conducting the study voted on the final decision.

In fulfilling its mandate, the CHEO REB is guided by: Tri-Council Policy Statement; ICH Good Clinical Practice Practices: Consolidated Guideline; Applicable laws and regulations of Ontario and Canada (e.g., Health Canada Division 5 of the Food and Drug Regulations & the Food and Drugs Act - Medical Devices Regulations).

Final approval is granted with the understanding that the investigator agrees to comply with the following requirements:

- The investigator must conduct the study in compliance with the protocol and any additional conditions set out by the Board.
- The investigator must not implement any deviation from, or changes to, the protocol without the approval of the REB except where necessary to eliminate an immediate hazard to the research subject, or when the change involves only logistical or administrative aspects of the study (e.g., change of telephone number or research staff). As soon as possible, however, the protocol deviation form and, if appropriate, the proposed protocol amendment(s) should be submitted to the Board for review.
- The investigator must, prior to use, submit to the Board changes to the study documentation, e.g., changes to the informed consent letters, recruitment materials. Should major revisions to the consent form be made, the investigator agrees to re-consent those subjects who have originally consented to the study and who wish to continue on the study.
- For clinical drug or device trials, investigators must promptly report to the REB all adverse events that are both serious and unexpected (SAEs). For SAE reports on CHEO patients, the investigator must also comply with the hospital-wide Policy regarding, Procedures For Considering Medical Error In The Differential Diagnosis of Severe Adverse Events (SAE) Associated with the Drugs Administered in a Clinical Trial (see http://cheonet/data/1/rec_docs/3792_Medical%20Error%20Policy%20revised%20january%2020061.doc).
- For all other research studies, investigators must promptly report to the REB all unexpected and untoward occurrences (including the loss or theft of study data and other such privacy breaches).
- Investigators must promptly report to the REB any new information regarding the safety of research subjects (e.g., changes to the product monograph or investigator's brochure for drug trials). Where available, any reports produced by Data Safety Monitoring Board should be submitted to the REB.
- Investigators must notify the REB of any study closures (temporary, premature or permanent), in writing along with an explanation of the rationale for such action.
- Investigators must submit an annual renewal report to the REB 30 days prior to the expiration date stated above.
- Investigators must submit a final report at the conclusion of the study.
- Investigators must provide the Board with French versions of the consent form, unless a waiver has been granted.

For complete procedures relating to these modifications, please refer to the REB website at http://www.cheori.org/about_ethics.html or contact Sharon Haig, Ethics Coordinator at shaig@cheo.on.ca or 613-737-7600 ext. 2128.

Dr. Carole Gentile, C.Psych.
Chair, Research Ethics Board

G. Manuscript Submitted to Journal of Physical Activity and Health

Full title: Results from the Kenya's 2014 Report Card on the Physical Activity and Body Weights of Children and Youth

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≠ Authors contributed equally to this work.

Running head: 2014 Kenyan Report Card

Manuscript type: Brief Report

Key words: Body composition, sedentary behaviour, sport, child

Abstract word count: 196 words

Manuscript word count: 2743 words

Date of manuscript submission: February 3rd, 2014

Current status: In press

Abstract

Background: This report card presents available evidence on the physical activity (PA) and body weight of Kenyan children and youth. It highlights areas where Kenya was succeeding and those in which more action is needed.

Methods: Comprehensive analyses of available data on core indicators for Kenyan children and youth (5 – 17 years) were conducted. The grading system used was based on a set of specific criteria and existing grading schemes from similar report cards in other countries.

Results: Of the 10 core indicators discussed, body composition was favourable (grade B) while overall PA levels, organized sport participation, and active play were assigned grade C. Active transportation and sedentary behaviours were also favorable (grade B). Family/peers, school, governmental and non-governmental strategies were graded C.

Conclusions: Majority of Kenyan children and youth have healthy body composition levels and acceptable sedentary time; but are not doing as well in attaining the World Health Organization's (WHO) recommended PA levels. Kenya seems to be doing well in most indicators compared to some developed countries; however, there is a need for action to address the existing trends towards unhealthy lifestyles. More robust and representative data for all indicators are required in Kenya.

