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ORIGINAL ARTICLE

In search of effective interventions for preventing obesity among secondary school children in Nigeria: Systematic review

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ABSTRACT

BACKGROUND:
School-based obesity interventions can significantly impact the knowledge and behavior of adolescents regarding their lifestyle. This can help to prevent the development of obesity or lead to weight loss behaviors. However, while there are several school-based obesity interventions in existence, it is unclear which ones have been proven effective among Nigerian school children.

OBJECTIVE:
To identify and appraise effective school-based interventions for preventing obesity among Nigerian school children.

METHODS:
The review followed the PRISMA and SWiM guidelines. We searched eight online databases to retrieve relevant studies on overweight and obesity interventions that have been conducted in Nigerian schools. Two reviewers independently screened the articles for inclusion, extracted data, and conducted quality appraisal of the included studies, with a third reviewer arbitrating.

RESULTS:
From the 984 screened records, two studies met the inclusion criteria. One study included 60 participants, with equal numbers of children (50%) randomized into the intervention group (subjected to physical exercise, 2 hours a day for eight weeks) and control group (no physical exercise). There was a 9.88% weight decrease in the intervention group, while the control group had 7.20% weight gain. In the control group, females had an 8.09% weight increase, while it was 6.37% for males. Overall, the study's risk of bias was high. The second study included 417 participants, with 49.9% in the intervention group (health education). There was a statistically significant change from baseline to three months post-intervention ($\chi^2 = 10.45$; $p = 0.015$) and six months post-intervention ($\chi^2 = 40.84$; $p<0.001$) in BMI for age percentile of respondents between the intervention and control groups. The study's risk of bias was low.

CONCLUSION:
This review underscores the importance of school-based obesity interventions but highlights significant gaps in current research in Nigeria. There was a low to high risk of bias in the included studies. Future studies should focus on methodologically rigorous, culturally tailored, with multi-level and multi-component interventions to ensure meaningful and lasting impacts on child and adolescent health.

KEYWORDS:
Adolescent, Childhood Obesity, Childhood Overweight, School-based obesity intervention

INTRODUCTION

Overweight and obesity among adolescents have emerged as one of the most serious public health concerns in the 21st century[1]. Between 1975 and 2016, the worldwide prevalence of childhood overweight and obesity nearly tripled[2]. The prevalence in Africa was 8.5% in 2010[3] and about a decade later, it has doubled[4]. In Nigeria, the prevalence ranges from 0.2% to 13.8% with variations by location and study period[5-7].

Due to the rapid growth and maturational changes associated with the onset of puberty, adolescents' appetite increases, and can contribute to obesity and its associated risks[8]. Adolescents who are overweight or obese are more likely to remain obese as adults and to develop non-communicable diseases such as diabetes and cardiovascular disease at a younger age[2]. Overweight and obesity have been shown to have an increased propensity for high morbidity and mortality across different age groups. Adolescents who are overweight or obese may suffer psychological conditions such as depression, anxiety, low self-esteem, and peer rejection[6].

Secondary school children, aged approximately 11 to 18 years, represent a critical group for addressing this issue, as this period of life is marked by significant physiological, psychological, and social changes that influence behaviors and health outcomes[9]. The secondary school stage, as defined in the Nigerian education system, encompasses students in junior secondary schools (JSS) and senior secondary schools (SSS), typically ranging from Grades 7 to 12[10]. During this time, adolescents are particularly susceptible to the formation of lifestyle habits, including eating patterns and levels of physical activity, which can persist into adulthood and contribute to the development of obesity[11]. Despite the recognition of this issue, the effectiveness of interventions aimed at preventing obesity among this population remains unclear, necessitating a focused investigation into potential school-based solutions.

To combat childhood obesity, the treatment should be an element of universal health coverage and integrated into existing systems where children spend most of their time to achieve maximum effectiveness[12]. Research has shown that the use of healthy diet, physical activity, and behavioral interventions can improve Body Mass Index (BMI) outcomes in schools and other settings[13,14]. Many school-based obesity interventions, perhaps also in Nigeria, focus on a single approach, such as health education or physical activity, rather than integrating multiple strategies[15]. Multi-component interventions, which combine physical activity, nutritional education, behavioral counseling, and environmental modifications, are more effective in tackling childhood obesity[15]. However, the interventions so far implemented in Nigeria appear to lack this comprehensive approach due to limited integration of nutritional education and behavioral modification, insufficient physical activity interventions, and limited school environment modifications[16, 17].

Implementation of comprehensive school health programs provides guidance to children and adolescents, their parents, caregivers, teachers, and health professionals on healthy body size, healthy diet, physical activity, sleep behaviors and appropriate use of screen-based entertainment[12].

