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Effects of nutrition education, physical activity and motivational interviewing interventions on metabolic syndrome among females of reproductive age in Wakiso district, central Uganda: a randomised parallel-group trial

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Abstract

Background The prevalence of metabolic syndrome (MetS) has increased significantly in sub-Saharan African countries, including Uganda. Females are disproportionately affected by MetS compared to males. This study evaluated the effects of 12 weeks of community-based nutrition education (NE), physical activity (PA), and motivational interviewing (MI) interventions on MetS and its components among females of reproductive age in central Uganda.

Methods We conducted a randomised parallel-group trial involving 120 females aged 15–49 years with MetS in Wakiso district, central Uganda. Participants were recruited between April and May 2023 and were randomly assigned to either the intervention ($n=60$) or the control ($n=60$) group. The 12-week intervention included NE, PA, and MI. The outcomes included changes in MetS and its components. Data were collected at baseline and endline using a modified STEPS questionnaire to assess sociodemographic factors, blood pressure (BP), waist circumference (WC), fasting blood glucose (FBG), triglycerides, HDL cholesterol (HDLC), and other variables. A generalised linear model was used to evaluate the impact of time and study groups on metabolic outcomes. Analyses were conducted using intention-to-treat in Stata (SE/14.0), at a p-value of < 0.05.

Results The group x time interaction showed significant positive effects on MetS and its components at the endline. The intervention group had significantly lower odds of MetS compared to the control group [OR = 0.588, 95% CI (0.501, 0.690), p-value < 0.0001)]. The intervention showed reduced mean diastolic BP (coeff=-4.556, 95% CI (-9.035, -0.077), p-value = 0.046), reduced mean FBG (coeff=-1.012, 95% CI (-1.553, -0.470), $p < 0.001$), and increased mean HDLC (coeff = 0.139, 95% CI (0.015, 0.262), p-value = 0.028). Additionally, the intervention group had significantly higher odds of daily fruit and vegetable intake compared to the control group (OR = 6.31, 95% CI: 1.18–

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33.64,$p = 0.031$), increased moderate-intensity recreational activity (Coeff = + 155.65 min/week, 95% CI:19.11-292.22, $p = 0.025$) and reduced sedentary time by 43.94 min per day (Coeff= -43.94, 95% CI: -87.75 to– 0.13, $p = 0.049$).

Conclusions The community-based interventions significantly improved MetS outcomes among females of reproductive age in Uganda. Scaling up this package of interventions should be explored.

Trial registration ISRCTN, ISRCTN17445597. Registered 06 June 2024 - Retrospectively registered, https://www.isrctn.com/ISRCTN17445597.

Keywords Metabolic syndrome, Nutrition education, Physical activity, Motivational interviewing, Intervention, Females of reproductive age

Introduction

Background

Despite the proven effectiveness of community-based preventive measures in high-income countries [1, 2], metabolic syndrome (MetS) continues to significantly contribute to the morbidity and mortality associated with cardiovascular disease (CVD) and diabetes [3], particularly in low-income settings, such as Uganda, where interventions are limited. Globally, the prevalence of MetS ranges from 12.5 to 31.4% [4]. In Africa, the prevalence is higher, estimated at 32.4% (95% CI: 30.2–34.7) [5], with females being more susceptible than males [5]. Although limited studies exist, a recent study showed a significant prevalence of MetS (17.8%) among women of reproductive age in Uganda [6].

Metabolic syndrome (MetS) development in females has been correlated with hormonal changes (such as the decline in oestrogen and adiponectin levels linked with menopause) [7]. MetS can be influenced by modifiable risk factors such as an unhealthy diet, obesity, a sedentary lifestyle or a lack of physical activity. Physical inactivity and obesity are more common in females than males [8, 9]. MetS is associated with a 5-fold greater risk of type 2 diabetes mellitus (T2DM), a 2-fold greater risk of CVD, a 2–4-fold greater risk of stroke, and a 2-fold greater risk of mortality [10]. The adverse consequences of diabetes and CVD impact the socioeconomic status and well-being of individuals, families, communities, and nations.

Community-based interventions in high-income countries incorporating nutrition education, physical activity, and motivational interviewing have reduced MetS in various population groups [11–13]. Effective strategies to deliver nutrition education and counselling have included weekly group nutrition education sessions and individual or group counselling sessions over varied periods to effect the adoption of lifestyle changes. Furthermore, short-term nutritional counselling and education interventions have effectively reduced MetS components and improved health outcomes globally [14–16].

Studies conducted in Brazil, Korea, Iran, Western Australia, and Italy [13–17] have shown that community-based interventions can reduce body fat, cholesterol, and triglyceride levels while addressing other risk factors. Additionally, these interventions can promote healthier dietary habits and increased physical activity. Behavioural changes have been documented with as few as two motivational interviewing sessions, a technique that can be effectively administered by trained undergraduate students, counsellors, dieticians, and nurses [17].

Despite the success of community-based interventions in other settings, significant information and evidence gaps remain regarding their effectiveness in addressing MetS in low-income settings. Specifically, studies on the effects of integrated approaches incorporating nutrition knowledge, physical activity, and motivational interviewing on behavioural change and health outcomes are lacking. Furthermore, studies on MetS among females of reproductive age group are limited. This impedes the development of evidence-based interventions to prevent adverse pregnancy outcomes related to MetS such as gestational diabetes, pre-eclampsia and adverse birth outcomes, as well as the inter-generational transmission of MetS from mother to child through genetic [18, 19], epigenetic [20] and environmental/behavioural [21] factors. Therefore, this study evaluated the effects of community-based nutrition education, physical activity, and motivational interviewing interventions on metabolic syndrome and its components in females of reproductive age in Wakiso district, central Uganda.