Key words: Body composition, sedentary behaviour, sport, child.

Introduction

Worldwide populations are increasingly facing lifestyle-related health risks due to rising prevalence of overweight/obesity, physical inactivity, and sedentary behaviours.[1] Of major concern is the potential for lifelong health consequences in children and youth. It is therefore our responsibility to act to preserve healthy active living behaviours for the promotion and maintenance of health, wellness, and healthy body weights among children and youth.[2,3]

Healthy Active Kids Kenya (HAKK) and the Kenyan International Development Study – Canadian Activity Needs (KIDS-CAN) Research Alliance have been working jointly towards the establishment of relevant research, effective dissemination of findings, and interventions for Kenyan child and youth populations. These alliances, in partnership with Active Healthy Kids Canada (AHKC) prepared and produced an evidence-informed, knowledge synthesis 'Report Card', in both short and long form, as part of a knowledge translation and dissemination strategy.

Kenya's 2014 Report Card is the second report card completed in Kenya, after the first Report Card released in 2011, designed to synthesize the best available evidence and provide increased awareness on issues concerning physical activity (PA) among children and youth. The Report Card highlights areas where Kenya is succeeding as a nation and those in which more action is needed, in order to realize healthy active lifestyle goals for children and youth. This Report Card was modelled after similar report cards done in Canada, Mexico, the United States of America, and South Africa.

The primary purpose of this manuscript is to present a summary of the methodology and results of the Kenya's 2014 Report Card, which is based on the best available evidence on Kenyan children and adolescents.

Methods

Relevant data sources on the core indicators for school-age Kenyan children and youth (5 – 17 years) were searched and analyzed. This report card was informed by two systematic reviews, the first on overweight/obesity trends,[4] and the second on PA, sedentary behaviour, and fitness levels.[5] In these reviews, studies were identified by searching the MEDLINE, Embase, Africa Index Medicus, Global Health, Geobase, and EPPI-Centre electronic databases. All published, peer-reviewed studies were included if they reported using subjective or objective measures in apparently healthy or population-based samples of children and youth aged 5 to 17 years. Intervention studies were excluded unless they conducted baseline measurements. Study quality was assessed using a modified Downs and Black instrument.[6] Due to heterogeneity in study methodology and cut-points used to categorize samples, the authors were unable to carry out a meta-analysis in these reviews; however, quantitative syntheses were conducted and complemented with narrative syntheses of the included studies.

Other sources included data from supporting governmental organizations and practitioner communities, graduate students' theses and the recently concluded International Study of Childhood Obesity, Lifestyle and Environment (ISOCLE-Kenya). ISCOLE-Kenya was carried out to investigate the influence of behavioural settings, and the physical, social, and policy environments on the observed relationship between lifestyle characteristics and weight status in school-aged children recruited from schools in Nairobi. Details of the ISCOLE study protocol are provided elsewhere.[7]

Data on child and youth body composition, PA, sedentary behaviours, school infrastructure, family and peers, community and the built environment, governmental and non-governmental strategies and policies, were collected, collated and synthesized. Thereafter, a stakeholder and reviewer group rigorously discussed and critiqued the evidence, and consultatively assigned grades based on a set of specific criteria and existing grading schemes from similar report cards in other countries. The grading system used is presented in *table 1*. Consensus was achieved on the final grade assignments for each indicator. More information on the report card development and grading is available in the long form of the report card, accessible from the HAKK (http://www.hakkenya.org/) website.[8]

< INSERT TABLE 1 HERE>

Results

While no nationally representative surveys were used to inform the Kenyan 2014 Report Card (front cover illustrated in *figure 1*), we included results from studies conducted countrywide where possible, for most of the core indicators. A summary of the indicators and final grades assigned is presented in *table 2*.

