

# Improving Healthy Eating Behaviour among In-School Adolescents through Collaborative Instructional Intervention: A Theory-Driven Quasi-Experimental Study

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## Research Article

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# Abstract

## Background

Adolescence is a critical window for establishing dietary behaviours that shape long-term health outcomes. In Nigeria and other Sub-Saharan African countries, school-based nutrition education has been largely ineffective when delivered through conventional didactic approaches. This study evaluated the effect of a Health Belief Model–guided collaborative learning intervention on diet quality, nutrition knowledge, and perceived dietary behaviour among in-school adolescents in Ogun State, Nigeria.

## Methods

A quasi-experimental, pre-test–post-test control group design was used. Three hundred adolescents aged 13–19 years from two public secondary schools in Odeda Local Government Area were recruited, with 150 assigned to each group. The intervention group received eight weeks of structured nutrition education delivered through collaborative learning techniques, while the control group received the same content through conventional didactic instruction. Diet quality was assessed using the Global Diet Quality Questionnaire (DQQ), nutrition knowledge using a validated 20-item questionnaire, and perceived dietary behaviour using an HBM-based scale. Data were analysed using paired t-tests, independent t-tests, Difference-in-Differences analysis, and ANCOVA.

## Results

The intervention group demonstrated statistically significant improvements in dietary diversity (DDS: 33.74%), NCD-Protect score (153.22%), and GDR score (39.86%), while the NCD-Risk score showed no significant change in either group ( $p = 0.967$ ). Nutrition knowledge improved significantly in the intervention group ( $\text{DiD} = 7.94$ ;  $p = 0.007$ ), with no meaningful change in the control group. All six HBM constructs improved significantly in the intervention group, including self-efficacy (13.46%) and perceived severity (18.96%). ANCOVA confirmed that the intervention independently predicted improvements in both dietary diversity and nutrition knowledge after adjusting for baseline scores and sociodemographic covariates.

## Conclusions

Collaborative learning–based nutrition education guided by the Health Belief Model is effective in improving diet quality, nutrition knowledge, and health beliefs among in-school adolescents. These findings support the integration of participatory and theory-driven instructional approaches into school-based nutrition programming in Nigeria and similar low-resource settings.

## Introduction

In life, the age range of 10–19 years is one of the most critical growth phases in a human's life, and this is associated with very rapid development in physical growth, neurocognitive maturation, hormonal changes, independent behavioural patterns, and self-reliance mechanisms. This stage is often referred to as adolescent [1, 2]. Adolescents require adequate nutrition during this period to meet the biological system's requirements for

physical growth, peak bone mass, bone density formation through mineralisation, a healthy immune system, and neuro-cognitive performance [2, 3]. Despite the importance of healthy dietary practices in this stage, adolescents remain highly vulnerable to unhealthy dietary habits and practices. Dietary habits and patterns exhibited during adulthood are established during this stage of life, which may later affect the health and nutritional status [3].

Various factors, such as peer pressure, social influence, autonomy in food selection, exposure to excessive advertisement of unhealthy foods, and most especially limited access to tailored collaborative nutrition education, have been implicated as major determinants of adolescent poor dietary behaviours [4, 5]. Poor dietary behaviours are more problematic among adolescents who live in low and middle-income countries like Nigeria and countries in Sub-Saharan Africa, where over 90% of global adolescents reside and are affected by how nutrition transition, globalisation, and trade liberalisation are reshaping their food system landscape [4, 6].

Globally, the dietary patterns of the adolescent population have often been negatively affected by trade liberalisation, and nutrition transition to a large extent, which is often show by poor nutrient dense food, consumption of excessive energy-dense food, sparing consumption of fruits, pulses, legumes, whole grain, and vegetables [2, 7]. Previous study findings on the diet quality assessment of adolescents often show poor adherence to dietary recommendation guidelines due to their excessive intake of saturated fat, sugary food products, and carbonated sweetened drinks [8, 9]. One of the main causes of the triple burden of malnutrition (persistent undernutrition, micronutrient deficiencies) and the increasing prevalence of noncommunicable diseases, such as overweight and obesity, among adolescents in Nigeria and some other Sub-Saharan African countries is the dietary pattern brought on by the nutrition transition [3, 10, 11].

Recent evidence reports overweight and obesity prevalence ranging between 7.4% and 13.2% among Nigerian adolescents, with emerging concerns in parts of Ogun State [12]. These patterns highlight the urgency of implementing preventive strategies during adolescence before unhealthy dietary behaviours become established and track into adulthood.

During adolescent formative years, schools provide opportunities and privileges for frequent contact with health-related messages that can impact their lives. School premises provide a platform for structured and policy-driven nutrition education programs, which have the potential to transform the lives of adolescents [13]. However, didactic or traditional methods of teaching have rendered many school-based nutrition education interventions ineffective in transforming and impacting adolescent behavioural patterns, but it has rather been evident in improving passive nutrition knowledge only [14, 15]. The didactic teaching approach is more teacher-centred rather than student-centred, which can only be possible through a collaborative, cooperative and participatory learning approach. Psychosocial factors such as perceived severity, perceived benefits, perceived barriers, self-efficacy, perceived risk, and desire to take action that often determine dietary behaviours are commonly excluded in nutrition education interventions delivered with a didactic teaching method [3, 16, 17]. Dietary behaviours of adolescents are mostly affected by peer pressure and social influence; nutrition guides and methods of delivery must, at all costs, incorporate collaborative, cooperative and participatory involvement of adolescents, without this, the effect, if any, will be negligible and the outcomes will be short-lived [18].

Collaborative instructional techniques offer an alternative approach, such as peer discussion, cooperative learning, reciprocal teaching, problem-based learning, and role-playing, that help in encouraging active participation, shared responsibility, co-creation of solutions, and social modelling [17]. Collaborative learning techniques promote knowledge retention, assurance, and positive behavioural intention that align with the

dynamism of adolescent developmental stages [17, 19]. While evidence suggests that participatory strategies can improve dietary behaviour, limited comparative research exists within sub-Saharan African school contexts evaluating collaborative learning against conventional didactic instruction. In addition, many interventions lack a structured behavioural framework to guide both design and evaluation.

In this study, the Health Belief Model (HBM) was utilised in the assessment of the perceived dietary behaviours. This behaviour model provides a rooted theoretical framework for understanding how the model constructs affect individual decision-making. This framework proposes that individual health behaviour decisions are affected by six HBM constructs: perceived susceptibility, perceived severity, perceived benefits, perceived barriers, cues to action, and self-efficacy [20, 21]. Nutrition education interventions that incorporate this framework provide a reliable pathway for evaluation of the beliefs and perceptions that impact food choice among adolescents and also means to shape these factors through tailored messages and a collaborative teaching approach. Findings from previous studies have helped to establish the effectiveness of this model in promoting quality health behaviours; however, the use of HBM in collaborative structure nutrition education programs remains inadequately explored [17].

In Nigeria, socioeconomic disparities, evolving dietary environments, and limited institutionalised school-based nutrition programming underscore the need for innovative and scalable strategies. Odeda Local Government Area (LGA) in Ogun State presents a relevant context for intervention due to documented nutritional concerns among adolescents and emerging reports of overweight prevalence [12]. Public secondary schools within this LGA provide a structured setting for implementing and evaluating a theory-driven educational intervention capable of influencing dietary behaviour across diverse socioeconomic backgrounds.

Against this backdrop, this study evaluated the effectiveness of a Health Belief Model-guided collaborative instructional intervention in improving healthy eating intention, diet quality, nutrition knowledge, and perceived dietary behaviour among in-school adolescents.

## Study Aim and Hypotheses

The primary aim of this study was to determine the effect of a collaborative technique instructional intervention guided by the Health Belief Model on diet quality, nutrition knowledge, and perceived dietary behaviour among adolescents attending public secondary schools in Odeda LGA, Ogun State, Nigeria.

The study tested the following hypotheses:

H1: The participants receiving nutrition education in a collaborative context would demonstrate significant improvement in diet quality parameters when compared with the participants receiving nutrition education in a conventional didactic teaching approach.

H2: The participants in the collaborative learning group would demonstrate significant improvement in nutrition knowledge when compared with the control group receiving nutrition education in a conventional didactic teaching approach.

H3: The participants in the collaborative learning group would demonstrate positive changes across Health Belief Model constructs (perceived susceptibility, perceived severity, perceived benefits, perceived barriers, cues to

action, and self-efficacy) compared with the participants receiving nutrition education in a conventional didactic teaching approach.

This study incorporates participatory pedagogy driven by behavioural theory, which provides empirical evidence on the behavioural advantages offered by nutrition education interventions that incorporate collaborative techniques in their instructional guide. The study findings provide public health and policy-relevant insights towards empowering, strengthening, and supporting adolescent nutrition programming in Nigeria and most especially in underserved communities with limited resources, for advancing health and developmental goals relevant to nutrition.

## **Methodology**

### **Study design and setting**

This school-based quasi-experimental study was conducted among adolescents aged 13 to 19 years in two public schools in Odeda Local Government, Ogun State, Nigeria. Odeda LGA is a semi-urban area with a population that reflects a mix of rural and peri-urban characteristics. The study area was purposively selected due to its nutritional challenges, including evidence of both undernutrition and rising prevalence of overweight/obesity among adolescents [3]. The study was reported using Transparent Reporting of Evaluations with Non-randomised Designs (TREND) guidelines [22].

### **Study participants**

Study participants included 300 in-school adolescents, aged 13 to 19 years, who were in SS 1 to SS 3 classes (Fig. 1). Students who were able to answer the questionnaire items and were present on the day of data collection were included in this study. Adolescents with medical conditions, such as physical and psychological issues, as well as those who were reluctant to participate and were absent on program days, were excluded from the study. The study population consisted of adolescents enrolled in public secondary schools within the LGA. Adolescents in this age range were selected because of their unique physiological and psychosocial developmental needs, as well as their increased susceptibility to poor dietary behaviours.

## **Outcomes**

The primary outcome of this study was to measure the change in nutrition knowledge of participants after an 8-week nutrition educational intervention, and the secondary outcomes were to evaluate the change in perceived dietary behaviour and diet quality indicators among in-school adolescents.

## **Intervention**

This study employed a quasi-experimental, pre-test to post-test control group design to evaluate the effect of a collaborative learning-based nutrition education intervention on diet quality and nutrition knowledge among in-school adolescents in Ogun State, Nigeria. Participants in the intervention group received a structured nutrition education package delivered using collaborative learning strategies, while the control group continued with the

standard school curriculum delivered through conventional didactic teaching methods without exposure to collaborative learning.

The intervention was implemented over eight consecutive weeks, with one 60-minute session per week conducted separately for each grade level to ensure age-appropriate delivery. Nutrition education sessions were held within regular classroom settings during school hours. The educational content was identical for both groups and was adapted from nationally and internationally recognised nutrition guidance documents, including the Food-Based Dietary Guidelines for Nigeria and national dietary and physical activity guidelines. However, the mode of delivery differed substantially between groups. In the intervention group, nutrition education was delivered using collaborative learning techniques designed to promote active participation, peer interaction, and shared problem-solving. These included buzz group discussions, reciprocal teaching using a Jigsaw design, problem-based learning through the “send-a-problem” approach, and role-playing activities that simulated real-life food choice and dietary decision-making scenarios. Students worked in small groups, assumed rotating roles, and collectively constructed knowledge through guided facilitation rather than passive reception of information. To reinforce learning, participants produced session summaries in the form of wall newspapers at the end of each session.