Methods

Study area

The study was conducted in Wakiso district, central Uganda. See Fig. 1. Out of the total population of 1,636,000 females, who represent 52.7% of the overall population, approximately 793,770 are women of reproductive age (15–49 years) [22]. The district is surrounded by Kampala, the capital city, which is experiencing rapid urbanisation [22]. Coupled with socioeconomic development, risk factors for NCDs, such as obesity and hypertension, are prevalent [23].

Trial design

We conducted an individually randomised group treatment trial in Wakiso district between April and May 2023. Using a block randomisation sequence, an

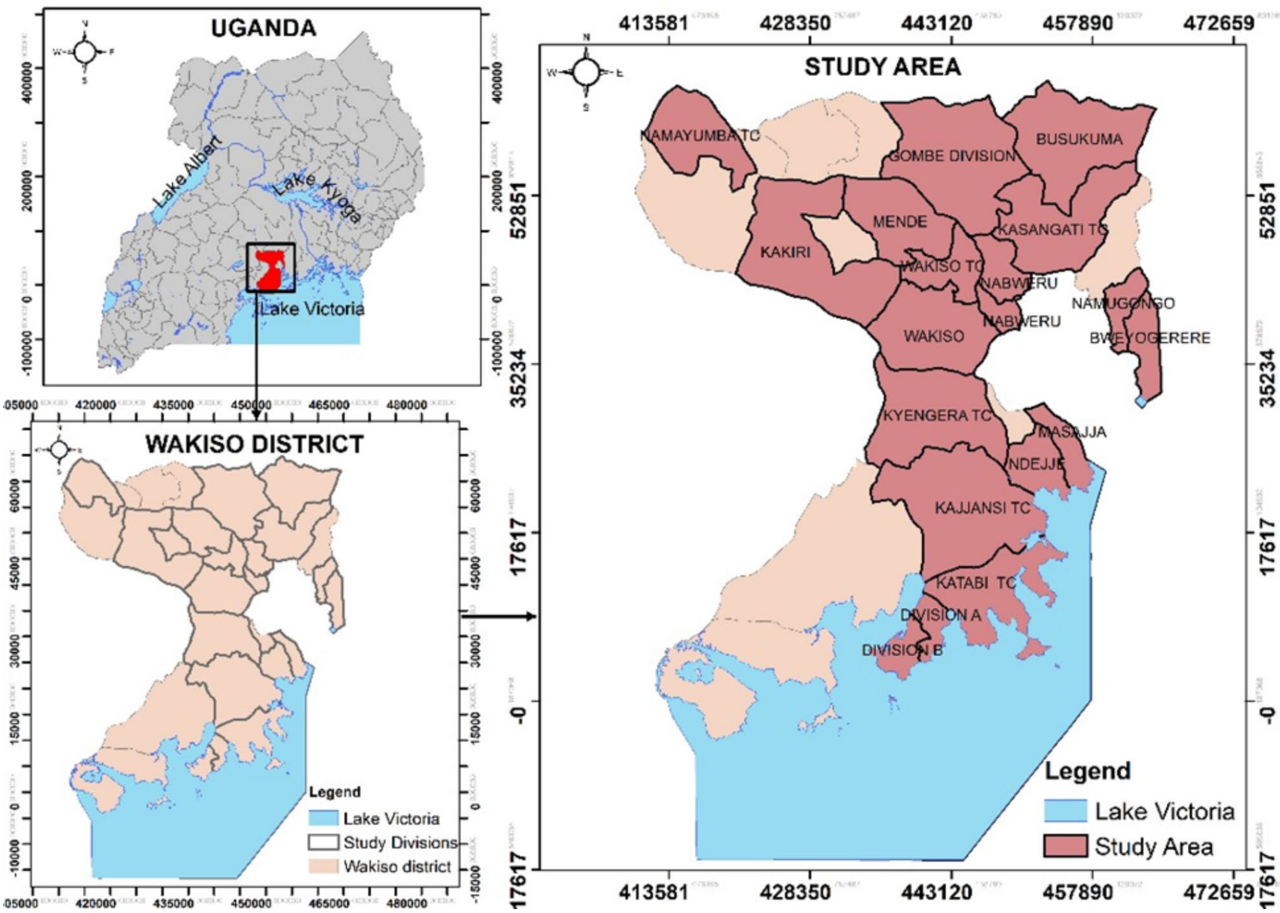

Fig. 1 Map of Wakiso district showing the study area

independent statistician allocated the participants to either the intervention or control arm in a 1:1 ratio. The study was conducted per the Consolidated Standards of Reporting Trials (CONSORT) Statement (see Fig. 2 for the CONSORT flow diagram and Additional file 1 for the CONSORT checklist). The trial was registered with the International Standard Randomised Controlled Trial Number Registry (ISRCTN17445597).

Study participants

The study participants were females aged 15–49 years with MetS in Wakiso district. They were recruited from the database of our baseline study, which determined the prevalence and factors associated with MetS in Wakiso district [6].

The eligibility criteria for participants included being a female aged 15–49 years residing in Wakiso district, with metabolic syndrome as defined by the 2009 Joint Interim Statement (JIS) [10]. Additional requirements were at least one year of community residency, written informed consent and a three-month follow-up commitment. Exclusion criteria included females who reported no history of pregnancy or lactation, as well as those with no history of chronic diseases such as liver, kidney, or heart diseases or any conditions that the intervention could exacerbate. Those on a prescribed diet or likely to undergo surgical procedures during the intervention were also excluded.

Description of the intervention arm

The intervention was conducted in Wakiso district at five community locations, including community centres, health facilities, and places of worship. These were selected due to their safety and convenience. Sixty (60) participants in the intervention group were divided into five groups of 12. Each group met weekly at one designated location and received the intervention package from a dedicated public health nutritionist, physical activity trainer, and motivational interviewer, who also provided direct supervision throughout the sessions.