To date, many school-based intervention programs have been developed to combat obesity in adolescents. The Medical Education for children/Adolescents for Realistic prevention of obesity, diabetes and for healthy AGeing (MARG) project was the largest conducted in South Asia among about 40,000 children (8 – 18 years), which indicated a significant impact of educative intervention on knowledge and behavior of urban Asian Indian school children with regards to health, nutrition and non-communicable diseases[18]. However, quantitative data on diet, nutrition and anthropometric measurements were not provided to measure effect changes across the different age groups. Other school-based obesity intervention programs are Trends in Childhood Nutrition and Lifestyle Factors in India (TEACHER) conducted in India[18], School health program and school canteen guidelines (Malaysia), World Heart Federation Campaign (Brazil), and the Community Children's Program (South Africa) [19, 20]. However, the methods and outcome measures of these school-based interventions vary from one study to another,

which makes the generalizability of studies somewhat difficult. In Nigeria, there is a dearth of obesity interventions' research among secondary school children.

To date, several systematic reviews gathering evidence on school-based interventions for reducing and preventing adolescent obesity have been documented. There are, however, no previous systematic reviews assessing the effectiveness of school-based obesity interventions among secondary school children in Nigeria. Contextual findings from a systematic review focused on Nigeria can help inform policies, programs, campaign projects, and interventions aimed at reducing overweight and obesity among in-school adolescents in the country. This would further reduce the burden of childhood overweight and obesity, help children and adolescents, parents and teachers to make better health choices, and improve the overall health and well-being of children and adolescents in the country.

This systematic review sought to identify and evaluate the effectiveness of school-based interventions aimed at preventing obesity among secondary school children in Nigeria. The review aimed to assess various interventions, including dietary modifications, physical activity programs, health education initiatives, and multi-component approaches that target both behavioral and environmental factors within the school setting. The expected outcomes of these interventions include a reduction in the prevalence of obesity, improved physical activity levels, enhanced nutritional knowledge, and the promotion of healthier eating behaviors among students. By evaluating both the short-term and long-term impacts of school-based interventions, this review would provide valuable insights into the most effective strategies for combating obesity in Nigerian secondary school children, offering guidance to policymakers, educators, and health practitioners working to mitigate this growing health concern

METHODS

Ethical considerations

This review was a synthesis of evidence from already published studies. Therefore, ethical approval was not required.

Protocol and Registration

We followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement[21] and Synthesis Without Meta-analysis (SWiM) guideline[22] in conducting this review. The protocol for the study was registered in the International Prospective Register for Systematic Reviews (PROSPERO) with ID CRD42023402355.

Search Strategy and Selection Criteria

We searched eight online databases of medical literature. They include PubMed, Science Direct, Cumulative Index to Nursing and Allied Health (CINAHL), Scopus, Cochrane Library (Cochrane Database of Systematic Reviews, Cochrane Central Register of Controlled Trials (CENTRAL), and Cochrane Methodology Register), PakMediNet, African Index Medicus (AIM), and Web of Science. The searches were carried out between May 06 and 09, 2023, and updated from December 5-9, 2024. They covered articles published in the respective databases from October 1960 (or date of establishment of the database if later than 1960) to December 2024. No language restriction was applied. Furthermore, non-English language studies were not encountered during the search. Supplementary Text shows the search strategies used in searching each of the databases.

Inclusion and exclusion criteria

Intervention studies, such as cluster randomized controlled trials, quasi-experimental studies, controlled before-and-after studies were included in this review. However, low-level evidence studies such as case reports, case series, opinion papers, and experimental studies conducted on non-human subjects were excluded.

Study participants included Nigerian secondary school students aged between 10 and 19 years enrolled in a public or private school and of any gender, ethnic, and social background. Students younger than 10 years or

older than 19 years were not eligible. Studies that were conducted outside Nigeria or that focused on populations in other countries were also excluded.

PICO components

Participants (P): Secondary school children (ages 10-19 years) from Nigeria

Intervention: School-based interventions aimed at preventing obesity. These may include dietary modifications (e.g., healthy eating programs), physical activity programs (e.g., exercise, sports), health education (e.g., obesity awareness), or multi-component interventions targeting both behavioral and environmental changes within the school setting. These must have been conducted in any region, state, or district of the Nigerian geopolitical zones.

Comparison: Studies that compare the intervention group to a control group (e.g., no intervention or usual school health practices). Studies without a control group will be included if they provide robust baseline and post-intervention measurements.

Outcome: The primary outcome was the prevention or reduction of overweight and obesity prevalence measured by BMI or other related indicators (e.g., waist circumference, body fat percentage). Secondary outcomes may include improvements in dietary habits, increased physical activity levels, and improved knowledge about healthy lifestyles.

Study Selection

All records retrieved from the respective databases were exported to EndNote Reference Manager where duplicate articles were removed. After the deduplication process, the articles were exported to Rayyan for literature screening. Two reviewers independently screened the articles (OO and DKE), with a third reviewer (BN) arbitrating any disagreement. After the screening of titles and/or abstracts, the full-texts of papers considered to be potentially eligible were retrieved and independently assessed by OO and DKE for inclusion. The three reviewers reached a consensus on the final list of included articles.