The control group received the same nutrition education content, delivered over the same duration and frequency, but through traditional teacher-led lectures consistent with routine classroom instruction. These sessions relied primarily on verbal explanations and textbook-based teaching, without structured peer interaction, group tasks, or collaborative activities. All sessions were facilitated by trained nutritionists and dietitians using standardised educational materials, including posters, leaflets, pamphlets, and PowerPoint presentations. The nutrition education package was developed by the research team and reviewed by academic and professional experts in nutrition before implementation. Intervention fidelity, participant engagement, and adherence to the delivery protocol were monitored throughout the intervention period using structured observational checklists. To minimise contamination, intervention and control participants were drawn from different schools. Follow-up data were collected four weeks after completion of the eight-week intervention using the same instruments administered at baseline to assess changes in diet quality and nutrition knowledge attributable to the intervention.

## Nutrition Education Guide

A structured, curriculum-based Nutrition Education Guide developed specifically for this study guided the nutrition education intervention. The guide was designed to ensure content validity, logical sequencing, and consistency across sessions. It was adapted from authoritative national and international nutrition education frameworks, including the Food-Based Dietary Guidelines for Nigeria, MyPlate, Kenya’s National Dietary and Physical Activity Guidelines, and established clinical nutrition texts [23, 24, 25, 26]. These sources were selected to ensure scientific rigour, cultural relevance, and alignment with global recommendations for adolescent nutrition.

The guide was structured into eight progressive lessons, each building on the previous session to promote cumulative learning and reinforcement of key concepts. Initial sessions introduced the importance of healthy eating during adolescence, emphasising links between diet, growth and development, academic performance, mental well-being, and long-term risk of diet-related non-communicable diseases. Subsequent lessons focused

on understanding food groups, nutrient functions, and the principles of constructing a balanced diet using visual dietary models, enabling students to translate abstract nutrition concepts into practical meal choices.

Mid-intervention sessions addressed applied dietary skills, including portion control, meal planning, interpretation of nutrition labels, and selection of healthier snack options. These components were intended to strengthen food literacy and empower adolescents to make informed choices within real-world food environments. Additional sessions emphasised hydration and healthy beverage choices, highlighting the role of water and the health risks associated with sugar-sweetened beverages. The guide also explicitly addressed frequent consumption of fast foods, discussing their nutritional composition, associated health risks, and practical strategies for making healthier alternatives.

The final sessions focused on overcoming barriers to healthy eating, including social influences, economic constraints, and limited access to healthy foods. Students were encouraged to identify context-specific challenges and collaboratively develop feasible solutions, reinforcing problem-solving skills and personal agency. Throughout the curriculum, learning was supported using interactive discussions, visual aids, practical demonstrations, and scenario-based activities, which were particularly suited to the collaborative learning approach adopted in the intervention.

## **Sample size determination**

The sample size was calculated using the formula for comparison of two independent means in the OpenEpi software. Estimates were derived from a similar school-based collaborative nutrition education intervention [27], which reported a mean difference of 7.78 in nutrition knowledge change between intervention and control groups, with a pooled standard deviation of 14.39. Assuming a two-sided significance level of 5% (95% confidence interval) and 80% statistical power, the minimum required sample size was 54 participants per group. Given the limited number of clusters, analyses were conducted at the individual level while ensuring baseline comparability between groups. No statistically significant differences were observed in key sociodemographical or outcome variables at baseline, supporting exchangeability between study arms.

Because the intervention was delivered at the school level, a design effect of 1.5 was applied to account for clustering of participants within schools. After adjusting for an anticipated attrition rate of 10%, the final minimum required sample size was 90 participants per group (total = 180). However, to increase statistical precision and strengthen the robustness of findings, 150 participants were recruited per group, resulting in a total baseline sample size of 300. Given the limited number of clusters, analyses were conducted at the individual level while ensuring baseline comparability between groups.

## **Recruitment**

A comprehensive list of registered public secondary schools was obtained from the Local Education Authority of Odeda Local Government Area, Ogun State, Nigeria. At the time of the study, each public secondary school had an average enrolment of approximately 400–450 adolescents. From the sampling frame, two public secondary schools were purposively selected based on the adequacy of their adolescent population to meet the predetermined sample size requirement for the study. To minimise allocation bias, assignment of the selected schools to either the intervention or control arm was conducted using a simple randomisation procedure (coin

toss). One school was designated as the intervention site, while the other served as the control site. School-level allocation was adopted to prevent contamination of intervention content between groups. Following selection and allocation, meetings were held with school administrators to explain the study objectives, procedures, and ethical considerations, and to obtain institutional approval. With the assistance of the school registry, class lists for Senior Secondary School (SSS) 1 to SSS 3 were compiled to identify eligible participants. All adolescents aged 13–19 years who met the inclusion criteria were approached and invited to participate. Although each school had a large student population, the study sample size had been predetermined. Therefore, recruitment continued until the required number of participants was attained. Written informed consent was obtained from parents or guardians, and written assent was obtained from the adolescents before enrolment. A total of 300 adolescents were enrolled at baseline, with 150 participants in the intervention group and 150 participants in the control group. Some eligible students were not included due to absence during data collection, refusal to provide parental consent or personal assent, illness at the time of enrolment, or subsequent loss to follow-up. The detailed recruitment and enrolment process is presented in the study flow diagram (Fig. 1).

## Data collection tools and techniques

Data were collected using a pretested, interviewer-administered semi-structured questionnaire designed to obtain information on sociodemographic characteristics, diet quality, and anthropometric indices. Trained research assistants who consisted of Master's students in Public Health Nutrition, Clinical Nutrition, and Health Education and Promotion graduate students administered questionnaires within the school environment between May 2024 and November 2024, during regular academic sessions and outside examination periods to minimise disruption and participant fatigue. Class teachers assisted only with logistical coordination and were not present during data collection to reduce response bias. All the tools were originally developed in the English language.

The sociodemographic information includes age, sex, class, religion, ethnicity, occupation of the parent, household income, Household size and education of the parent. The nutrition knowledge, health belief constructs, questions, and diet quality questionnaires were adapted from a previous study [3, 28, 29] and then pretested for validity and reliability.

## Nutrition knowledge

Nutrition knowledge was assessed using a modified version of a validated questionnaire originally developed by Turconi et al. (30) and subsequently adapted by Ademiluyi & Uthman-Akinhanmi, (28) for use in the Nigerian context. The modified nutrition knowledge questionnaire was pre-tested among twenty (20) adolescents in a secondary school outside the study area to assess clarity, comprehensibility, and cultural appropriateness. Internal consistency reliability was assessed using Cronbach's alpha ( $\alpha = 0.83$ ), indicating good reliability ( $\alpha \geq 0.80$ ) for the composite scale in this adolescent sample. The questionnaire evaluated participants' knowledge of healthy diet composition, basic nutrition principles, and the health consequences of unhealthy eating. The instrument comprised twenty (20) questions (Q1–Q20) covering food groups, nutrient functions, and recommended healthy eating practices. Each correct response was assigned a score of 1, while incorrect, "don't know," or missing responses were scored 0. Individual item scores were summed to generate a total nutrition knowledge score, with higher scores indicating greater nutrition knowledge.

# Diet quality assessment

Diet quality was assessed using the Global Diet Quality Questionnaire (DQQ), a standardised, low-burden dietary assessment tool developed by the Global Diet Quality Project in collaboration with Gallup, the Harvard T.H. Chan School of Public Health, and the Global Alliance for Improved Nutrition (GAIN) [31, 29]. The DQQ captures dietary patterns based on reported consumption of sentinel foods representing 29 food groups during the previous day and night and is designed for population-level assessment rather than individual nutrient intake estimation. The questionnaire was administered strictly according to the standardised protocol, without modification, to ensure methodological consistency and comparability.

Diet quality indicators were derived a priori in accordance with the DQQ Indicator Guide (29). Dietary diversity was assessed using the Dietary Diversity Score (DDS), calculated as the sum of ten predefined food groups consumed, yielding a score ranging from 0 to 10, with higher scores indicating greater dietary diversity. For female participants, the Minimum Dietary Diversity for Women (MDD-W) was additionally derived from the DDS and expressed as a binary indicator, with a value of 1 assigned if five or more of the ten food groups were consumed and 0 otherwise, reflecting a higher likelihood of adequate micronutrient intake at the population level [32, 33].

Adherence to dietary components protective against non-communicable diseases was assessed using the NCD-Protect score, which awards one point for consumption of each of nine health-promoting food groups, producing a score from 0 to 9. Dietary exposure to foods recommended to be limited was assessed using the NCD-Risk score, based on consumption of eight food groups associated with increased NCD risk, with processed meat double-weighted, resulting in a score from 0 to 9, where higher values indicate greater dietary risk. An overall measure of alignment with global dietary recommendations was calculated using the Global Dietary Recommendations Score (GDRS), computed as  $(NCD-Protect - NCD-Risk) + 9$  and transformed to a scale of 0 to 18, with higher scores indicating healthier dietary patterns [28, 29]. All indicators were analysed and interpreted at the population level.

## Perceived dietary behaviour

Perceived dietary behaviour was assessed using an HBM-based questionnaire adapted from Keshani et al. [17] and Saghaei-Asl et al. [21]. The questionnaire was pretested in a population with similar characteristics to the study participants. Content validity was assessed using Lawshe's [34] method as updated by Sürücü et al. [35]. Ten public health and nutrition experts reviewed the instrument. The overall reliability coefficient for the HBM scale was 0.85. Construct-specific Cronbach's alpha values were 0.89 for perceived severity, 0.75 for perceived susceptibility, 0.73 for perceived barriers, 0.86 for perceived benefits, 0.78 for cues to action, and 0.91 for self-efficacy. Six constructs were measured: perceived severity, perceived susceptibility, perceived benefits, perceived barriers, cues to action, and self-efficacy. Perceived severity assessed the seriousness of unhealthy eating across emotional and mental health, physical fitness, short- and long-term health outcomes, and social well-being. Perceived susceptibility measured the perceived likelihood of experiencing nutrition-related health problems. Perceived benefits captured beliefs about the advantages of healthy eating, while perceived barriers assessed practical and personal challenges such as cost, availability, preferences, and motivation. Cues to action evaluated internal and external triggers, including family support, peer influence, and exposure to nutrition

information. Self-efficacy assessed confidence in maintaining healthy eating across various contexts, including at home, with peers, and in public settings.

## Instrument Development and Validation

Perceived dietary behaviour was measured using a 56-item HBM-based questionnaire adapted from Keshani et al. [17] and Saghafi-Asl et al. [21]. The instrument was pretested among adolescents with similar characteristics and reviewed for content validity by ten experts. Content validity indices (CVI) ranged from 0.74 to 1.00, and Content Validity Ratios (CVR) ranged from 0.62 to 1.00. Construct validity was assessed using exploratory factor analysis (EFA) with principal component extraction and varimax rotation. The Kaiser–Meyer–Olkin measure was 0.88, and Bartlett’s test of sphericity was significant ( $\chi^2 = 4213.57$ ,  $p < 0.001$ ). Six factors corresponding to HBM constructs were extracted, explaining 68.4% of total variance, with factor loadings ranging from 0.52 to 0.84. Internal consistency reliability (Cronbach’s alpha) was 0.85 for the total scale, with construct-specific values ranging from 0.73 to 0.91. Test–retest reliability over a two-week interval ( $n = 30$ ) yielded an ICC of 0.82 (95% CI: 0.74–0.89). Items were scored on a 5-point Likert scale (1 = strongly disagree to 5 = strongly agree), with higher scores indicating stronger perceived healthy dietary behaviour. No significant floor or ceiling effects were observed.