<INSERT FIGURE 1 HERE>

Regarding the body composition indicator, the findings generally revealed an age difference in the measures, with a higher percentage of older children being underweight compared with younger children; a sex difference, with girls having higher proportions of overweight/obesity and lower incidence of underweight compared to boys; and, a positive socioeconomic (SES) relationship with body weight. Findings also revealed that urban or town populations had higher body composition measures compared to their rural or village peers. Based on the World Health Organization's (WHO) cut-points for weight status in children and youth, up to 4% of rural and 21% of urban children were overweight/obese. However, there was a persistence of under-nutrition, with up to 9% of rural and 4% of urban children found to be underweight, also based on WHO cut-points. This category received a B grade since well over half of the study samples had appropriate body weights.

<INSERT TABLE 2 HERE>

The overall indicator of PA had sufficient data to inform the grading process; however, the grades differed among the component's indicators. While the evidence-base to inform the grades also included results of a systematic review[5] and those from the ISCOLE-Kenya research,[7] a majority of the studies included were based on non-representative samples. For overall PA levels, the evidence consistently showed that children from rural Kenya were more physically active than their urban counterparts. In one study, 72% of rural children were classified as physically active as per the WHO guidelines for PA, which recommend that children and youth, 5 – 17 years of age, should accumulate at least 60 minutes of daily moderate-to-vigorous physical activity (MVPA).[9] In another study, the proportion of children meeting the WHO PA guidelines was 35% in a combined sample of urban and rural children.[10] In yet another study on urban children, only 13% met the recommended PA guidelines.[7] Taken together, this indicator was graded C, implying that only about half of Kenyan children were engaging in sufficient levels of PA.

Organized sport participation was also graded C since about half of participating schools in the ISCOLE-Kenya study offered soccer, volleyball, track and field, and swimming thus allowing the children to participate in organized sports.[7] Active play was also graded C, given that data on urban children revealed that self-reported average time spent in outdoor play, either before and after school, or on weekend-days, was 6.0 hours, while studies on the rural population also reported engagement in active play albeit included with other leisure time activities and not quantified as a separate entity. Consequently, the research work group and review panel reached consensus regarding the grading of this indicator. Active transportation was graded B, reflecting that well over half of the children used active transport rather than motorised tranportation. The evidence revealed that a large percentage of children living in rural areas – between 87% and 100% – and about half – between 42% and 50% – of children residing in urban areas used active transport to/from school.

The sedentary behavior indicator included both screen-based and non-screen based sedentary pursuits. The evidence-base for this grade included results of a systematic review[5] and those of the ISCOLE-Kenya study.[7] Directly measured daily sedentary time was 398 minutes (6.6 hours), including time spent in sedentary behaviours while at school. Based on self-report, urban children were spending an average of 1.75 hours in screen-based sedentary activities during the school day, and 4.25 hours on weekend days. Evidence also showed that rural Kenyan children accumulated less time in sedentary behaviours than their urban counterparts. The B grade was assigned since more than half of the population had acceptable sedentary time.

The family and peers was graded C based on the evidence examined on parental perception, education attainment, and household SES. ISCOLE-Kenya data revealed a decreasing trend in the number of children who met the guidelines with increasing maternal and paternal education attainment. Further, proportions of children meeting the PA guidelines decreased with increasing household SES. Children of mothers with a high school education or lower (compared to a primary school or lower education level), were 65% less likely to meet the PA guidelines. Among mothers with a diploma, higher diploma, or degree (compared to a primary school or lower education level), their children were 75% less likely to meet the guidelines.

The school infrastructure, policies, and programs category was also graded C based on the evidence examined on physical education (PE) and opportunities for sports and PA offered in the school environment. Public schools are mandated by Kenyan education policy to allocate 35 minutes of PE, 3 times per week. ISCOLE-Kenya data revealed that only 14% private and 13% public school children reported not having participated in any PE classes during the past week. All sampled schools had access to an outdoor sports field where children could participate in formal or informal sports or physical activities. The data also showed that 69% of the sampled schools reported having existing written policies and/or practices concerning PA.[7] There was however no supporting evidence for this indicator from the rural setting. Based on expert consensus, the grade C was assigned for this indicator.