Data Extraction and Risk of Bias

A customized Microsoft Excel data extraction form was developed. All necessary adjustments to cover all relevant information were done to answer the review question, including sociodemographic characteristics. Two reviewers used the concluded form to extract data (Supplementary Table 1). Discrepancies in the extraction were resolved by discussion between OO and VN until an agreement was achieved. A third reviewer (BN) had a final look at the data extraction for consistency, accuracy and reduction of bias.

Quality Appraisal

The risk of bias (RoB) for the included studies was assessed using the Cochrane's Effective Practice and Organization of Care Group (EPOC) tool[23]. The tool appraised six areas for the studies: selection bias, performance bias, attrition bias, reporting bias, and other bias. Each domain is graded as 'high risk', 'low risk' or 'unclear risk'. Two reviewers (OO and DKE) independently assessed the quality of the included studies, and disagreement was resolved by arbitration of the third author (BN).

Grouping studies for synthesis

We could not group studies for synthesis since only two studies were included.

Data synthesis and statistical analysis

We used descriptive tables and textual narration to summarize key characteristics of the included studies. Meta-analysis was not possible because only two studies with varying characteristics were included. Therefore, we conducted a narrative-only synthesis using the SWiM guideline to summarize the key findings for the study.

RESULTS

Search results

The database searches yielded 1,275 records. After removing duplicates, we screened 984 records by titles and/or abstracts. A total of four papers were left for full-text screening after 980 papers were removed. One paper was excluded because of the wrong primary outcome. Another paper was excluded because it was not accessible. We reached out to the authors of the paper twice but there was no response. We identified a study protocol that was published by Oluwasanu and Oladepo[24] but the full-text article has not been published. It is possible that the study is still ongoing.

The additional search yielded one study that met the inclusion criteria. The authors were contacted, and the full text article was sent to the corresponding author. Finally, two studies met the inclusion criteria for the review. Figure 1 shows the PRISMA flowchart for the study selection and literature screening process.