The intervention consisted of group nutrition education, physical activity, and motivational interviewing sessions delivered by a multidisciplinary team (public health nutritionists, sports scientists, clinical psychologists, public health specialists, and an assistant medical clinical officer). The nutrition education sessions were facilitated

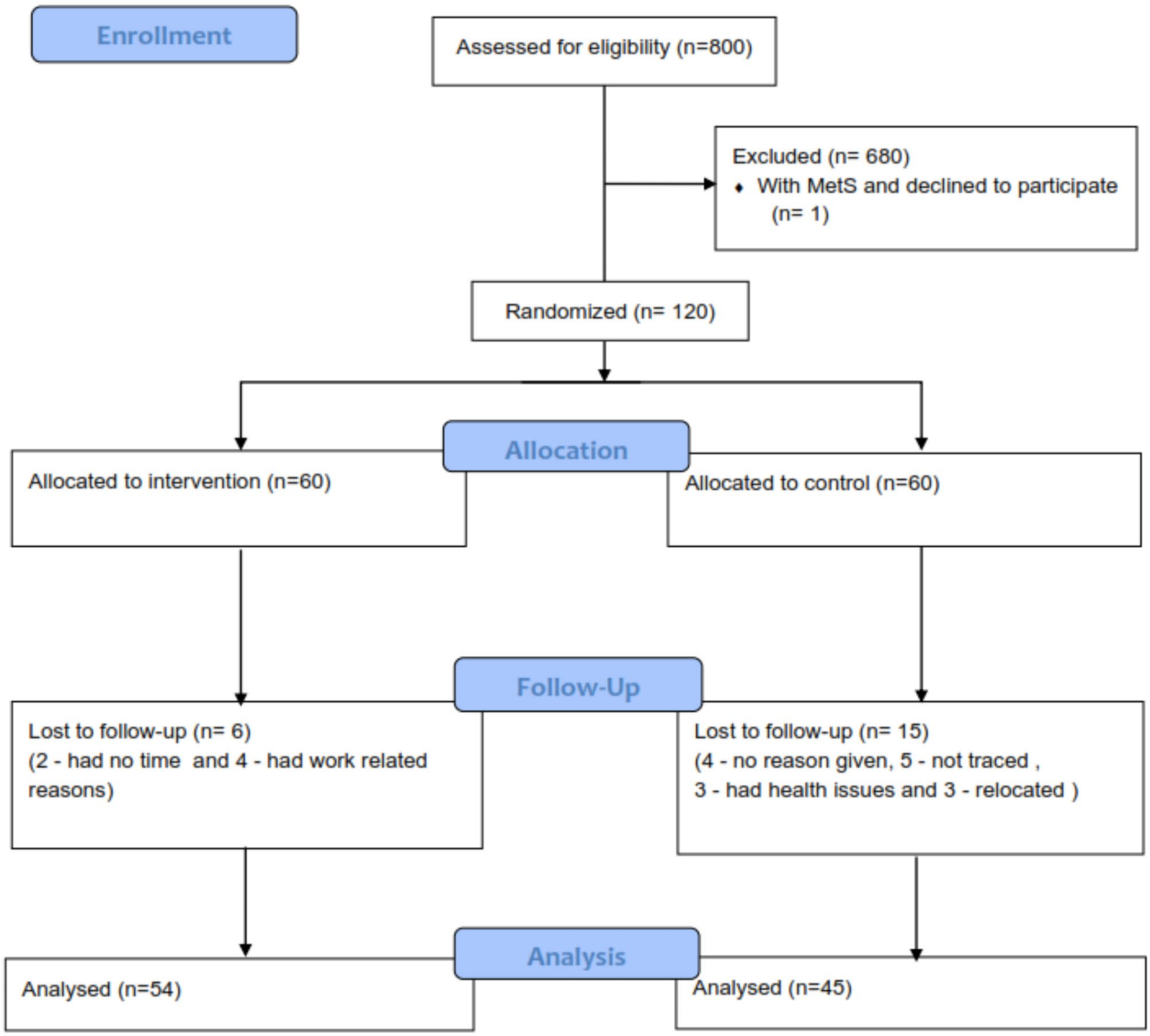

Fig. 2 Flow diagram of study participants throughout the study. MetS = metabolic syndrome

by five public health nutritionists, each with a master's degree in public health nutrition. Physical activity sessions were conducted by five trainers with bachelor's degrees in sports science, and the motivational interviewing sessions were led by five clinical psychologists who were master's degree finalists in clinical psychology and with skills in motivational interviewing.

The public health nutritionists, physical activity trainers and clinical psychologists facilitated group sessions using a combination of written and oral instructions, such as lectures and posters. Nutritionists provided nutrition education, trainers conducted physical activity education supplemented with practical, structured physical activity exercises, and the clinical psychologists conducted motivational interviewing sessions.

The intervention consisted of weekly one-hour nutrition education sessions offered over 12 weeks, followed by one hour of physical activity sessions with supervised, structured, practical exercises consisting of moderate-intensity aerobic activities such as brisk walking and jumping rope. Additionally, group motivational interviewing sessions, each lasting one hour, were conducted monthly over three months. Studies with similar methodologies informed the 12-week intervention duration [24].

The study employed self-determination theory (SDT) and motivational interviewing to encourage self-directed change [25]. The SDT theory focuses on how intrinsic motivation and meeting basic psychological needs (competence, autonomy, and relatedness) lead to long-term behaviour change [25, 26]. Physical activity was promoted as enjoyable, beneficial for well-being, and a skill worth learning. Autonomy was supported by respecting participants' choices and encouraging ownership of health decisions (such as improving diet and exercising). Competence was built through skills development (nutrition education and physical activity training), addressing barriers, and building confidence. Relatedness was developed through a good interpersonal environment, group-based interventions, and a sense of belonging to motivate participants to adopt healthier behaviours. Therefore, SDT was the theory underlying our study, while MI was the set of techniques we employed in the study to strengthen intrinsic motivation for behaviour change [26]. Motivational interviewing was used at the start to build rapport and assess readiness for change, address ambivalence by aligning behaviour change with personal goals, setting personal goals for change, reviewing progress, and maintaining motivation and commitment throughout the study.