The governmental and non-governmental strategies, policies, and investments category was graded C based on the evidence that Kenya has several national government policies which target some of the core indicators included in the report card though lack of implementation and follow-through of some key policies is evident to a great exent.

While rural versus urban residence has been found to significantly influence total PA volume and percent of time spent in MVPA as previously described, there was a critical absence of data to grade the community and the built environment indicator, highlighting a significant research gap.

Discussion

The primary purpose of this manuscript was to present a summary of the procedure and results of the Kenya's 2014 Report Card, based on the best available evidence on Kenyan children and adolescents. While the grades from Kenya compare favorably to those from high income countries[11] there is still room for improvement, considering the concern of a PA transition towards behaviors from more developed countries.[12,13] Furthermore, it is clear that more robust and representative surveillance measures are needed to fully understand and monitor the healthy living behaviours of Kenyan children and adolescents.

Examination of body composition measures revealed age and sex differences, as well as a positive relationship of SES with body weight, since urban-living children and those of higher SES had higher body composition measures and higher proportions of overweight/obesity compared to children in rural areas and those who have lower socio-economic backgrounds respectively. The findings showing an existing prevalence of overweight/obesity and underweight indicate that Kenya may be facing a double-burden of under- and over-nutrition, among other behavioural factors.

In view of the vast heterogeneity in measurement devices, methods, and cut-off points used by the studies concerning PA, it is difficult to make meaningful comparisons across studies. Only 3 studies determined the proportion of children meeting global PA guidelines.[10,12,14] Based on a weighting of these findings, we estimated that about half of Kenyan children met the global PA guidelines. Notably, accelerometry data also revealed that urban children had significantly lower MVPA than their rural peers. Representative national-level surveillance estimates on PA is needed to determine the overall PA patterns among Kenyan children, and should include the key sources of PA such as active play, active transportation, sports participation, and PE.

The grade for the sedentary behaviours category was based on self-reported time spent on screen based sedentary activity and directly measured daily sedentary time. Rural Kenyan children were found to engage in fewer minutes of sedentary behaviour compared to their urban counterparts.[12] The Canadian sedentary behaviour guidelines recommend that children should limit their recreational sedentary screen time to no more than 2 hours per day.[15] The Kenyan results revealed that urban children spent more than the recommended daily time on screen activities on weekend-days. To our knowledge, there are no studies that have reported screen-based verses non-screen based sedentary behaviours among Kenyan children and youth. Generally, sedentary behaviours among

Kenya children appear comparatively low[11] however, with the emerging PA transition[12,13], this indicator must be watched closely.

Family and peers significantly influence the PA behaviours of children and youth. Indeed, ISCOLE-Kenya data revealed that maternal education level, paternal education level, and total annual household income were associated with meeting recommended PA guidelines.[14] There was a decreasing trend in the number of children who met the guidelines with increasing maternal and paternal education attainment and increasing household SES. A study on a pastoralist community noted gender differences in the encouragement and acceptability of, or participation in PA.[16] Certain socio-cultural beliefs do exist in some Kenyan communities, whereby female children are discouraged from being physically active – a trait deemed unfeminine.[17] The grade assigned to this indicator was based on the evidence for the influence of parental education and SES on meeting PA guidelines, since there were no studies found that discussed peer influence. Parents in Kenya need to be educated about the negative effects of sedentary lifestyle and the importance of maintaining a healthy body weight, such that they are able to encourage and support their children to lead physically active lifestyles. More studies are needed on peer influence and the achievement of PA guidelines.

School infrastructure, policies, and programs that promote PA were found to play an average role in encouraging and supporting PA among children and youth hence it was assigned grade C. The quality of school infrastructure and programs were dependent on the type of school (private versus public), and the level of socio-economic development of the location. Kenya needs to improve on these factors, especially in the rural and low income urban settings, since school environments that encourage PA and healthy eating are strongly associated with improved health, PA, and fitness outcomes in students.[18, 19]

There was insufficient data on proximity and availability of infrastructure, usage of facilities, programs, parks, and playgrounds, community programming, policies, and regulations, perceptions of safety and maintenance, nature and the outdoors, as factors that promote PA at the community level. There was also a critical absence of governmental or non-governmental strategies to address the built environment, and its impact on children's PA. This indicator requires earnest investment of time and resources for future research.