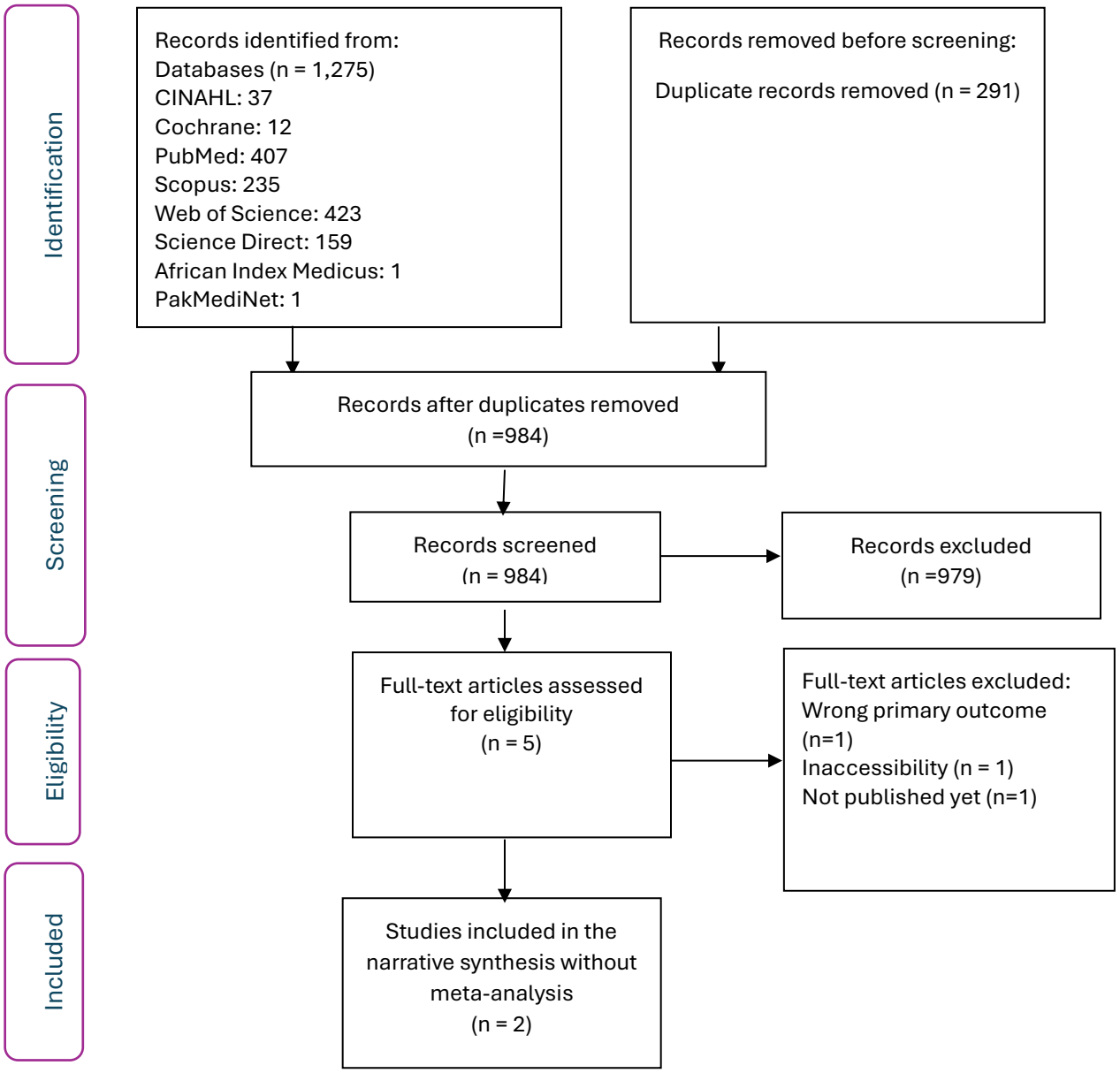

Figure 1. PRISMA flow diagram of study selection

General characteristics of the study

Study participants

A combined total of 477 Nigerian school children participated in the two studies that met the inclusion criteria. The study by Oly-Alawuba and Nnam[25] included 60 participants aged 6-12 years (30 in each of the control and intervention groups) in Enugu South Local Government Area, Enugu State, Nigeria. Results from this study focused only on available data for children between 11-12 years. Shapu et al.[26] included 417 participants aged 10-19 years (208 in the intervention group and 209 in the control group) from four

government secondary schools in Maiduguri, Nigeria. We did not identify any ongoing studies.

Study design

Oly-Alawuba and Nnam[25] did not state the study design they adopted in their study. However, randomization of study participants was done by balloting, and participants were assigned to either an intervention or control group. Shapu and colleagues[26] conducted a cluster randomized control trial. Random selection of participants was done across the six arms of the schools. The school was the unit of randomization (two schools were used as intervention groups and two schools as control groups).

Sampling technique

Oly-Alawuba and Nnam[25] used simple random sampling technique by balloting without replacement to select 60 obese school children. Half (30) of the 60 children were further selected randomly for the exercise and the remaining 30 served as the control. Shapu and colleagues[26] used a two-stage random sampling to select four out of the six schools in Maiduguri Metropolitan Council (MMC). The allocation of study groups and study participants wasalso done by simple random sampling. Single blinding was employed to avoid possible contamination. The participants, facilitators and enumerators were unaware of the randomization and allocation process.

Study context, intervention and duration of intervention

The study by Oly-Alawuba and Nnam[25] was an intervention study that focused on the influence of physical exercise on obese children. Data were collected using a structured questionnaire. Baseline measurements were taken and repeated every two weeks for the 2-month duration period. The intervention group was subjected to physical exercise (jogging, dance aerobics, rope skipping, handball and football) that lasted two hours a day for eight weeks. The physical exercise was performed using standard equipment and under the guidance of well-trained sport experts, at a recognized sports center (Liberty center) in Enugu, Enugu State, Nigeria. The control group received no physical exercise. In the study by Shapu and colleagues[26], a health education intervention consisting of six modules was given to the intervention group. The six modules included prevention of malnutrition (through nutrient-rich diet), food groups (macro and micro nutrients), food preparation and food storage, motivation and lessons learned about prevention of malnutrition, anthropometric measurements, and behavioral skills on practical cooking demonstration. The control group received health education intervention on malaria.

Participation rate

The participation rate in the study by Oly-Alawuba and Nnam[25] was 100% for both intervention and control groups. There was no attrition. In Shapu and colleagues'[26] study, the attrition rate was 4% in the intervention group and 2% in the control group.

Instrument and method of data collection

In their study, Oly-Alawuba and Nnam[25] collected data using a structured questionnaire. It included information on personal data, family background, parents' socio-demographic status, physical activity pattern of the family, monthly income range of the parents, medical history, and socio-demographic characteristics of the children. Anthropometric measurements of weight, height, and triceps were done. Weight measurements of the children were taken at baseline and end of the exercises. Shapu and colleagues[26] in their study used KoBo collect toolbox as the data collection tool. Data were collected at baseline, three months post-intervention, and six-months post-intervention.

Outcomes studied

The outcome studied in Oly-Alawuba and Nnam's[25] study was obesity reduction. A survey was used to collect data on the outcome before and two months after the intervention. Weight was measured in kilograms (kg) and BMI in kg/m^2. Measurements before and after the exercises reflected the percent weight loss differences to measure effect sizes.

However, in Shapu and colleagues'[26] study, the outcome studied was the improvement in the nutritional status among secondary school adolescent girls. The parameters that were assessed included changes in BMI for age percentile and mid-upper arm circumference. The study assessed the impact of a health education intervention on nutritional status. A

survey was used to collect data on the outcomes before and three and six months after the intervention.