Intervention package

The group nutrition education package, based on a study-specific curriculum (see additional file 3), covered topics such as the definition of MetS, healthy diet in management, nutritious food choices, and daily meal distribution. It also addressed eating habits, portion sizes, weight loss strategies, and diet compliance. Participants were guided on selecting healthy foods, preparing food, and planning meals. Emphasis was placed on increasing fruits, vegetables, fish, and water intake while reducing sugar, fat, sodium, and fried foods (see additional file 3).

The group physical activity sessions covered various topics, including the types and importance of physical activity, integrating physical activity into daily life, and the World Health Organisation (WHO) recommendations [27]. The sessions provided participants with information on basic physical activity routines, activity levels, strategies for enhancing physical activity, exercise safety, injury prevention and associated risks. Further topics included strategies for overcoming obstacles to exercise, sustaining motivation, the role of nutrition in physical activity, and using exercise logs for progress tracking (see additional file 3).

The participants were advised to follow a weekly physical activity regimen, consisting of "at least 150 minutes of moderate-intensity, or 75 minutes of vigorous-intensity aerobic activity (climbing stairs, running, sports), or a combination of both", distributed throughout the week as per WHO guidelines [27]. The participants were encouraged to engage in muscle-strengthening activities (lifting heavy items, going to the gym, and practising yoga) of at least moderate intensity for a minimum of two days a week. They were advised to reduce sedentary time by replacing it with physical activity of any intensity [27]. Leaflets containing key messages were provided to participants for reference (see additional file 4).

The three monthly group motivation interviewing (MI) sessions covered a range of topics, such as goal setting, factors influencing lifestyle and behavioural change, relapse management, coping strategies and support and eating habits in different settings. Discussions were held on relevant topics using MI techniques to explore participants' current behaviours, identify challenges preventing them from engaging in recommended activities, and develop personalised plans to overcome these obstacles.

Control arm

In the control group, participants were given an information leaflet about healthy lifestyle principles to prevent MetS. Those with complications were referred to the nearest healthcare facilities to manage their conditions, following the established protocols of routine healthcare facilities.

Adherence/Fidelity

Several measures were taken to reduce nonadherence in the intervention group, including monitoring session attendance, clearly scheduled appointments, providing paper reminders, and disseminating information regarding the study and meeting schedules. Additionally, the importance of adherence was reinforced during follow-up sessions. If participants skipped a session, they were contacted via phone and encouraged to attend the next session.

Quality control measures

Data collection

In this study, five trained laboratory technicians and one laboratory technologist were recruited to draw blood and conduct laboratory analyses. Five experienced data collectors (female nurses and graduate nutritionists) were trained on the study protocol for three days. The research assistants used the Open Data Kit (ODK) to collect data and transmit it to the servers at both the baseline and end points of the study. The data collection tools were field tested in a district near the study district.

In addition to the 72 hours of training previously received in the study, the study team members underwent an extra 18 hours of training on delivering the curriculum designed for the study.

Outcomes

Primary outcomes

The change in MetS prevalence between the intervention and control groups was assessed to determine whether the intervention had an effect 12 weeks from the start of the study (April to June 2023). MetS was defined according to the 2009 Joint Interim Statement (JIS) as the presence of ≥3 of the following five factors: "increased WC (women: ≥ 80 cm), low HDL-C (women: <50 mg/dl (1.3 mmol/l) or treatment of low HDL-C), hypertriglyceridaemia ≥ 150 mg/dl (1.7 mmol/l) or treatment, elevated BP (systolic BP ≥ 130 mmHg and/or diastolic ≥ 85 mmHg or treatment for hypertension) and elevated fasting blood glucose (FPG ≥ 100 mg/dl (5.6 mmol/l) or diabetes mellitus or treatment" [10].

Secondary outcomes

The secondary endpoints were the within-group and between-group variations in the intervention and control groups for each of the following measured variables: dietary habits and behaviours (intake of fruits and vegetables, number of food groups consumed); anthropometric factors (BMI, WC and weight); cardiometabolic factors (HDL cholesterol, blood glucose, triglycerides, blood pressure); and lifestyle factors (cigarette smoking, alcohol intake, physical activity).

Sample size estimation

We used G.Power 3.1.9.4 software to calculate the sample size using the z-test family and statistical tests for the difference between two independent proportions [28]. We used a significance level of 5% and a power of 80% to detect a 0.2 difference in MetS prevalence between groups (intervention and control) after a 3-month intervention. We opted for a 0.20 difference, as it aligns with previous studies [29–31], which showed comparable or greater reductions. A 5% prevalence of individuals without exposure who experienced the outcome and an allocation ratio 1:1 was considered. A total sample size of 98 was obtained, with 49 in the intervention group and 49 in the control group. After accounting for the intraclass correlation coefficient (ICC), design effect and 10% nonresponse rate, the sample size in each arm was adjusted to 60 participants.

Sampling procedure

We started by identifying all participants with MetS from our baseline survey [6]. We then contacted all 121 participants with MetS via telephone and, with the assistance of local council leaders, asked about their interest in participating in the trial and their availability. A total of 120 individuals agreed to participate in the trial and were screened against the eligibility criteria. After meeting these criteria, participants were invited to provide written consent before randomisation. See Fig. 2. The principal investigator and the study team, working with the village chairpersons, identified the participants' current physical addresses within Wakiso district.