Table 1  
Psychometric Properties of the HBM-Based Perceived Dietary Behaviour Scale

| Construct                | Number of Items | Cronbach’s $\alpha$ | Factor Loading Range | Variance Explained (%) |
|--------------------------|-----------------|---------------------|----------------------|------------------------|
| Perceived Severity       | 10              | 0.89                | 0.61–0.84            | 14.2                   |
| Perceived Susceptibility | 8               | 0.75                | 0.52–0.73            | 11.3                   |
| Perceived Benefits       | 9               | 0.86                | 0.58–0.81            | 12.6                   |
| Perceived Barriers       | 9               | 0.73                | 0.54–0.76            | 10.1                   |
| Cues to Action           | 10              | 0.78                | 0.55–0.79            | 9.8                    |
| Self-Efficacy            | 10              | 0.91                | 0.63–0.83            | 10.4                   |
| Total Scale              | 56              | 0.85                | —                    | 68.4%                  |

## Data Management and Analysis

Data were entered into Microsoft Excel 2016 and analysed using IBM SPSS Statistics version 27 (IBM Corp., Armonk, NY, USA). Diet quality indicators were computed using the interactive Diet Quality Questionnaire (DQQ) calculator in conjunction with Microsoft Excel. Descriptive statistics were generated for all sociodemographic, nutrition knowledge, perceived dietary behaviour, and diet quality variables. Categorical variables were summarised as frequencies and percentages, while continuous variables were expressed as means  $\pm$  standard deviations (SD). Statistical significance was set at  $p < 0.05$  with 95% confidence intervals (CIs) throughout all analyses.

Baseline comparability between the intervention and control groups was assessed using the Chi-square test or Fisher's exact test for categorical variables, and the independent samples t-test for continuous variables. Normality of continuous outcome variables was evaluated using the Shapiro–Wilk test, and homogeneity of variance was assessed with Levene's test. Within-group changes from baseline to endline in diet quality scores (Dietary Diversity Score [DDS], NCD-Protect Score, NCD-Risk Score, and Global Dietary Recommendations [GDR] Score), nutrition knowledge, and Health Belief Model (HBM)-based perceived dietary behaviour constructs were assessed using paired t-tests. Between-group differences at baseline and endline were examined using independent t-tests. The Difference-in-Differences (DiD) method was applied to estimate the net intervention effect by comparing within-group changes over time between the intervention and control groups, expressed as a percentage of the intervention group's baseline mean. This approach accounts for pre-existing group differences and temporal trends, thereby strengthening causal inference in the quasi-experimental design.

To obtain adjusted estimates of the intervention effect, Analysis of Covariance (ANCOVA) was conducted for the primary outcomes of dietary diversity and nutrition knowledge at endline. For the DDS model, covariates included baseline DDS, position in household, parental education levels, household monthly income, household size, number of siblings, and living arrangements. For the Nutrition Knowledge Score model, covariates included baseline nutrition knowledge score, age, gender, parental education levels, and living arrangements. Maternal educational attainment was specifically retained as a covariate in both models, given the statistically significant baseline imbalance observed between groups ( $\chi^2 = 24.856$ ;  $p < 0.001$ ). Homoscedasticity of ANCOVA residuals was verified through visual inspection of residual scatterplots.

## Results

### Sociodemographic and economic characteristic of the adolescents

A total of 300 adolescents participated in the study, equally distributed between the intervention ( $n = 150$ ) and control ( $n = 150$ ) groups. Their sociodemographic and economic characteristics are summarised in Table 2. Participants ranged in age from 13 to 17 years (mean:  $15.13 \pm 1.06$  years), with the majority aged 14 to 15 years (67%). Just over half of all participants were female (56%). The sample was predominantly from households with secondary-educated fathers (56.7%) and monthly incomes exceeding 100,000 (38%). Most participants lived in households of 5 to 8 members (61.3%) with 0 to 4 siblings (86%), and the majority resided with both parents (65.3%).

At baseline, the intervention and control groups were comparable across all sociodemographic and economic variables, including age, gender, paternal education, household income, household size, number of siblings, and living arrangements (all  $p > 0.05$ ). The only statistically significant difference observed was in maternal educational attainment ( $\chi^2 = 24.856$ ;  $p < 0.001$ ), where the intervention group had a higher proportion of mothers with primary education (19% vs. 3%) and the control group had more mothers with tertiary education (37% vs. 21%). This variable was therefore retained as a covariate in subsequent adjusted analyses (Table 2).

Table 2  
Sociodemographic and economic characteristic of the adolescents

| Group                                                                                                                                       |                    |           |               |                     |          |
|---------------------------------------------------------------------------------------------------------------------------------------------|--------------------|-----------|---------------|---------------------|----------|
| Variable                                                                                                                                    | Intervention Group |           | Control Group |                     |          |
| Age                                                                                                                                         | N (%)              | N (%)     | N (%)         | $\chi^2$            | p-value  |
| 13                                                                                                                                          | 4 (1.3)            | 2 (1)     | 2 (1)         | 1.413 <sup>b</sup>  | 0.842    |
| 14                                                                                                                                          | 92 (30.7)          | 47 (31)   | 45 (30)       |                     |          |
| 15                                                                                                                                          | 109 (36.3)         | 58 (39)   | 51 (34)       |                     |          |
| 16                                                                                                                                          | 50 (16.7)          | 22 (15)   | 28 (19)       |                     |          |
| 17                                                                                                                                          | 45 (15)            | 21 (14)   | 24 (16)       |                     |          |
| Total                                                                                                                                       | 300 (100)          | 150 (100) | 150 (100)     |                     |          |
| Mean $\pm$ SD                                                                                                                               | 15.13 $\pm$ 1.06   |           |               |                     |          |
| <b>Gender</b>                                                                                                                               |                    |           |               |                     |          |
| Male                                                                                                                                        | 132 (44)           | 74 (49)   | 58 (39)       | 3.463 <sup>a</sup>  | 0.063    |
| Female                                                                                                                                      | 168 (56)           | 76 (51)   | 92 (61)       |                     |          |
| Total                                                                                                                                       | 300 (100)          | 150 (100) | 150 (100)     |                     |          |
| <b>Father highest level of education</b>                                                                                                    |                    |           |               |                     |          |
| No formal education                                                                                                                         | 14 (4.7)           | 6 (4)     | 8 (5)         | 4.459 <sup>a</sup>  | 0.216    |
| Primary education                                                                                                                           | 18 (6)             | 12 (8)    | 6 (4)         |                     |          |
| Secondary education                                                                                                                         | 170 (56.7)         | 78 (52)   | 92 (61)       |                     |          |
| Tertiary education                                                                                                                          | 98 (32.7)          | 54 (36)   | 44 (29)       |                     |          |
| Total                                                                                                                                       | 300 (100)          | 150 (100) | 150 (100)     |                     |          |
| <b>Mother highest level of education</b>                                                                                                    |                    |           |               |                     |          |
| No formal education                                                                                                                         | 14 (4.7)           | 6 (4)     | 8 (5)         | 24.856 <sup>a</sup> | < 0.001* |
| Primary education                                                                                                                           | 32 (10.7)          | 28 (19)   | 4 (3)         |                     |          |
| Secondary education                                                                                                                         | 166 (55.3)         | 84 (56)   | 82 (55)       |                     |          |
| Tertiary education                                                                                                                          | 88 (29.3)          | 32 (21)   | 56 (37)       |                     |          |
| Total                                                                                                                                       | 300 (100)          | 150 (100) | 150 (100)     |                     |          |
| <b>Household's monthly income</b>                                                                                                           |                    |           |               |                     |          |
| <sup>a</sup> $\chi^2$ -Chi-square, <sup>b</sup> Fisher's Exact test, Asterisk (*) signify statistical significant differences at $p < 0.05$ |                    |           |               |                     |          |
| SD-Standard Deviation                                                                                                                       |                    |           |               |                     |          |

| Group                                                                                                                                     |            |                    |               |                    |         |
|-------------------------------------------------------------------------------------------------------------------------------------------|------------|--------------------|---------------|--------------------|---------|
| Variable                                                                                                                                  |            | Intervention Group | Control Group |                    |         |
| Age                                                                                                                                       | N (%)      | N (%)              | N (%)         | χ²                 | p-value |
| Less than 20,000                                                                                                                          | 62 (20.7)  | 34 (23)            | 28 (19)       | 4.718 <sup>a</sup> | 0.194   |
| 20,000–50,000                                                                                                                             | 68 (22.7)  | 40 (27)            | 28 (19)       |                    |         |
| 50,001–100,000                                                                                                                            | 56 (18.7)  | 24 (16)            | 32 (21)       |                    |         |
| More than 100,000                                                                                                                         | 114 (38)   | 52 (35)            | 62 (41)       |                    |         |
| Total                                                                                                                                     | 300 (100)  | 150 (100)          | 150 (100)     |                    |         |
| Household Number                                                                                                                          |            |                    |               |                    |         |
| 0–4                                                                                                                                       | 102 (34)   | 52 (35)            | 50 (33)       | 0.412 <sup>a</sup> | 0.814   |
| 05-Aug                                                                                                                                    | 184 (61.3) | 90 (60)            | 94 (63)       |                    |         |
| 09-Dec                                                                                                                                    | 14 (4.7)   | 8 (5)              | 6 (4)         |                    |         |
| Total                                                                                                                                     | 300 (100)  | 150 (100)          | 150 (100)     |                    |         |
| Number of Sibling                                                                                                                         |            |                    |               |                    |         |
| 0–4                                                                                                                                       | 258 (86)   | 132 (88)           | 126 (84)      | 2.540 <sup>b</sup> | 0.281   |
| 5–8                                                                                                                                       | 40 (13.3)  | 18 (12)            | 22 (15)       |                    |         |
| 9–12                                                                                                                                      | 2 (0.7)    | 0                  | 2 (1)         |                    |         |
| Total                                                                                                                                     | 300 (100)  | 150 (100)          | 150 (100)     |                    |         |
| Who do you live with?                                                                                                                     |            |                    |               |                    |         |
| Both Parent                                                                                                                               | 196 (65.3) | 88 (59)            | 108 (72)      | 9.084 <sup>b</sup> | 0.059   |
| Mother only                                                                                                                               | 48 (16)    | 32 (21)            | 16 (11)       |                    |         |
| Father only                                                                                                                               | 12 (4)     | 8 (5)              | 4 (3)         |                    |         |
| Guardian                                                                                                                                  | 26 (8.7)   | 14 (9)             | 12 (8)        |                    |         |
| Other relatives                                                                                                                           | 18 (6)     | 8 (5)              | 10 (7)        |                    |         |
| Total                                                                                                                                     | 300 (100)  | 150 (100)          | 150 (100)     |                    |         |
| <sup>a</sup> χ²-Chi-square, <sup>b</sup> Fisher's Exact test, Asterisk (*) signify statistical significant differences at <i>p</i> < 0.05 |            |                    |               |                    |         |
| SD-Standard Deviation                                                                                                                     |            |                    |               |                    |         |

## Food groups consumption pattern

Figures 2, 3, and 4 present the diet quality indicators at baseline and endline for both groups. At baseline, the intervention group had lower consumption of most NCD-Protect food groups relative to the control group.

Following the intervention, marked improvements were observed in several health-protective food categories, including other vegetables (73% to 85%), other fruits (33% to 57%), vitamin A-rich foods (38% to 57%), pulses (23% to 55%), and whole grains (30% to 65%), while the control group showed negligible change across these food groups (Fig. 2).

For NCD-Risk food groups, the intervention group demonstrated reductions in consumption of unprocessed meat (65% to 35%), baked or grain-based sweets (85% to 50%), other sweets (65% to 62%), and packaged ultra-processed salty snacks (55% to 50%). Modest reductions were also observed in the control group for some NCD-risk items, while deep-fried food and fast food consumption remained largely unchanged in both groups (Fig. 3).

Regarding dietary diversity adequacy, the proportion of intervention group participants meeting the Minimum Dietary Diversity for Women (MDD-W) threshold increased by 20 percentage points (33% to 53%), compared to negligible change in the control group (69% to 70%), indicating meaningful gains in overall dietary diversity among intervention participants (Fig. 4).