Results of Risk of Bias

The summary of the assessment of risk of bias is shown in Supplementary Text S1. Again, the quality appraisal was reported using the EPOC tool.

Risk of bias assessment for Oly-Alawuba and Nnam's[25] study: There was random allocation of participants into test and control groups but there was no report regarding allocation concealment. Also, there was no blinding of participants, investigators or other persons involved in the study. The study did not state the type of intervention study design that was used. There was no attrition. The control group had similar characteristics with the intervention group as they were selected from the same population. Aside from the intervention, there was no report on whether or not the groups were treated differently. The study included school children between 6 and 12 years. However, reports of children between 11 and 12 years were only extrapolated for the review. Sociodemographic data were not reported to gain information about the participants' essential characteristics. No ethical issues were addressed in this study. Overall, the study's risk of bias is high.

Risk of bias assessment for Shapu and colleagues'[26] study: In their study, a two-stage cluster randomization was employed to initially select the schools in MMC and then the allocation of the schools and participants into intervention and control groups. Single blinding was employed in the randomization and allocation process. The attrition rate was low in the intervention and control groups (4% vs. 2%), and they also had similar characteristics. Although the four schools that made up the intervention and control groups were in the same geographical area, the blinding process helped to avoid possible contamination. The interventions received by both groups were stated clearly, and both groups were treated uniformly. A formal ethical approval was obtained from a recognized institutional review board and registered in a Clinical Trials Registry repository. Overall, the risk of bias in this study is low.

Main findings

Oly-Alawuba's[25] study revealed that the intervention group had a weight reduction of 9.88% while the control group had 7.20% weight gain. The females in the intervention group had a percent weight loss of 9.68% while the males had 11.84% weight reduction. Obese children in the intervention group dropped from 100% to 47% after the exercise, while there was no effect in the control group ($p < 0.05$). There was an 8.09% and 6.37% weight increase in the female and male children, respectively in the control group.

Children 11–12 years had a mean initial weight of 70.53kg and a mean final weight of 47.36kg after the intervention, giving a mean weight loss of 23.16kg. However, this weight loss difference was not statistically significant ($p = 0.26$). No comparison was made between the intervention and control groups in terms of measuring the significant associations of weight differences of the age groups.

In the study by Shapu and colleagues[26], results showed that there was a statistically significant change from baseline to three months post-intervention ($\chi^2 = 10.45$; $p = 0.015$) and six months post-intervention ($\chi^2 = 40.84$; $p<0.001$) in BMI for age percentile of respondents between the intervention and control groups. Although the study reported some significant changes in the participants' nutritional status, the actual number of overweight adolescent girls in the intervention group remained the same from baseline to six months post-intervention.

DISCUSSION

Summary of main findings

This review included two school-based obesity intervention studies. One study comparing physical exercise intervention method to no treatment resulted in a 10% weight decrease in the intervention group and 7% weight gain in the control group (Table 1).

Table 1. Weight differences of obese children in the intervention and control groups (Oly-Alawuba's study)

	Intervention Group			Control Group		
	Before n (%)	**After n (%)**	**Percent weight difference (%)**	**Before n (%)**	**After n (%)**	**Percent weight difference (%)**
Male	18 (60.0)	10 (33.7)	11.84	21 (70.0)	20 (66.7)	6.37
Female	12 (40.0)	4 (13.3)	9.68	9 (30.0)	9 (30.0)	8.09
Combined	30 (100.0)	14 (47.0)	9.88	30 (100.0)	29 (100.0)	7.24

Children 11–12 years had a mean weight loss of 23.16kg (Table 2).

Table 2. Influence of exercise on weight loss of the children (n = 30) in the intervention group (Oly-Alawuba's study)

Age group (years)	Initial weight	Final weight	Weight loss	p-value
11-12	70.53	47.36	23.16	0.26

Table 3. Changes in nutritional status of intervention and control groups (Shapu's study)

Duration of intervention	BMI for age percentile (Overweight)				
	Intervention N (%)	**Control N (%)**	**Total N (%)**	**χ^2**	**p-value**
Baseline	5 (100.0)	0 (0.0)	5 (100.0)	5.28	0.072
3 months post-intervention	5 (31.3)	11 (68.4)	16 (100.0)	10.45	0.015
6 months post-intervention	5 (71.4)	2 (28.6)	7 (100.0)	40.84	<0.001

However, these differences were not statistically significant ($p > 0.05$). The second study used a health education intervention program to improve the nutritional status of adolescent girls and found some significant changes between the intervention and control groups. There was a weight reduction from 100% at baseline to 68.4% at three months post-intervention and 28.6% at six months post-intervention in the intervention group. However, there was a weight increase of 68.4% in the control group at three months post-intervention and a 28.6% decrease at six months post-intervention.