Randomisation

Working with an independent statistician, a balanced allocation randomisation sequence list was generated using a computer-based random number generator. The list contained blocks of size 8 with an allocation ratio of 1:1. Block randomisation ensured a balanced allocation between the intervention and control groups [32]. The allocation sequence was used to assign 120 participants to either the intervention (60 participants) or the control (60 participants) arms. To ensure the concealment of allocation, 120 sealed opaque envelopes were prepared by an independent statistician containing the assigned allocation for a single participant, arranged in sequential order based on the randomised allocation list. The envelopes were numbered by the independent statistician from 1 to 120 and were distributed to the study team for participant enrolment. The study statistician was blinded to the allocation, although the intervention effect became apparent after the analysis. The participants were enrolled consecutively following the numbered opaque envelopes.

Data collection procedures

Baseline data were collected from household participants in the intervention and control groups before the intervention. The questionnaire, which covered sociodemographic factors, dietary intake, smoking, alcohol use, medication, physical activity, anthropometry, BP, FBS, and lipid profile tests, was adopted from the WHO Stepwise Approach to NCD Surveillance (STEPS) tool [33]. Endline data, similar to the baseline, were collected and analysed for comparison between the two groups.

For biochemical measurements, participants were instructed to fast before the measurements. A 5-millilitre blood sample was collected in the morning after a 12-hour overnight fast and analysed using the COBAS 6000 Analyser Series (Roche Diagnostics, manufactured by Hitachi High -Technologies Corporation, Tokyo, Japan; serial number 1098-22) at the Mulago National Referral Hospital's Clinical Chemistry Laboratory to assess fasting blood glucose, total cholesterol, high-density lipoprotein (HDL)-cholesterol and triglycerides.

Anthropometric measurements: Body weight was measured to the nearest 0.01 kg using portable SECA electronic weight scales (model 874; SECA, Germany), while height was measured to the nearest 0.5 cm using calibrated UNICEF height boards. The participants had to stand barefoot on a level surface during the height measurement. The body mass index (BMI) was subsequently calculated using these two measurements. Waist circumference was measured to the nearest 0.1 cm with non-stretchable standard tape, placed in a horizontal plane just above the uppermost lateral border of the right ilium following a normal expiration. Female nursing and medical students conducted the WC measurements. Blood pressure was measured using a calibrated OMRON M3 automated BP monitor (Omron Healthcare, Kyoto, Japan) following standard protocols [34].

Data management and analysis

The quantitative data collected in the field were electronically captured using a questionnaire designed with Open Data Kit (ODK) software. This data was downloaded from the server and exported to Stata version 14 for cleaning and analysis. We conducted an intention-to-treat (ITT) analysis [35], including all participants with baseline assessments, to evaluate the sensitivity of the results. Continuous variables were summarised as means (standard deviations) if normally distributed or medians (interquartile ranges) if non-normally distributed, based on the Shapiro-Wilk test. Categorical characteristics were presented as percentages (frequencies).

The success of the randomisation was evaluated by comparing the baseline characteristics between the intervention and control groups, including probability values from chi-square tests for categorical variables and Student's t-tests for continuous variables with normal distributions. The Wilcoxon Rank-Sum (Mann-Whitney U) test was applied for non-normally distributed continuous variables (Table 1).

The chi-square test was used to analyse for differences in proportions in the categorical outcomes: metabolic risk factors (raised WC, raised BP, raised Triglycerides, raised FBS, and reduced HDL cholesterol) (Table 2); lifestyle behaviours - dietary habits (fruits and vegetable intake, food groups consumed) and other lifestyle behaviours (alcohol intake and cigarette smoking) (Table 3) between the intervention group and the control group at both baseline and endline.

The independent samples Student's t-test with pooled variance (Two-sample t-test with equal variances) was used to compare means in the continuous variables of metabolic risk factors and their variations (Table 4), lifestyle behaviours: physical activity, dietary habits (fruits and vegetable intake, food groups consumed) and lifestyle behaviours (alcohol intake and cigarette smoking) (Tables 3 and 5). This analysis aimed to identify any potential differences between the intervention group and the control group at both the baseline and endline.

A mixed effects generalised linear model (GLM) was used to identify the contribution of changes in time/round (baseline, end-line) and group/study arm (control, intervention) to changes in metabolic parameters (BP, WC, HDL cholesterol, FBS and triglycerides) independent of age. The model allowed for data analysis with repeated measures (baseline and end-line) for each individual, assessment of intervention effects and addressed the correlation of observations within individuals (due to repeated measures) and the clustering of individuals within the groups. Analyses were conducted using Stata statistical software (SE/14.0, StataCorp, College Station, TX, USA), with a p-value of 0.05 set to determine statistical significance.

Results

Flow diagram of study participants throughout the study

A total of 800 females of reproductive age (15–49 years) were screened for eligibility in the Wakiso district. Out of these, 120 women with metabolic syndrome were enrolled and randomly allocated equally into the intervention ($n = 60$, 50%) and control ($n = 60$, 50%) groups. By the endline, 6 participants from the intervention group and 15 from the control group were lost to follow-up (Fig. 2).

Baseline characteristics of the study participants

Table 1 shows the characteristics of the study participants at baseline. The mean ages for the intervention and control groups were 35.9 years (SD ± 6.95) and 33.5 years (SD ± 8.67), respectively with a p-value of 0.089. The median waist circumferences (cm) were 97.5 (interquartile range (IQR), 91.5–102.0) in the intervention group and 96.5 (IQR, 89.1-105.6) in the control group ($p = 0.877$). The majority of participants in both groups [intervention group (96.7%) and control group (98.3%)] reported prior school attendance ($p = 0.559$), with no significant differences observed in the highest educational level attained ($p = 0.458$). The intervention group had a slightly higher proportion of paid and employed individuals (63.3% vs. 56.7%) and a higher proportion meeting the recommended physical activity levels (55% vs. 41.7%), but these differences were not statistically significant ($p = 0.456$ and $p = 0.144$, respectively). Alcohol use in the past 30 days was similar between groups (21.7% vs. 20.0%), with no significant differences ($p = 0.822$). Overall, there were no significant differences in baseline characteristics between the two groups (all $p > 0.05$).