## Effect of Intervention on Diet Quality Scores

Table 3 and Fig. 5 present diet quality outcomes across both groups at baseline and endline. The intervention group demonstrated statistically significant improvements in three of the four diet quality indicators. The DDS improved from 4.12 ( $\pm 1.95$ ) to 5.60 ( $\pm 1.57$ ) ( $p < 0.001$ ), with a significant DiD of 1.39 (95% CI: 0.96–2.24;  $p < 0.001$ ), representing a 33.74% gain over baseline. The NCD-Protect Score showed the largest relative improvement, rising from 2.33 ( $\pm 1.56$ ) to 6.20 ( $\pm 1.67$ ) ( $p < 0.001$ ), yielding a DiD of 3.57 (95% CI: 2.60–4.54;  $p < 0.001$ ) and a 153.22% improvement. The GDR Score also improved significantly from 8.88 ( $\pm 2.30$ ) to 12.71 ( $\pm 2.06$ ) ( $p < 0.001$ ), with a DiD of 3.54 (95% CI: 0.72–2.12;  $p < 0.001$ ), reflecting a 39.86% improvement and significantly higher endline scores compared to the control group ( $p < 0.001$ ). In contrast, the NCD-Risk Score did not change significantly in either group, and the DiD of 0.02 was non-significant (95% CI: -0.93–0.97;  $p = 0.967$ ), indicating that the intervention did not significantly reduce NCD-risk food consumption scores. There is no significant within-group or between-group changes were observed in the control group across all four indicators.

Table 3  
Effect of Intervention on Diet Quality Indicators

| Indicators                                 | Group                | Baseline    | Endline      | p.value <sup>†</sup> | MD   | DiD (Improved %) | 95% CI of the DiD | p.value <sup>‡</sup> |
|--------------------------------------------|----------------------|-------------|--------------|----------------------|------|------------------|-------------------|----------------------|
|                                            |                      | Mean ± SD   | Mean ± SD    |                      |      |                  | (LL-UL)           |                      |
| <b>DDS (0–10)<sup>a</sup></b>              | Intervention         | 4.12 ± 1.95 | 5.60 ± 1.57  | < 0.001*             | 1.48 | 1.39 (33.74)     | 0.96–2.24         | < 0.001*             |
|                                            | Control              | 5.48 ± 1.87 | 5.39 ± 1.87  | 0.329                | 0.09 |                  |                   |                      |
|                                            | p.value <sup>‡</sup> | < 0.001*    | 0.527        |                      |      |                  |                   |                      |
| <b>NCD-Protect Score (0–9)<sup>b</sup></b> | Intervention         | 2.33 ± 1.56 | 6.20 ± 1.67  | < 0.001*             | 3.86 | 3.57 (153.22)    | 2.60–4.54         | < 0.001*             |
|                                            | Control              | 3.20 ± 2.25 | 3.49 ± 1.29  | 0.446                | 0.29 |                  |                   |                      |
|                                            | p.value <sup>‡</sup> | 0.026*      | < 0.001*     |                      |      |                  |                   |                      |
| <b>NCD-Risk Score (0–9)<sup>c</sup></b>    | Intervention         | 2.45 ± 1.54 | 2.49 ± 1.45  | 0.879                | 0.04 | 0.02 (0.82)      | -0.93–0.97        | 0.967                |
|                                            | Control              | 4.10 ± 2.46 | 4.12 ± 2.33  | 0.961                | 0.02 |                  |                   |                      |
|                                            | p.value <sup>‡</sup> | < 0.001*    | < 0.001*     |                      |      |                  |                   |                      |
| <b>GDR Score (0–18)<sup>d</sup></b>        | Intervention         | 8.88 ± 2.30 | 12.71 ± 2.06 | < 0.001*             | 3.82 | 3.54 (39.86)     | 0.72–2.12         | < 0.001*             |
|                                            | Control              | 8.10 ± 3.34 | 8.37 ± 2.96  | 0.642                | 0.28 |                  |                   |                      |
|                                            | p.value <sup>‡</sup> | 0.171       | < 0.001*     |                      |      |                  |                   |                      |

Statistical Test: <sup>†</sup>Paired T Test, <sup>‡</sup>Independent Test; Asterisk (\*) signify statistical significant differences at  $p < 0.05$ ; Improved (%) = (Difference-in-difference ÷ Baseline intervention mean) × 100. SD, Standard Deviation; MD, Mean Difference; CI, Confidence Interval; LL, Lower Limit; UL, Upper Limit; N, Frequency; DiD, Difference in difference; CMD, Change mean difference; GDR, global dietary recommendations; NCD, non-communicable disease.

<sup>a</sup> Dietary diversity Score (DDS) includes ten food groups: (1) grains, white roots and tuber, and plantains; (2) pulses (beans, peas and lentils); (3) nuts and seeds; (4) dairy; (5) meat, poultry and fish; (6) eggs; (7) dark green leafy vegetables; (8) other vitamin A-rich fruits and vegetables; (9) other vegetables; (10) other fruits.

<sup>b</sup> NCD – protect score measures adherence to global dietary recommendations on foods to consume: (1) whole grains; (2) pulses; (3) nuts and seeds; (4) vitamin A-rich orange vegetables; (5) dark green leafy vegetables; (6) other vegetables; (7) vitamin A-rich fruits; (8) citrus; (9) other fruits.

<sup>c</sup> NCD – risk score measures adherence to global dietary recommendations on foods to limit including: (1) soft drinks; (2) baked/grain-based sweets; (3) other sweets; (4) processed meats; (5) unprocessed meat; (6) deep fried food; (7) fast food and instant noodles; (8) packaged ultra-processed salty snacks.

<sup>d</sup> GDR score = (NCD – Protect – NCD – Risk) + 9; measures adherence to global dietary recommendations protective against non-communicable diseases.

## Effect of Intervention on Nutrition Knowledge

Table 4 displays the nutrition knowledge scores of participants at baseline and endline. The intervention group exhibited a statistically significant improvement in nutrition knowledge, increasing from a mean of 54.35 (± 12.27) at baseline to 64.63 (± 18.20) at endline (p = 0.001), yielding a mean difference of 10.28. The control group showed no significant improvement (51.40 ± 11.54 to 53.74 ± 10.99; p = 0.288), with a mean difference of only 2.34 (Fig. 6). The DiD of 7.94 was statistically significant (95% CI: 2.18–13.69; p = 0.007), representing a 14.61% improvement relative to the intervention group's baseline score. By endline, the intervention group's nutrition knowledge score was significantly higher than that of the control group (p < 0.001), indicating that the intervention was effective in improving nutrition knowledge among participants (Table 4).

| Table 4<br>Nutrition Knowledge Score of the participant |                      |               |               |                      |                      |              |            |                      |
|---------------------------------------------------------|----------------------|---------------|---------------|----------------------|----------------------|--------------|------------|----------------------|
| Variable                                                | Group                | Baseline      | Endline       | p.value <sup>a</sup> | Mean difference      | DiD          | 95% CI     | p.value <sup>a</sup> |
|                                                         |                      | Mean ± SD     | Mean ± SD     |                      | (Endline - Baseline) | (Improved %) | LL-UL      |                      |
| Nutrition Knowledge                                     | Intervention         | 54.35 ± 12.27 | 64.63 ± 18.20 | 0.001*               | 10.28                | 7.94 (14.61) | 2.18–13.69 | 0.007                |
|                                                         | Control              | 51.40 ± 11.54 | 53.74 ± 10.99 | 0.288                | 2.34                 |              |            |                      |
|                                                         | p-value <sup>b</sup> | 0.096         | < 0.001*      |                      |                      |              |            |                      |

N-Frequency; SD-Standard Deviation; M-Mean; Improved (%) = (Difference-in-difference ÷ Baseline intervention mean) × 100.

a= Paired t-test, b= Independent t-test

\*Signifies Statistical Significant difference

## Effect of Intervention on Perceived Dietary Behaviour (Health Belief Model Constructs)

Table 5 presents changes in Health Belief Model (HBM) constructs related to perceived dietary behaviour across both groups. All six HBM constructs showed statistically significant improvements in the intervention group, while the control group demonstrated no significant within-group changes across most constructs.

Perceived Severity increased significantly in the intervention group from 56.43 ( $\pm 10.96$ ) to 68.17 ( $\pm 6.26$ ) ( $p < 0.001$ ), with a DiD of 10.70, representing an 18.96% improvement. Perceived Susceptibility also improved significantly from 17.96 ( $\pm 4.79$ ) to 22.93 ( $\pm 3.43$ ) in the intervention group ( $p < 0.001$ ), with a DiD of 3.74 (20.82% improvement). Perceived Barrier scores improved from 21.43 ( $\pm 4.56$ ) to 26.03 ( $\pm 3.67$ ) in the intervention group ( $p < 0.001$ ), with a DiD of 3.57 (16.66% improvement). Perceived Benefit showed a significant improvement from 36.39 ( $\pm 5.16$ ) to 40.57 ( $\pm 3.63$ ) ( $p < 0.001$ ), with a DiD of 3.10 (8.51% improvement). Cue to Action scores increased from 19.74 ( $\pm 3.31$ ) to 22.99 ( $\pm 2.16$ ) in the intervention group ( $p < 0.001$ ), with a DiD of 1.30 (6.59% improvement). Finally, Self-Efficacy demonstrated a significant improvement from 50.31 ( $\pm 7.11$ ) to 57.94 ( $\pm 5.23$ ) in the intervention group ( $p < 0.001$ ), with a DiD of 6.77 (13.46% improvement). At baseline, all six HBM construct scores were significantly higher in the intervention group compared to the control group (all  $p < 0.001$ ), as shown in Table 5 and illustrated in Fig. 7.

Table 5  
Perceived Dietary Behaviour using HBM Construct

| Variable                 | Group                  | Baseline          | Endline           | p.value <sup>a</sup> | Mean difference<br>(baseline - follow-up) | DiD<br>(Improved %) |
|--------------------------|------------------------|-------------------|-------------------|----------------------|-------------------------------------------|---------------------|
|                          |                        | Mean $\pm$ SD     | Mean $\pm$ SD     |                      |                                           |                     |
| Perceived Severity       | Intervention (N = 150) | 56.43 $\pm$ 10.96 | 68.17 $\pm$ 6.26  | < 0.001*             | 11.74                                     | 10.70 (18.96)       |
|                          | Control (N = 150)      | 60.15 $\pm$ 9.46  | 61.19 $\pm$ 10.16 | 0.517                | 1.04                                      |                     |
|                          | p-value <sup>b</sup>   | 0.070             | < 0.001*          |                      |                                           |                     |
| Perceived Susceptibility | Intervention (N = 150) | 17.96 $\pm$ 4.79  | 22.93 $\pm$ 3.43  | < 0.001*             | 4.97                                      | 3.74 (20.82)        |
|                          | Control (N = 150)      | 19.11 $\pm$ 4.97  | 20.33 $\pm$ 4.99  | 0.133                | 1.23                                      |                     |
|                          | p-value <sup>b</sup>   | 0.100             | < 0.001*          |                      |                                           |                     |
| Perceived Barrier        | Intervention (N = 150) | 21.43 $\pm$ 4.56  | 26.03 $\pm$ 3.67  | < 0.001*             | 4.60                                      | 3.57 (16.66)        |
|                          | Control (N = 150)      | 23.16 $\pm$ 5.82  | 24.19 $\pm$ 5.99  | 0.289                | 1.03                                      |                     |
|                          | p-value <sup>b</sup>   | 0.440             | < 0.001*          |                      |                                           |                     |
| Perceived Benefit        | Intervention (N = 150) | 36.39 $\pm$ 5.16  | 40.57 $\pm$ 3.63  | < 0.001*             | 4.18                                      | 3.10 (8.51)         |
|                          | Control (N = 150)      | 36.69 $\pm$ 4.33  | 38.49 $\pm$ 4.52  | 0.014                | 1.08                                      |                     |
|                          | p-value <sup>b</sup>   | 0.678             | < 0.001*          |                      |                                           |                     |
| Cue to Action            | Intervention (N = 150) | 19.74 $\pm$ 3.31  | 22.99 $\pm$ 2.16  | < 0.001*             | 3.25                                      | 1.30 (6.59)         |
|                          | Control (N = 150)      | 21.36 $\pm$ 6.81  | 23.31 $\pm$ 7.16  | 0.090                | 1.95                                      |                     |
|                          | p-value <sup>b</sup>   | 0.567             | < 0.001*          |                      |                                           |                     |
| Self-Efficacy            | Intervention (N = 150) | 50.31 $\pm$ 7.11  | 57.94 $\pm$ 5.23  | < 0.001*             | 7.64                                      | 6.77 (13.46)        |
|                          | Control (N = 150)      | 50.57 $\pm$ 5.89  | 51.44 $\pm$ 6.30  | 0.386                | 0.87                                      |                     |
|                          | p-value <sup>b</sup>   | 0.456             | < 0.001*          |                      |                                           |                     |