Strengths and weaknesses

This review followed PRISMA-recommended steps for undertaking systematic reviews; therefore, it adhered to required rigors in the processes, including a comprehensive search of eight leading electronic databases to identify relevant studies. Nevertheless, as it is possible that some studies relevant to the topic might have been published in local journals that are not

indexed in the mainstream databases that were searched, it is possible that our database searches might have missed studies that might be relevant to the topic. The screening of the obtained literature, data extraction, and quality appraisal were undertaken independently in pairs, ensuring that all necessary checks and balances were employed to attain high quality evidence generation. Despite employing a thorough search strategy and conducting a thorough search, we were only able to identify two potential studies, an indication that only a few studies have been conducted on the topic in Nigeria. The protocol for the systematic review was registered in PROSPERO a priori according to international recommendations to avoid any post-hoc conclusion or bias.

The primary studies included in this review assessed the impact of interventions on obesity reduction in adolescents. While both studies addressed a growing public health concern and adopted strong randomization techniques in selecting and allocating participants, the studies fell short in pertinent cases that have implications for interpreting the findings. For instance, in Oly-Alawuba's[25] study, the sample size was relatively small, which limits the study's generalizability. Also, there was no blinding of participants in the randomization process, which could serve as a potential source for selection/allocation bias. The short duration of intervention in the study could limit the participants' weight reduction sustainability and long-term behavior changes. The randomization process in the study was not adequately reported; therefore, it is unclear whether potential confounding factors such as dietary habits, socioeconomic and environmental factors were taken into consideration. While Shapu and colleagues[26] in their study made use of an RCT, adequate sample size, and reliable data collection tools, reliance on self-reported data (especially in educational interventions) could result in potential recall or reporting bias. The unchanged number of overweight adolescents post-intervention in Shapu et al.'s study highlights the potential influence of external factors such as socioeconomic status, food availability, and cultural practices. Meta-analysis could not be done to combine estimates from the two studies due to differences in study design and outcomes between the studies. Overall, the evidence for the effectiveness of school-based obesity interventions in Nigeria is weak.

Comparing the findings with previous studies

Exercise Intervention for Childhood Obesity

The study by Oly-Alawuba and Nnam[25] focused on the impact of physical exercise on obese children. The intervention group experienced a weight reduction of 9.88%, while the control group saw a weight gain of 7.20%. Gender-specific results indicated weight reductions of 9.68% in females and 11.84% in males within the intervention group. Additionally, the prevalence of obesity in the intervention group decreased from 100% to 47% post-exercise.

These findings align with a systematic review by Kelley and Kelley[27], which analyzed the effects of exercise on overweight and obese children and adolescents. The review concluded that exercise interventions led to significant reductions in percent body fat among participants. However, it noted that changes in other adiposity measures, such as BMI and body weight, were not statistically significant. This suggests that while exercise effectively reduces body fat percentage, its impact on overall weight and BMI may be limited. Findings of a systematic review by Jacob and colleagues[28] among adolescents in high-income countries showed a small difference between intervention and control in change in BMI z-scores (− 0.06 [95% CI -0.10, − 0.03]). Effective physical activity-based interventions, resulting in improved BMI outcomes, were characterized by familial involvement and training for teachers and students on behavioral techniques such as self-monitoring[28]. Since the review included studies from high-income countries such as the USA, the Netherlands, Australia, etc., contextual factors such as interpersonal (parents, teachers, peers) factors and environmental factors (digital components) could have contributed to weight reduction among adolescents.

In the Nigerian context, cultural perceptions of body weight can influence the effectiveness of such interventions. In certain Nigerian communities, a larger body size is perceived to be an indicator of good health, beauty, and prosperity[29]. This cultural perception can lead to a preference for chubbier children, with the belief that moderate chubbiness is desirable, and only

excessive weight is problematic. Such attitudes may affect parental support for weight loss programs, as parents might not recognize overweight or obesity as health concerns. A study conducted in southeastern Nigeria found that nearly half of the population perceives large body size as desirable, which significantly increased the odds of obesity[30]. Moreover, environmental factors play a crucial role in hindering children's participation in regular physical activity. Limited access to safe play areas and organized sports facilities can discourage physical activity among adolescents[31]. A study exploring perceptions of built environmental factors in Nigeria highlighted that adolescents often face challenges such as inadequate recreational facilities and unsafe neighborhoods, which impede their engagement in physical activities[32].