Prevalence of MetS and MetS risk factors at baseline and three months postintervention

Table 2 shows a statistically significant decrease in the prevalence of metabolic syndrome ($p < 0.0001$) and various MetS risk factors in the intervention group: elevated waist circumference ($p = 0.006$), elevated BP ($p < 0.0001$), elevated fasting blood glucose ($p = 0.038$), and reduced HDL cholesterol ($p < 0.0001$) between the baseline and the endline.

The control group showed no significant improvements in MetS risk factors, with elevated waist circumference ($p = 0.162$), elevated blood pressure ($p = 0.600$), elevated triglycerides ($p = 0.909$), and elevated fasting blood glucose ($p = 0.257$), although reduced HDL cholesterol

Table 1 Characteristics of the intervention and control participants at baseline ($N = 120$)

Variables		Intervention arm $n = 60$	Control arm $n = 60$	*P*. value
Age (Mean ± SD)	Years	35.9 (6.95)	33.5 (8.67)	0.089[a]
Weight (Mean ± SD)	Kgs	76.3 (12.3)	75.2 (11.2)	0.608[a]
Body mass index (Mean ± SD)	kg/m^2	30.4 (4.4)	30.0 (4.2)	0.629[a]
Waist circumference (Median (IQR[c])	Cm	97.5 (91.5, 102)	96.5 (89.1, 105.6)	0.877[b]
Religion, no. (%)				
	Anglican	15 (25.0)	16 (26.6)	0.654
	Catholic	20 (33.3)	24 (40.0)	
	Moslem	15 (25.0)	10 (16.7)	
	Pentecostal	9 (15.0)	10 (16.7)	
	Seventh-day Adventist	1 (1.6)	0 (0.0)	
Tribe, no. (%)				
	Baganda	40 (66.7)	37 (61.6)	0.374
	Banyankore	6 (10.0)	9 (15.0)	
	Basoga	4 (6.7)	4 (6.7)	
	Banyoro/Batoro	0 (0.0)	3 (5.0)	
	Others	10 (16.6)	7 (11.7)	
Marital status, no. (%)				
	Married/cohabiting	44 (73.33)	50 (83.30)	0.187
	Single/separated/widowed	16 (26.70)	10 (16.70)	
Employment status, no. (%)				
	Paid and employed	38 (63.3)	34 (56.7)	0.456
	Unpaid and unemployed	22 (36.7)	26 (43.3)	
Ever attended school, no. (%)				
	No	2 (3.33)	1 (1.7)	0.559
	Yes	58 (96.7)	59 (98.3)	
Highest level of education, no. (%)				
	Less than primary school	13 (21.7)	17 (28.3)	0.458
	Completed primary school	24 (40)	21 (35.0)	
	O level completed	17 (28.3)	12 (20.0)	
	A level and above completed	6 (10.0)	10 (16.7)	
Food groups consumed, no. (%)				
	≥ 5 food groups	26 (48.3)	32 (53.3)	0.273
	< 5 food groups	34 (56.7)	28 (46.7)	
Eat 5 servings of fruits and vegetables per day, no. (%)				
	≥ 5 servings	10 (34.5)	10 (50)	0.277
	< 5 servings	19 (65.5)	10 (50)	
Alcohol consumption (past 30 days), no. (%)				
	Yes	13 (21.7)	12 (20.0)	0.822
	No	47 (78.3)	48 (80.0)	
Smoking status, no. (%)				
	Current smoker	02 (3.3)	02 (3.3)	0.915
	Nonsmoker	58 (96.7)	58 (96.7)	
Physical activity(min/wk)[d], no. (%)				
	Yes	33 (55.0)	25 (41.7)	0.144
	No	27 (45.0)	35 (58.3)	

[a]Independent Samples t-test between intervention and control group to compare baseline characteristics

[b]Wilcoxon Rank-Sum (Mann-Whitney U) test was used to compare the waist circumference distribution between intervention and control groups at baseline (z= -0.155, $p = 0.877$)

P.value- χ2 tests between intervention and control group for all baseline characteristics expect p-values [a] and [b]

[c]IQR (interquartile range)

[d] Physical activity was categorised based on frequency and duration. Participants who attained at least 150 min of moderate-intensity or 75 min of vigorous-intensity aerobic physical activity per week were classified as “Yes”. In contrast, those who did not meet these criteria were classified as “NO”

Table 2 Prevalence of MetS and MetS risk factors at baseline and 3 months postintervention

Variable	Intervention *n* (%)			Control *n* (%)				
	Baseline *n* = 60	Endline *n* = 54	*P*. value[1]	Baseline *n* = 60	Endline *n* = 45	*P*. value[2]	*P*. value[3]	*P*. value[4]
MetS present	60 (100.0%)	18 (33.3%)	$p < 0.0001$[e]	60 (100.0%)	39 (86.7%)	0.005[e]	#	$p < 0.0001$
Elevated WC	59 (98.3%)	45 (83.3%)	0.006[e]	59 (98.3%)	41 (91.1%)	0.162[e]	$P > 0.999$	0.254
Elevated BP	42 (70.0%)	16 (29.6%)	$p < 0.0001$	39 (65.0%)	27 (60.0%)	0.600	0.559	0.002
Elevated Triglycerides	27 (45%)	15 (27.8%)	0.057	34 (56.7%)	26 (57.8%)	0.909	0.201	0.003
Elevated Fasting Blood glucose	11 (18.3%)	3 (5.6%)	0.038[e]	14 (23.3)	15 (33.3%)	0.257	0.500	$p < 0.0001$
Reduced HDL Cholesterol	49 (81.7%)	27 (50.0%)	$p < 0.0001$	52 (86.7%)	27 (60.0%)	0.002	0.453	0.320

p value[1]- between baseline and end-line for the intervention group

p value[2]- between baseline and end-line for the control group

P.value[3]- χ2 tests between intervention and control groups at baseline

P.value[4]- χ2 tests between intervention and control groups at endline

[e]-Fishers Exact test

#- p.value[3] not calculated. There is no variation in the data (all observations are in the same category of metabolic syndrome)