N-Frequency; SD-Standard Deviation; M-Mean; Improved (%) = (Difference-in-difference ÷ Baseline intervention mean) × 100.

a= Paired t-test, b= Independent t-test

\*Signifies Statistical Significant difference

## ANCOVA: Adjusted Effects of Intervention on Dietary Diversity and Nutrition Knowledge

To account for potential confounders, Analysis of Covariance (ANCOVA) was conducted for the endline Dietary Diversity Score (DDS) and Nutrition Knowledge Score (Table 6a and Table 6b, respectively).

For the DDS (Table 6a), the overall ANCOVA model was statistically significant ( $F(9, 96) = 5.30, p < 0.001; R^2 = 0.332; \text{Adjusted } R^2 = 0.269$ ). After controlling for baseline DDS and sociodemographic covariates (position in household, parents' education levels, household income, household size, number of siblings, and living arrangements), the intervention group effect remained statistically significant ( $F = 5.08, p = 0.026; \text{partial } \eta^2 = 0.050$ ), indicating that group assignment independently predicted a meaningful difference in endline dietary diversity. Baseline DDS was also a significant covariate ( $F = 33.25, p < 0.001; \text{partial } \eta^2 = 0.257$ ), confirming its strong predictive role in post-intervention dietary diversity. None of the sociodemographic covariates reached statistical significance.

For the Nutrition Knowledge Score (Table 6b), the ANCOVA model was similarly significant ( $F(7, 96) = 6.85, p < 0.001; R^2 = 0.333; \text{Adjusted } R^2 = 0.284$ ). After controlling for baseline nutrition knowledge scores and sociodemographic variables (age, gender, parents' education levels, and living arrangements), the intervention group effect remained significant ( $F = 8.98, p = 0.003; \text{partial } \eta^2 = 0.086$ ), demonstrating a robust independent effect of the intervention on nutrition knowledge. Baseline nutrition knowledge score was again the strongest covariate ( $F = 28.45, p < 0.001; \text{partial } \eta^2 = 0.229$ ). None of the other covariates reached statistical significance. Collectively, these ANCOVA findings confirm that the intervention independently improved both dietary diversity and nutrition knowledge, even after adjusting for baseline scores and relevant sociodemographic characteristics.

Table 6  
a. Adjusted Effects of Intervention on Dietary Diversity

| Source                                                                                                        | df | F     | p-value  | Partial $\eta^2$ |
|---------------------------------------------------------------------------------------------------------------|----|-------|----------|------------------|
| Intervention Group                                                                                            | 1  | 5.08  | 0.026*   | 0.050            |
| DDS Baseline (covariate)                                                                                      | 1  | 33.25 | < 0.001* | 0.257            |
| Position in household                                                                                         | 1  | 0.48  | 0.488    | 0.005            |
| Father's level of education                                                                                   | 1  | 0.22  | 0.644    | 0.002            |
| Mother's level of education                                                                                   | 1  | 0.40  | 0.529    | 0.004            |
| Household monthly income                                                                                      | 1  | 0.91  | 0.343    | 0.009            |
| People living in household                                                                                    | 1  | 3.72  | 0.057    | 0.037            |
| Number of siblings                                                                                            | 1  | 0.72  | 0.398    | 0.007            |
| Who participant lives with                                                                                    | 1  | 0.28  | 0.600    | 0.003            |
| <b>Model statistics:</b> F (9, 96) = 5.30, p < 0.001; R <sup>2</sup> = 0.332; Adjusted R <sup>2</sup> = 0.269 |    |       |          |                  |

*Dependent variable: Dietary Diversity Score (DDS) at endline.*

*Statistically significant at p < 0.05.*

Table 6  
b. Adjusted Effects of Intervention on Nutrition Knowledge

| Source                                                                                                        | df | F     | p-value  | Partial $\eta^2$ |
|---------------------------------------------------------------------------------------------------------------|----|-------|----------|------------------|
| Intervention Group                                                                                            | 1  | 8.98  | 0.003*   | 0.086            |
| Baseline Nutrition Knowledge Score (covariate)                                                                | 1  | 28.45 | < 0.001* | 0.229            |
| Age                                                                                                           | 1  | 2.80  | 0.097    | 0.028            |
| Gender                                                                                                        | 1  | 0.70  | 0.405    | 0.007            |
| Father's level of education                                                                                   | 1  | 0.25  | 0.621    | 0.003            |
| Mother's level of education                                                                                   | 1  | 0.05  | 0.818    | 0.001            |
| Who participant lives with                                                                                    | 1  | 0.47  | 0.495    | 0.005            |
| <b>Model statistics:</b> F (7, 96) = 6.85, p < 0.001; R <sup>2</sup> = 0.333; Adjusted R <sup>2</sup> = 0.284 |    |       |          |                  |

*Dependent variable: Nutrition Knowledge Score (NKS) at endline.*

*Statistically significant at p < 0.05.*

## Discussion

This study used a quasi-experimental design to showcase how nutrition education delivered in a collaborative learning environment improved diet quality indicators and nutrition outcomes, including perceived dietary

behaviour and nutrition knowledge, which are motivated by HBM constructs. Previous research has shown that a collaborative nutrition education intervention is important and useful for improving good dietary behaviour toward healthy eating, in addition to improving knowledge [17, 27]. Based on its constructs, which include perceived disease severity, perceived risk, expected benefits, perceived barrier, and readiness to act, HBM has been empirically demonstrated as a theoretical framework by several research studies as a valuable and useful behavioural model for designing nutrition education interventions that target individuals to adopt healthier dietary behaviours [17, 36, Baba et al., 2024]. Previous studies carried out by Keshani et al. [17], Naghashpour et al. [38], and Hazavehei et al. [39] reveal that HBM-based nutrition education intervention programs have shown significant improvement towards dietary behaviour among adolescents and children, while comparing with the didactic teaching methods adopted in a traditional mode of teaching.

In the present study, the intervention group shows significant improvement in several health-protective food groups, also known as NCD protective food groups. These include other vegetables, other fruit, vitamin A-rich foods, pulses, and whole grains, while the control group showed negligible change across these food groups. The significant improvement observed in the intervention group may be a result of the collaborative mode of teaching and delivery of nutrition education, which was among several other factors, while the negligible change seen in the control group may also be due to the traditional nutrition education carried out. The process by which adolescents make decisions is mostly affected by emotional development and peer influences, which in turn make intervention programs designed for this group of people, such as didactic education, less effective [40, 18] compared with a collaborative learning approach [17].

These study findings revealed that nutrition education intervention delivered using a collaborative and cooperative teaching approach has the potential to improve the consumption of fruits and vegetables among adolescents. Participatory nutrition education intervention improved the consumption of fruits and vegetables among school-going adolescents [41]. The consumption of fruits, vegetables and whole grains is vital in lowering the risk associated with nutrition-related noncommunicable diseases such as cardiovascular diseases, hypertension, type 2 diabetes, and several types of cancer [42]. The present study findings consolidate the potential and advantages of school-based nutrition education delivered in a collaborative context for improving the overall diet quality among adolescents. The findings of Salwa et al. [43] reported similar results to the present study, highlighting the role of a multiple-component intervention program in promoting the consumption of fruits and vegetables, which may potentially translate to increased consumption of a more diverse diet.

The intervention group showed a reduction in the consumption of unprocessed meat, baked or grain-based sweets, other sweets and packaged ultra-processed salty snacks. These are consistent with findings reported by Poll et al. [44] that the intervention group demonstrated a decrease in the consumption of sugary snacks, sweets, and processed foods after the initiation of collaborative-driven nutrition education, which aimed at reducing the consumption of sweets, sugary snacks and processed food. In contrast, the control group only reflected a negligible reduction in the consumption of NCD-risk food groups. There is an unexpected increase in the consumption of processed meat and deep-fried food that is identified as a risk factor for several noncommunicable diseases. These findings call for more targeted and structured interventions towards education and enlightenment of adolescents on the health risks associated with the consumption of processed meat and deep-fried foods.

Several factors may contribute to and explain these findings. Adolescents in the study may involuntarily have a substitutional or compensatory effect, which may have caused the participants to replace reduced sweets and

snacks with processed and fried foods, perceiving them as comforting and not as healthier alternatives. It has been noticed from previous studies that participants in an intervention program do manifest a selective message uptake due to the way they perceived the intervention messages, which might influence the uneven level of behavioural change [45].

There is also a considerable increase in the minimum dietary diversity for women among the intervention group, indicating better nutritional adequacy compared to the slight change observed in the control group. Previous studies have shown through empirical evidence that a participatory, cooperative, and collaborative approach has helped in targeted nutrition education programs geared towards adolescent girls in Nigeria and has often led to significant improvement in their minimum dietary diversity (MDD-W) [28, 46, 47]. This has also helped in addressing the high prevalence of anaemia and poor, starch-based diets prevalent in Nigeria [46].

This study intervention group reflect significant improvement in three of the four diet quality indicators. The intervention group showed significant mean score improvements from baseline to endline in DDS (33.74%), the GDR score (39.86%), and the NCD-protect score demonstrated the largest improvement, yielding 153.22%. In contrast, the NCD-risk score did not change significantly in either group ( $p = 0.967$ ), indicating that the intervention did not significantly reduce NCD-risk food consumption scores. The study revealed there were no significant within-group or between-group changes observed in the control group across all four indicators. NCD-risk score did not improve in the intervention and control group ( $p = 0.967$ ), which implies that the structured intervention was not effective in reducing the consumption of food groups that pose a health risk to the prevalence of nutrition-related noncommunicable diseases.

Previous studies have highlighted the importance and workability of school-based nutrition education interventions in the improvement of dietary diversity among in-school adolescents [48, 49]. Also, theory-driven and collaborative structured nutrition education is effective in improving consumption of a diverse diet and protective food intake [48, 49]. The study also highlighted the ongoing difficulties adolescents face in cutting back on unhealthy foods (processed, fast, sweet, and baked foods), all of which have been connected to an increased risk of the majority of noncommunicable diseases related to nutrition [50, 28]. When implementing larger health programs and interventions, incorporating nutrition education and delivering in a collaborative context has been reported to significantly improve diet diversity among school-going adolescents [51].