Health Education Intervention on Adolescent Girls' Nutritional Status Shapu et al.[26] conducted an RCT to evaluate the impact of health education on the nutritional status of adolescent girls in Maiduguri. The study reported statistically significant improvements in BMI-for-age percentiles at three and six months post-intervention ($p = 0.015$; $p < 0.001$, respectively). However, the number of overweight adolescent girls in the intervention group remained unchanged from baseline to six months post-intervention. A systematic review by Shapu et al.[33] assessed the effect of health education interventions on adolescents' knowledge, attitudes, and practices regarding malnutrition. The review found that such interventions significantly improved these aspects among adolescents. However, it emphasized the need for more targeted interventions in low- and middle-income countries, where the burden of malnutrition is higher. This underscores the importance of context-specific strategies to address nutritional challenges effectively. Furthermore, a systematic review and meta-analysis by Brown et al.[34] examined school-based interventions incorporating health education to reduce BMI in adolescents aged 10 to 19 years. The analysis revealed that while some interventions led to modest reductions in BMI z-scores, the overall effect was limited. The authors highlighted the necessity of comprehensive, multi-component interventions that address various factors influencing adolescent nutrition and weight status. Although school-based interventions were found to be generally effective in reducing excessive weight gain of children, the impact of combined components on the effectiveness of multi-component interventions requires further research. Previous reviews included studies in lower-middle to upper-middle income countries and continents such as Europe, Asia and the USA[28, 35-37].

Cultural and environmental factors in Nigeria play a significant role in the effectiveness of health education interventions. Traditional beliefs and food taboos can restrict the consumption of certain nutritious foods, especially among women and children. A study conducted in Imo State identified approximately 25 such taboos, which often prohibit the consumption of specific crops and livestock products[38]. Gender norms within Nigerian society can also impact adolescents' eating habits. Research in northern Nigeria revealed that adolescent girls often have less control over food choices compared to boys. Married adolescent girls, in particular, reported limited decision-making power regarding food acquisition and preparation, with husbands typically making these decisions. Additionally, during mealtimes, adolescent girls were often served after male family members and younger children, sometimes receiving smaller portions. These practices can limit girls' access to a balanced diet, affecting their overall nutritional health[39]. Economic challenges and food insecurity further impede the ability to make healthier food choices, even when individuals possess adequate nutritional knowledge. Nigeria has been facing a severe hunger crisis, with millions of people projected to be food insecure due to economic hardships, inflation, and rising food prices. Factors such as currency devaluation, removal of fuel subsidies, and flooding have exacerbated the situation, leading to increased transportation costs and reduced agricultural output. These economic constraints limit the availability and affordability of nutritious foods, making it difficult for individuals and families to maintain healthy diets despite being informed about proper nutrition[40, 41].

Interpretation of results

This review is the first to identify and examine studies that have evaluated the effectiveness of school-based obesity interventions in Nigeria. It serves to add to the body of scientific knowledge regarding the effectiveness of school-based obesity interventions.

Two intervention studies were found appropriate to be included in this review. The studies by Oly-Alawuba and Nnam[25], and by Shapu et al.[26], provide valuable insights into interventions aimed at improving the nutritional status of Nigerian children and adolescents. The study by Oly-Alawuba and Nnam[25] enrolled 60 participants, a relatively small sample that may limit the statistical power to detect significant differences between groups. Smaller sample sizes in clinical trials and research studies increase the risk of Type II errors, where true differences or effects remain undetected[42-44].

This occurs because inadequate sample sizes reduce the statistical power of a study, limiting its ability to identify significant associations or treatment effects[45]. In contrast, Shapu et al.'s[26] study involved 417 participants, enhancing its ability to identify statistically significant effects. Larger samples generally provide more reliable estimates and improve the generalizability of results. The eight-week duration of the exercise intervention in Oly-Alawuba and Nnam's study may have been insufficient for achieving substantial weight loss. Research suggests that interventions lasting less than 12 months tend to have higher adherence rates, but the effectiveness in terms of significant weight loss often requires longer durations. A meta-analysis indicated that interventions shorter than 12 months had higher adherence compared to those lasting 12 months or more, yet sustained weight loss typically necessitates extended intervention periods[46]. A plausible reason for the insignificant weight loss differences in age and gender could be due to variability in participants' adherence to the intervention. Variability in adherence can significantly impact intervention outcomes. Factors such as socioeconomic status, initial weight, and psychological health influence adherence levels. Studies have found that lower socioeconomic status and higher initial weight are associated with reduced adherence. Moreover, interventions incorporating supervised attendance and social support demonstrate better adherence rates. For instance, supervised programs had adherence rates of 68.6%, compared to 41.5% for self-monitoring interventions[46]. While Oly-Alawuba and Nnam's study reported weight reductions in the intervention group, the lack of detailed adherence data makes it challenging to assess how adherence influenced the results. The older adolescents may have committed more to the exercise routine than the younger adults. Similarly, the males may have spent a longer time and committed more to the exercise routine than the females. Other individual characteristics, such as fitness level and health status, were not reported in the study. These characteristics could serve as confounding variables and influence the rate of change in weight status. Furthermore, the choice of outcome measures can affect the detection of significant changes. Oly-Alawuba and Nnam[25] focused on weight reduction, while Shapu et al.[26] used BMI-for-age percentiles and mid-upper arm circumference (MUAC). BMI-for-age is a standardized measure that accounts for age and sex differences, potentially providing a more sensitive assessment of nutritional status changes in children and adolescents. The use of different metrics may partly explain the variation in statistical significance between the two studies. Also, in the Nigerian context, cultural perceptions of body weight and environmental constraints can influence intervention effectiveness. In some communities, a larger body size is associated with health and prosperity, potentially affecting parental support for weight loss programs. Additionally, limited access to safe play areas and organized sports facilities can hinder children's participation in regular physical activity. Addressing these cultural and infrastructural barriers is crucial for the success of exercise-based interventions in Nigeria. The present review presents low evidence for the effectiveness of school-based obesity interventions. The RoB of the quality of the evidence was high in Oly-Alawuba's[25] study, while it was low in Shapu's[26] study. The methodological limitations contributing to a high risk of bias in Oly-Alawuba's study included lack of allocation concealment and blinding, unclear study design and reporting procedures, and ethical considerations. While in Shapu's study, factors such as robust randomization and blinding minimized attrition bias, standardized intervention delivery and ethical transparency contributed to its low risk of bias. Although findings from this review indicate low effectiveness of school-based obesity intervention programs, they remain possible approaches for providing universal healthcare for the treatment or reduction of childhood obesity. They contribute valuable insights into public health interventions for childhood and adolescent nutrition in Nigeria. The results of this review should be interpreted with caution