Table 3 Lifestyle behavioural changes between and within groups 3 months post-intervention

Variable	Intervention *n* (%)			Control *n* (%)				
	Baseline data (*n* = 60)	Endline data (*n* = 54)	*P*.value[1]	Baseline data (*n* = 54)	Endline data (*n* = 46)	*P*.value[2]	*P*.value[3]	*P*. value[4]
Dietary habits								
Fruits and vegetables (At least 5 servings consumed per day)	10 (34.5)	31 (81.6)	< 0.0001	10 (50.0)	12 (57.1)	0.647	0.277	0.043
Food groups (5 groups or more consumed per day)	26 (43.3)	41 (75.9)	< 0.0001	32 (53.3)	30 (66.7)	0.169	0.273	0.308
Other lifestyle behaviours								
Alcohol intake (Past 30 days)	12 (20.0)	8 (14.8)	0.467	13 (21.7)	7 (15.6)	0.430	0.822	0.918
Cigarette smoking status (current smoker)	2 (03.3)	1 (1.8)	0.622[e]	2 (03.3)	0 (0.0)	0.216[e]	0.999	0.359

P. value[1]- between baseline and end-line for the intervention group

P. value[2]- between baseline and end-line for the control group

P. value[3]- χ2 tests between intervention and control groups at baseline

P. value[4]- χ2 tests between intervention and control groups at endline

[e]*-Fishers Exact test*

significantly improved ($p = 0.002$) between the baseline and the endline.

At baseline, there were no statistically significant differences in metabolic syndrome risk factors between the intervention and control group, as indicated by the p-value ranging from 0.201 to $P > 0.999$.

At the end-line, statistically significant differences were observed between the intervention and control groups with reductions in the prevalence of metabolic syndrome ($p < 0.0001$), elevated blood pressure ($p = 0.002$), elevated triglycerides ($p = 0.003$), and elevated fasting blood glucose ($p < 0.0001$). However, there were no significant differences between groups with elevated waist circumference ($p = 0.254$) and reduced HDL Cholesterol ($p = 0.320$).

Mean group changes in metabolic syndrome outcomes three months postintervention

Table 4 shows the mean group changes in metabolic syndrome outcomes within and between the intervention and control groups three months post-intervention. The intervention group had significant improvements in mean diastolic blood pressure ($p = 0.013$), HDL cholesterol ($p = 0.002$), fasting blood glucose levels ($p = 0.0009$), and BMI ($p = 0.040$) between the baseline and the endline. However, the changes in waist circumference ($p = 0.125$), systolic blood pressure ($p = 0.166$), triglycerides ($p = 0.243$), and body weight ($p = 0.127$) were statistically insignificant. The control group showed no statistically significant changes in any of these parameters with p-values ranging from 0.084 to 0. 976.

At baseline, there were no statistically significant differences between the intervention and control group, as indicated by the p-value ranging from 0.488 to 0.993. At the end-line, statistically significant differences were observed between the intervention and control groups in diastolic blood pressure ($p = 0.021$), HDL Cholesterol ($p = 0.030$), and fasting blood sugar ($p < 0.001$). However, there were no significant differences between groups in systolic blood pressure ($p = 0.085$), triglycerides ($p = 0.265$), waist circumference ($p = 0.437$), body weight ($p = 0.321$), or body mass index ($p = 0.156$).

Table 4 Mean group changes in metabolic syndrome outcomes and differences between groups 3 months postintervention

Variable	Intervention (Mean) (SD)			Control (Mean) (SD)				
	Baseline data ($N=60$)	Endline ($n=54$)	p-value[1]	Baseline ($n=60$)	Endline ($n=45$)	p-value[2]	p-value[3]	p-value[4]
Cardiovascular outcomes								
Blood pressure _Systolic	129.70 (15.50)	126.3 (9.34)	0.166	128.53 (17.77)	130.38 (13.77)	0.569	0.807	0.085
Blood pressure _Diastolic	85.02 (11.33)	80.20 (8.59)	0.013	85.05 (11.88)	84.78 (10.75)	0.904	0.993	0.021
Biochemical outcomes								
HDL Cholesterol	1.13 (0.27)	1.30 (0.32)	0.002	1.12 (0.29)	1.17 (0.24)	0.348	0.922	0.030
Triglycerides	1.66 (0.92)	1.47 (0.74)	0.243	1.77 (0.81)	1.66 (0.91)	0.511	0.488	0.265
Fasting blood glucose	4.86 (0.84)	4.02 (1.71)	0.0009	4.84 (0.87)	5.04 (0.72)	0.084	0.888	$p<0.001$
Anthropometric measures								
Waist circumference(cm)	97.72 (10.87)	94.08 (14.22)	0.125[f]	97.24 (10.81)	96.26 (13.35)	0.678[f]	0.807[g]	0.437[g]
Body weight(kg)	76.28 (12.26)	73.01 (10.25)	0.127	75.18 (11.23)	75.31 (12.77)	0.953	0.608	0.321
Body mass index (kg/m^2)	30.42 (4.37)	28.86 (3.54)	0.040	30.04 (4.18)	30.02 (4.50)	0.976	0.629	0.156

p value[1]- Dependent t-test between baseline and end-line (intervention group)

p value[2]- Dependent t-test between baseline and end-line (control group)

P.value[3]- Independent samples t-test between intervention and control groups (baseline)