More so, a well-diverse diet has been linked to the prevention of the occurrence of nutrition-related noncommunicable diseases if cultural preferences and food availability can be addressed through adequate and tailored nutrition education in a more collaborative and participatory context [27, 52]. This study's findings emphasise the fact that nutrition education delivered in a participatory and collaborative context has the potential to improve the nutritional knowledge and, in part, contribute to broader dietary habits and the selection of healthy food groups, which might in turn lead to consumption of more diverse diets.

Nutrition knowledge among the intervention group demonstrated a significant increase, while the control group showed no increase despite the didactic teaching approach used among the participants. This implies that the intervention approach that uses the collaborative teaching techniques was efficient and effective in improving the nutrition knowledge of the participants when compared with the participants in the control group. These findings are consistent with studies that reported that educational programs that incorporate active learning techniques and approaches are effective in improving the knowledge of in-school adolescents in Nigeria and

Nepal [27, 53, 54]. Incorporating collaborative learning techniques into nutrition education intervention is effective in increasing nutritional knowledge among in-school adolescents [27, 53].

There is improvement in the perceived severity and perceived susceptibility, which implies that there was an increased level of perception and awareness about health risks associated with poor dietary choices and unhealthy eating habits. In the same vein, the perceived benefits improve substantially while perceived barriers decline, which indicates a more positive perception of a healthier dietary pattern towards healthy eating.

These findings are consistent with a previous study that reported significant improvements in perceived susceptibility but comparatively smaller changes in perceived severity and benefits [55]. Strengthening these constructs is essential for fostering urgency and motivating behaviour change, consistent with prior studies applying the Health Belief Model (HBM) in collaborative learning contexts [17, 56]. Behavioural constructs, including cues to action and self-efficacy, also improved notably, reflecting the intervention's effectiveness in creating actionable triggers for healthier dietary behaviours and building adolescents' confidence in sustaining them [36, 57, 58].

The control group, on the other hand, displayed minimal changes in all constructs, with self-efficacy staying constant and perceived benefits marginally decreasing. This is in line with research showing that passive or didactic educational approaches only marginally improve outcomes related to HBM [17, 59]. A previous study by Naghashpour et al. [38] revealed improvement in all six HBM constructs after a well-structured cooperative and targeted intervention. The findings in this study point to the value and advantages of nutrition education intervention driven by behavioural theory and delivered in a collaborative learning context [38].

The intervention group revealed statistical significance and an independent effect result for dietary diversity after adjusting for baseline dietary diversity and sociodemographic and economic variables that are covariates. The study findings using ANCOVA highlighted that there are no significant covariate effects, which means that the improvement observed in dietary diversity cannot be associated with the confounding variable tested. Therefore, these findings support the internal validity and reliability of the intervention and findings. Controlling for the baseline dietary diversity, the findings revealed that baseline dietary diversity is the most reliable explanatory and predictor variable that best explains the intervention effect on dietary diversity. These findings are consistent with the empirical evidence reported by Keshani et al. [17] that baseline dietary diversity is among the most valid and reliable determinants or predictors of post-intervention dietary outcomes.

A similar pattern was observed for nutrition knowledge among the in-school adolescents in this study. The intervention group demonstrated greater statistical significance when compared with the dietary diversity effect outcome. After controlling for the baseline nutrition knowledge score and other confounding variables, which include age, gender, parental education, and living arrangement, the study findings revealed a large effect size for nutrition knowledge. This might be indicative of the collaborative techniques used during the nutrition education session, as this has been known to enhance learning and knowledge retention more than behavioural dietary change. Behavioural dietary change is influenced by broader complex factors and determinants in its individual, social, and environmental forms. The baseline nutrition knowledge stands out as the main covariate that predicts the outcome of the intervention among the adolescents in both groups. These findings highlighted empirical evidence that reinforces that the intervention independently improved nutrition knowledge and dietary diversity far more than the inherent differences that may exist within the sociodemographic and economic variables among the adolescents.

# Strengths and Limitations of the Study

This study has several notable strengths that support the validity and relevance of its findings. The use of a quasi-experimental pretest–posttest control group design, guided by TREND reporting standards, provides a structured and transparent basis for evaluating the intervention effect. Recruiting 300 adolescents across two schools, exceeding the minimum required sample size, strengthened the statistical precision and robustness of the findings. The integration of the Health Belief Model as a theoretical framework allowed for a systematic assessment of both cognitive and behavioural dimensions of dietary change, going beyond the knowledge outcomes that many comparable studies limit themselves to. The use of the Global Diet Quality Questionnaire, a standardised and internationally validated dietary assessment tool, ensured methodological consistency and comparability with other population-level studies. The application of Difference-in-Differences analysis and ANCOVA provided adjusted estimates of the intervention effect, accounting for pre-existing group differences and potential confounders. Additionally, the structured Nutrition Education Guide, developed and reviewed by academic and professional experts, ensured that content delivery was both scientifically grounded and culturally appropriate for the study population.

Some limitations of this study are worth noting. The use of only two schools, one per study arm, restricted the number of clusters available for analysis, which may limit the generalisability of the findings to other school contexts in Nigeria. Although individual-level analyses were conducted with baseline comparability confirmed, a larger number of clusters would have strengthened the cluster-level robustness of the design. The dietary assessment relied on a single-day recall through the DQQ, which may not fully capture the habitual dietary patterns of participants, given natural day-to-day variability in food consumption. The relatively short follow-up period of four weeks after the eight-week intervention does not allow conclusions to be drawn about the long-term sustainability of the observed improvements in diet quality and nutrition knowledge. Finally, social desirability bias is also a possibility, as self-reported dietary and behavioural data may not always reflect actual practices.

## Conclusion

This study provides clear empirical evidence that nutrition education delivered in a collaborative learning context and guided by the Health Belief Model produces meaningful improvements in diet quality, nutrition knowledge, and perceived dietary behaviour among in-school adolescents in Nigeria. Adolescents in the intervention group demonstrated significant gains in dietary diversity, NCD-protective food consumption, and overall alignment with global dietary recommendations, gains that were not observed in the control group receiving conventional didactic instruction.

The significant improvement across all six HBM constructs in the intervention group points to the value of anchoring nutrition education within a behavioural framework. When adolescents are actively engaged as participants rather than passive recipients of information, they are more likely to perceive healthy eating as personally relevant, feasible, and worth pursuing. The collaborative learning environment appeared to create the conditions for that shift to occur. The failure of the intervention to reduce NCD-risk food consumption in either group is a finding worth taking seriously. More targeted and sustained strategies will be needed to address this gap. Embedding collaborative and participatory nutrition education within standard school programming,

particularly in underserved communities, represents a practical and evidence-based step towards reducing the growing burden of diet-related noncommunicable diseases among Nigerian adolescents.

## **Declarations**

### **Acknowledgements**

All glory be to God Almighty.

### **Authors' contributions**

This study represents a collective effort, with all authors making meaningful contributions to its development. DD, OT, ED, OA, and GS were involved in developing both the nutrition education protocol and the adapted collaborative learning protocol. DD, AB, AE, and OE contributed to the study design and statistical analysis, while BT, OB, IO, OE, and DD took part in interpreting the results and drafting the manuscript. DD and OT provided overall leadership throughout the study, overseeing the development of the intervention protocol, the design of the collaborative learning approach, the creation of learning resources, and the recruitment of participants. All authors reviewed the manuscript, agreed with its contents, and approved the final version for submission.

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None

### **Data availability**

All data produced are available within the manuscript.

### **Ethical Approval**

Ethical clearance for this study was granted by the Health Research Ethics Committee of the Federal Medical Centre, Abeokuta (FMCA/470/HREC/17/2024/30). Throughout its conduct, the study adhered to internationally accepted ethical standards governing research involving human participants.

### **Consent to Participate**

Before data collection commenced, all eligible students and their parents or guardians were provided with full information about the study's objectives, procedures, potential benefits, and the rights of participants. Written informed consent was secured from parents or legal guardians, and written informed assent was obtained from each adolescent participant. Taking part in the study was entirely voluntary, and all participants were made aware of their right to withdraw at any point without facing any consequence. To protect confidentiality, participants were assigned anonymised identification codes, and access to study data was limited strictly to members of the research team.

### **Consent to publish**

Not applicable.