due to the methodological variations. The study by Shapu et al. is more methodologically rigorous and reliable than that of Oly-Alawuba and Nnam due to its strong randomization process, ethical transparency, and structured intervention. Future research should prioritize robust methodology, ethical compliance, and contextual relevance to ensure meaningful and applicable findings. Further well-designed cluster randomized controlled trials with longer follow-up are needed[47]. De Miguel-Etayo and colleagues[15] identified several strategies for reducing childhood obesity, ranging from lifestyle approaches, pharmacotherapy, to surgical interventions. Identification of risk factors for childhood obesity and a combination of interventions at the individual, interpersonal, community and public policy levels enhances the sustainability of such intervention programs[48]. Very few school-based obesity intervention studies have been conducted in Nigeria. This indicates that further research is required in this area with emphasis on the effectiveness of multi-component and multi-level interventions. In this review, the evidence for the effectiveness of school-based obesity intervention is weak and uncertain.

Implications of the findings

In this review, we identified two intervention studies for obesity reduction or prevention among adolescents.

Implications for policymakers: The findings from the reviewed studies highlight the need for policymakers to prioritize school-based obesity interventions as part of national health strategies. Childhood obesity is a growing public health concern, and addressing it at the school level can have long-term benefits in preventing non-communicable diseases. Policymakers should consider incorporating school-based obesity interventions into Nigeria's National Health Policy and National School Health Policy to ensure sustainability. They should allocate sufficient funding for the implementation and monitoring of obesity intervention programs in schools, particularly in low-income communities. They should develop culturally sensitive health promotion campaigns that address prevailing attitudes toward body weight, physical activity, and nutrition in different regions of Nigeria.

Implications for educators: Teachers and school administrators play a crucial role in the success of obesity intervention programs. Educators should be trained by public health and nutrition experts to incorporate health and nutrition education into the school curriculum and to support students in adopting healthier behaviors. Schools should establish structured and engaging physical activity programs that cater to all students, ensuring inclusivity and accessibility. Schools should also actively involve parents in nutritional and physical activity programs by organizing workshops and sending health-related newsletters.

Implications for researchers: Further research is required to strengthen the evidence base for effective school-based obesity interventions in Nigeria. Therefore, future studies should involve larger and more diverse sample sizes to improve statistical power and generalizability. Use of robust methodologies and study designs (such as cluster randomized controlled trials, quasi-experimental studies and field trials) with proper allocation concealment and blinding should be employed to reduce bias. Intervention programs should extend beyond eight weeks, as short-term interventions may not lead to significant and sustained weight loss. Furthermore, there should be longer term follow-up periods to ensure permanent health behavior changes. Future investment and further research in childhood obesity prevention interventions should be prioritized with multi-component (physical activity, diet and nutrition, health education, behavioral interventions) and multi-level approaches with the greatest impact by policymakers and other health practitioners within all settings.

CONCLUSION

This review underscores the importance of school-based obesity interventions but highlights significant gaps in current research and implementation strategies in Nigeria. There was a low to high risk of bias in the included studies. While lack of allocation concealment and blinding, unclear study design and small sample size contributed to the high risk of bias in one study, the use of robust methodological procedures contributed to the low risk of bias in the other study. Single-component interventions were adopted in both studies.

CONFLICT OF INTEREST

The authors have no competing interests to declare that are relevant to the content of this article.

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AUTHORS CONTRIBUTION

Conceptualization and design of the work; original draft preparation: Omobola Wopara, Bright Nwaru. Literature screening and quality appraisal (risk of bias): Dennis Kudu Egga. Data Extraction: Victoria Nwakanma Onwochei. Supervision, review and editing: Bright Nwaru. All authors read and approved the final manuscript.

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