The role of governmental and non-governmental strategies, policies, and investments in encouraging and supporting healthy lifestyles was found to be average, since Kenya has several national government policies and recommendations. They include the child's rights policies such as a child's right to play and the health sector policies that advocate for healthy nutritional status and control of lifestle diseases. The Kenyan education policy also advocate for provision of school facilities that support PA and manadatory teaching of PE in schools. However, Kenya must work harder to implement these policies and recommendations, while ensuring compliance by the relevant stakeholders. Prevention strategies are of paramount importance to reduce the predicted detrimental impact of PA.[17]

The major strength of this report lies in its comprehensive and systematic review of the most recent available data on the basis of which the core indicators were evaluated. Though the grades were assigned based on the best available data, there were a number of research and data gaps. Future studies need to be done on larger and more representative samples from around the country, and include both urban and rural populations. The samples should also cover all ages for children and youth. Such information will be vital in informing future report cards.

Another limitation was the vast heterogeneity in measurement devices and methods used, confounding comparative analyses. Common cut-points and protocols should be used in future studies in order to ease comparative analysis. It is our recommendation that Kenya develop specific guidelines for PA and sedentary behavior for use by researchers and policy makers.

In order to improve the report card grades, Kenyan children and youth need to be supported in making PA choices that are convenient, sustainable, and compatible with their needs and interests. There is also a need to enhance the development of social and physical environments that support the integration of PA into daily life. Kenya should also work at increasing the knowledge on healthy active living to cultivate the right attitudes and behaviours among its children and youth.

Conclusions

The Kenya's 2014 Report Card shows that the majority of the children and youth were of healthy body weight and had acceptable levels of sedentary behaviour, but were falling short in maintaining optimal PA levels. While Kenya seems to be doing comparatively well compared to several developed countries, it is necessary to address the emerging trends towards unhealthy lifestyles resulting from urbanization and the emerging PA transition.[12]

Acknowledgements

The authors thank members of the stakeholder and reviewers group: Drs. Peter Bukhala, Robert Ojiambo Mang'eni, Florence Kyallo, Joseph Kibachio and Muthoni Gichu, for their substantial contributions to the report card. We thank the supporting team of editors and graphic designers for their input in preparing the Kenya 2014 Report Card. In addition, we would like to thank the ISCOLE-Kenya research team, whose data informed the report card to a large extent. The development of the report card was supported by KIDS-CAN, HAKK, Kenyatta University, and the Healthy Active Living and Obesity Research Group at the Children's Hospital of Eastern Ontario (CHEO) Research Institute, Canada.

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TABLES

Table 1: Grading System

Grade	Interpretation
A	We are succeeding with a large majority of Kenyan children and youth (81 - 100%).
B	We are succeeding with well over half of Kenyan children and youth (61% to 80%).
C	We are succeeding with about half of Kenyan children and youth (41% to 60%).
D	We are succeeding with less than half of Kenyan children and youth (21% to 40%).
F	We are succeeding with very few Kenyan children and youth (00% - 20%).
INC	Denotes there is insufficient data for grading.

Table 2: Categories and Indicators of the Kenya's 2014 on the Physical Activity and Body Weights of Children and Youth

Categories	Indicators	Grade
Body Composition	Body weight status	B
Physical Activity	Overall physical activity levels	C
	Organized sport participation	C
	Active play	C
	Active transportation	B
Sedentary Behavior	Screen-based and non-screen based behaviors	B
School	Infrastructure, policy, and programs	C
Family and Peers	Support and behaviour	C
Community and the Built Environment	Infrastructure, policy, programs, and safety	INC
Government and Non-Governmental	Strategies, policies, and investments	C