### **Competing interests**

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## Figures

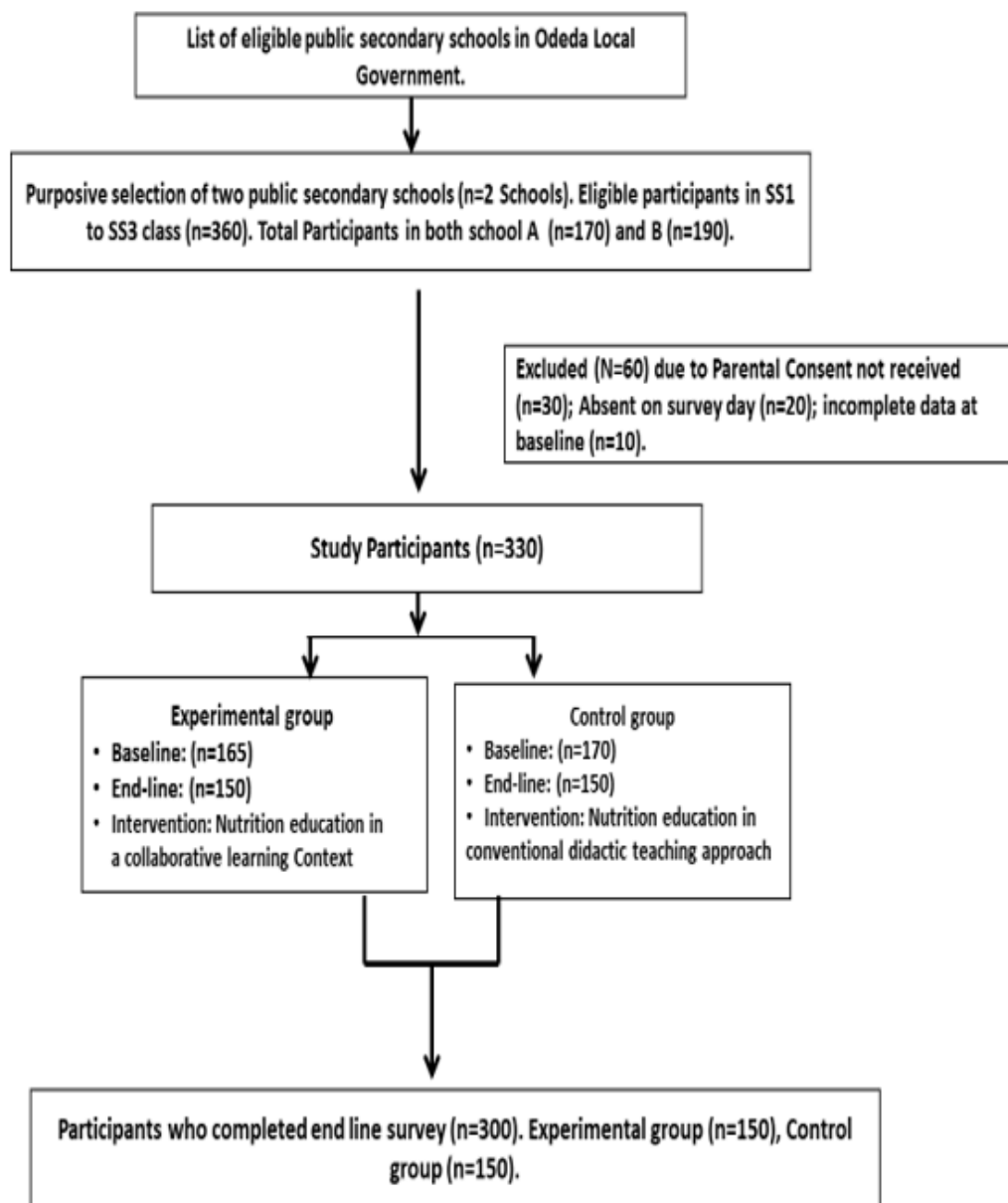


**Figure 1**

Flow diagram of the study

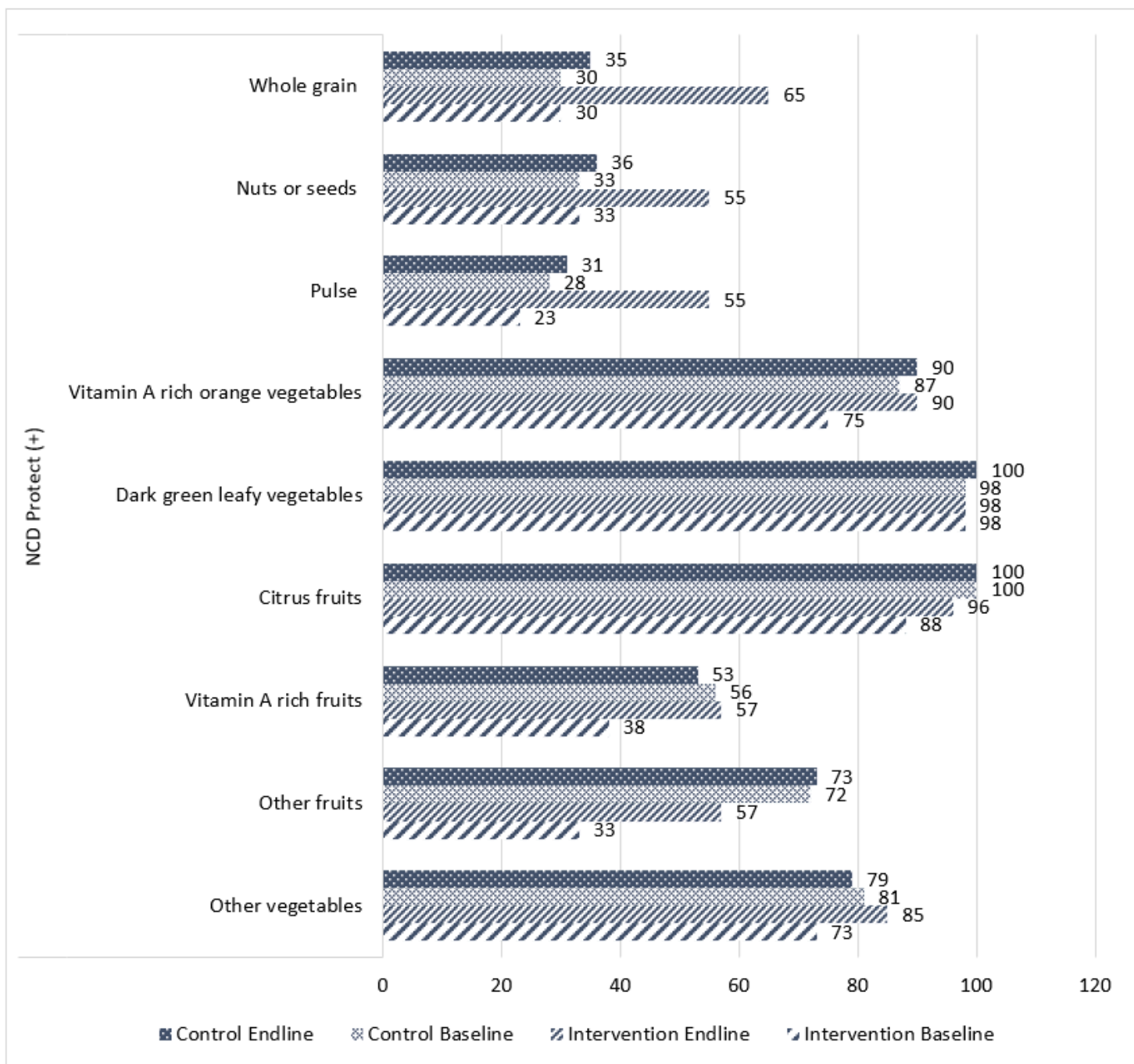


**Figure 2**

NCD Protect (+) - Consumption of these food groups

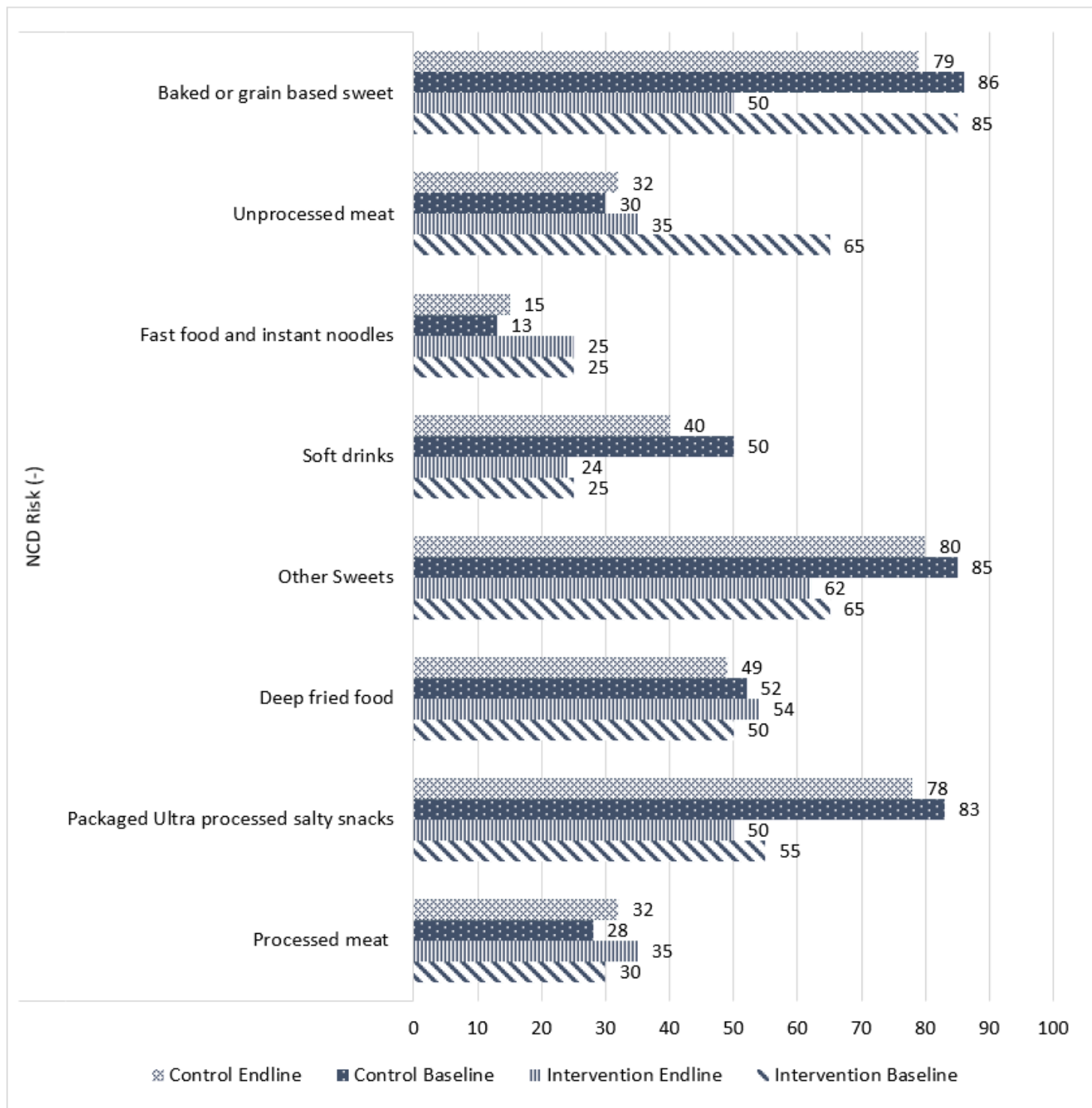


**Figure 3**

NCD Risk (-) - Consumption of these food groups

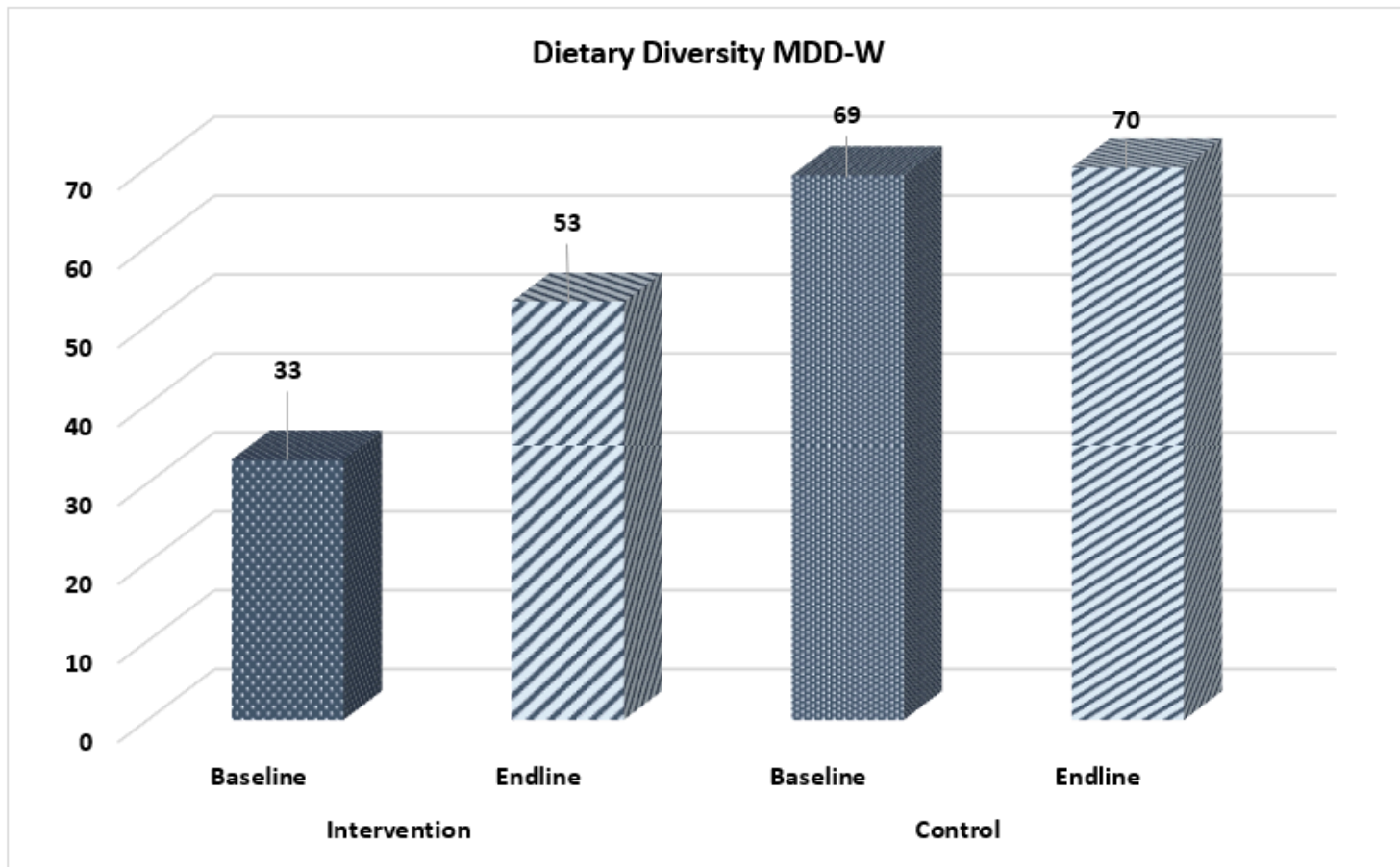


**Figure 4**

Minimum Dietary Diversity for Women

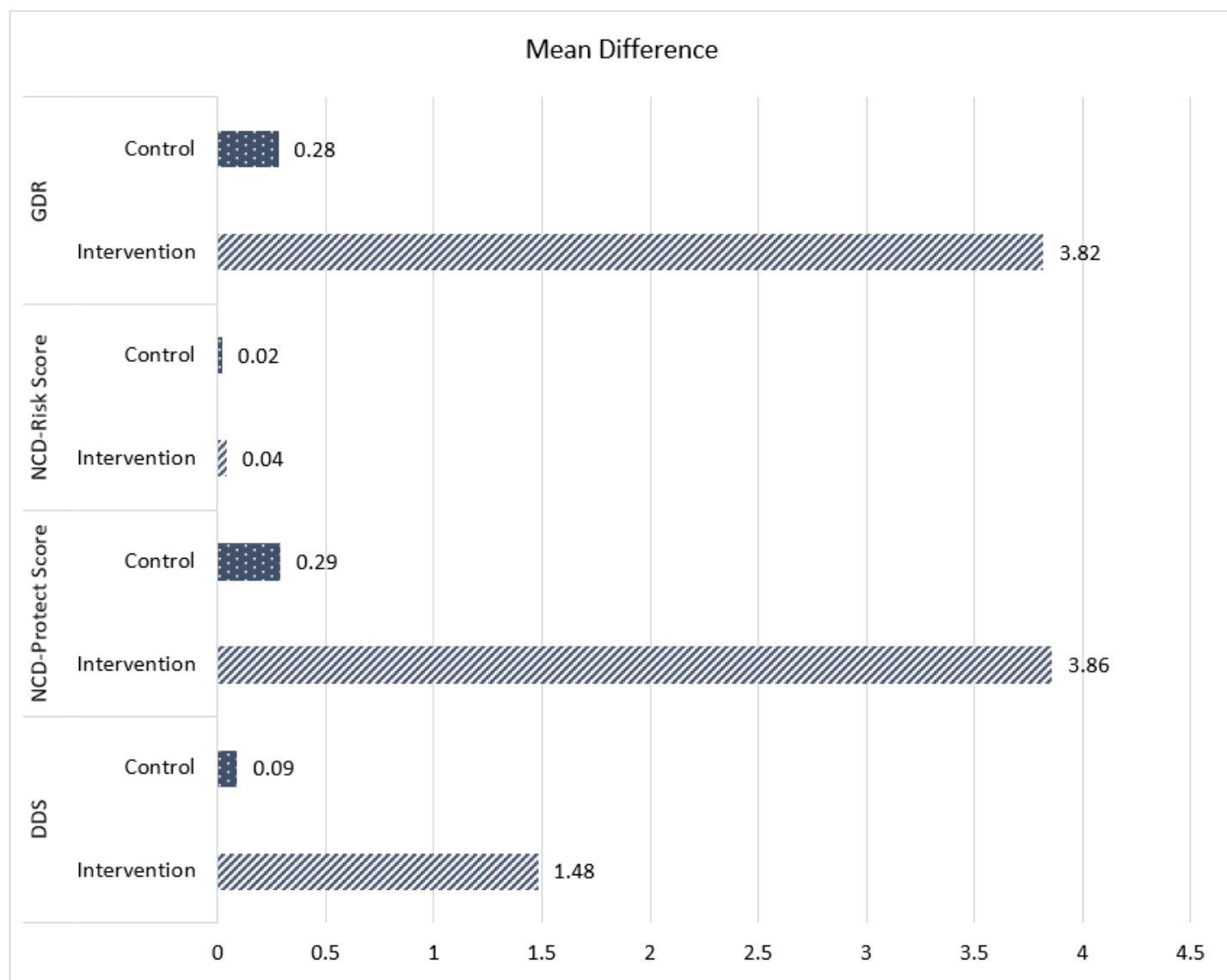


**Figure 5**

Change in Diet Quality Indicators

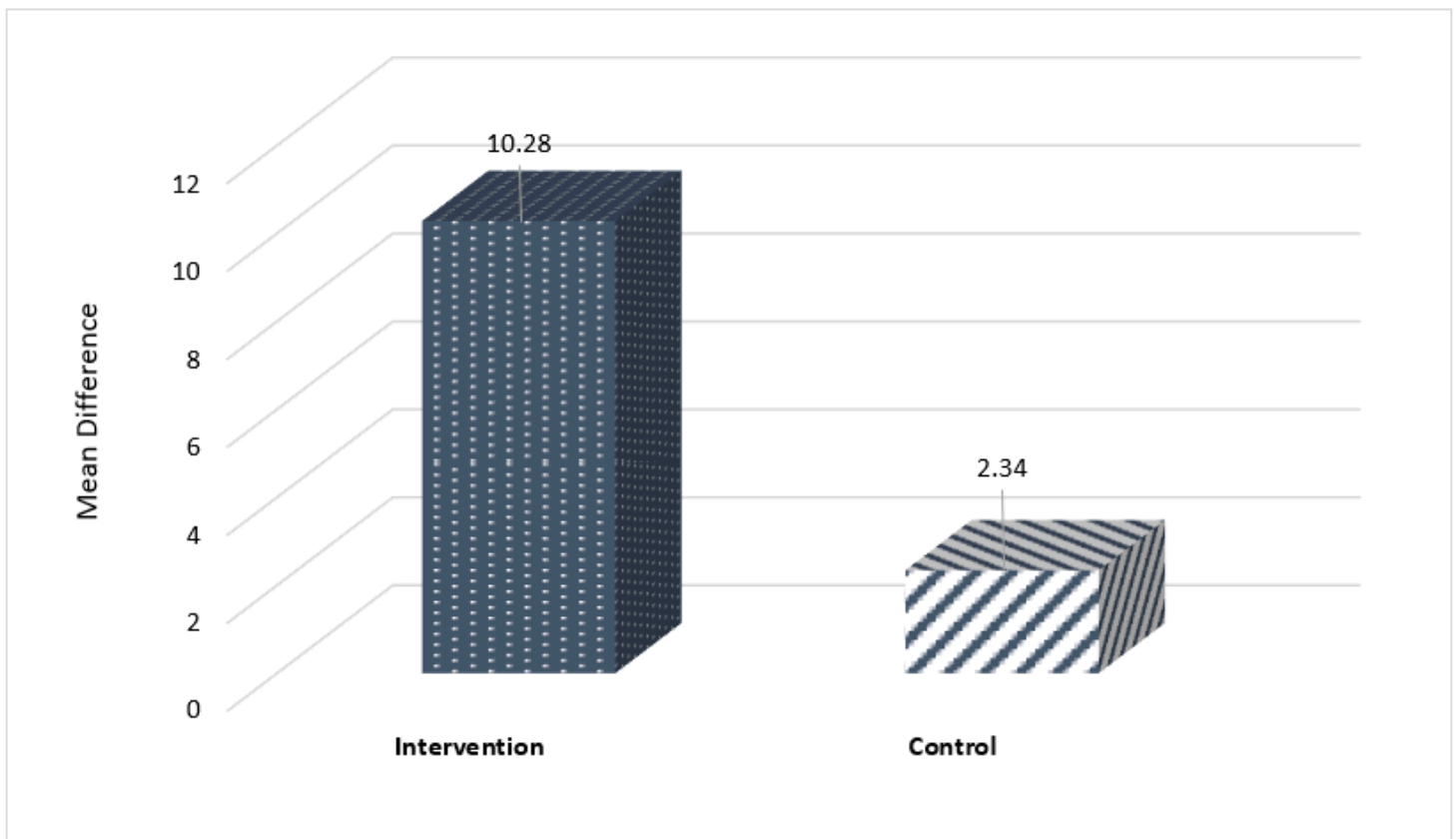


**Figure 6**

Change in Nutrition Knowledge

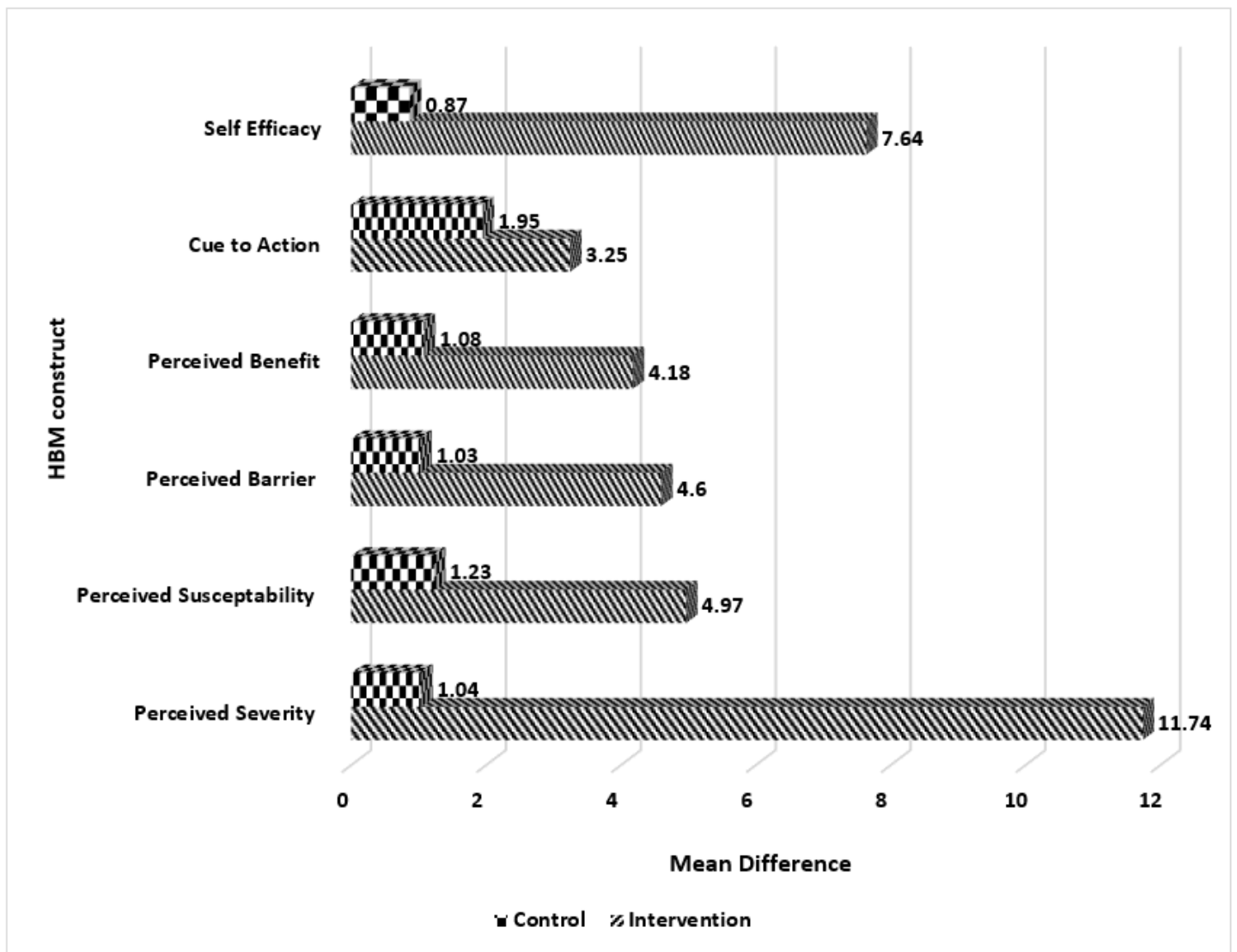


**Figure 7**  
Change in perceived dietary behaviour towards healthy eating