P.value[4]- Independent samples t-test between intervention and control groups (endline)

[f]Wilcoxon Signed-Rank test between baseline and end-line

[g]Wilcoxon Rank-Sum (Mann-Whitney U) test between intervention and control groups

Table 5 Changes in lifestyle (physical activity) within and between groups 3 months post-intervention

Variable	Intervention (Mean) (SD) (minutes/week)			Control (Mean) (SD) (minutes/week)				
	Baseline data ($n=60$)	Endline data ($n=54$)	*P*.value[1]	Baseline data ($n=54$)	Endline data ($n=46$)	*P*.value[2]	*P*.value[3]	*P*. value[4]
Physical activity								
Moderate-intensity physical activity	563.57 (577.75)	726.16 (695.81)	0.245	642.94 (482.77)	668.33 (370.55)	0.862	0.619	0.741
Vigorous-intensity physical activity	468.68 (291.35)	576.91 (329.07)	0.238	418.00 (190.56)	489.23 (302.25)	0.507	0.611	0.408
Moderate-intensity recreational activity	173.00 (28.19)	432.67 (278.82)	0.045	180.00 (51.96)	276.87 (120.68)	0.223	0.808	0.129
Vigorous-intensity recreational activity	116.25 (67.50)	657.06 (868.60)	0.227	202.50 (31.82)	343.33 (198.96)	0.380	0.175	0.389
Transport-related PA	427.65 (490.13)	482.09 (347.81)	0.559	394.36 (364.09)	445.71 (261.03)	0.570	0.733	0.673
Sedentary time/day	189.00 (98.28)	154.35 (68.91)	0.033	178.50 (80.60)	184.60 (97.20)	0.728	0.523	0.074

PA– Physical activity

P. value[1]- Paired samples t-test between baseline and end-line for the intervention group

P. value[2]- Paired samples t-test between baseline and end-line for the control group

P. value[3]- Independent samples t-test between intervention and control groups at baseline

P. value[4]- Independent samples t-test between intervention and control groups at the endline

Changes in lifestyle behaviours within groups and differences between groups 3 months post-intervention

Table 3 shows significant improvements in the intervention group in fruit and vegetable intake ($p<0.0001$) and consumption of five or more food groups (<0.0001) between the baseline and the endline. The intervention group showed a significant increase in fruit and vegetable consumption compared to the control group at the endline ($p=0.043$). No significant changes were observed in alcohol intake or cigarette smoking status within or between groups at the endline ($P>0.05$).

Changes in lifestyle (physical activity) within groups and differences between groups 3 months post-intervention

Table 5 shows that the intervention significantly increased moderate-intensity recreational activity ($p=0.045$) and decreased sedentary time ($p=0.033$) from baseline to endline. No significant changes were observed in other physical activity domains, including moderate- and vigorous-intensity physical activity, vigorous-intensity recreational physical activity, and transport-related physical activity ($p > 0.05$).

In the control group, no significant changes were observed in any physical activity variables within the control group ($p > 0.05$), and between-group comparisons at the endline showed no significant differences across physical activity domains ($p > 0.05$).

Mixed effects generalised linear model (GLM) analyses for the intervention and control groups for metabolic syndrome outcomes

In Table 6, the group x time interaction showed that the intervention's effect depended on time, leading to significant improvements in several outcomes. The intervention, in comparison to the control, showed a significant reduction in mean diastolic blood pressure and fasting blood glucose as well as an increase in mean HDL cholesterol levels. There were significant reductions observed in both body weight and body mass index. The intervention's effects were realised through the changes that took place over the study period. The main effects of the group variable (intervention group) and time (endline) were not statistically significant for most outcomes. Thus, neither the intervention alone nor the time had a significant independent effect. The respective coefficients, 95% CI, and p-values can be found in Table 6.

Mixed effects generalised linear model (GLM) analyses of lifestyle behaviours

Table 7 shows that the group x time interaction revealed that, at the endline, participants in the intervention group had significantly greater odds of daily fruit and vegetable consumption compared to baseline odds in the control group (OR = 6.31, 95% CI: 1.18–33.64, $p = 0.031$).

The intervention group also showed a significant increase in weekly moderate-intensity recreational activity levels at the endline (155.65 min more than the control group at baseline). ($p = 0.025$, 95%CI: 19.11-292.22).

The intervention group showed significantly higher vigorous-intensity recreational activity. Participants in the intervention group reported 494.31 more minutes per week of vigorous-intensity recreational activity at baseline than the controls ($p = 0.003$, 95% CI: 173.16-815.46). At the endline, a significant reduction of 212.50 min per week was observed in the intervention group ($p < 0.001$, 95% 273.19-275.82). However, vigorous activity levels increased significantly by 274.51 min per week across all participants from baseline to endline ($p < 0.001$, 95% CI: 273.19-275.82).

The group x time interaction showed a significant reduction in sedentary time among intervention participants, with a decrease of 43.94 min per day at endline relative to the expected outcome based on the combined effects of round and group (Coeff= -43.94, 95% CI: -87.75 to– 0.13, $p = 0.049$). The findings as shown in Table 7 indicate the effectiveness of the intervention in improving dietary intake, increasing physical activity, and reducing sedentary time.

Table 6 Mixed effects generalised linear model (GLM) analyses of metabolic syndrome outcome

Variable	Group: Intervention			Time: Endline			Group (Intervention) x Time (End-line		
	Coefficient	(95% CI of coefficient)	*p*-value	Coefficient	(95% CI of coefficient)	*p*-value	Coefficient	(95% CI of coefficient)	*p*-value
MetS (Odds Ratio) *	0.992	(0.977,1.008)	0.350	0.862	(0.773, 0.963)	0.008	0.599	(0.506, 0.709)	$p < 0.0001$
Systolic BP	0.499	(-5.615, 6.614)	0.873	0.982	(-4.770, 6.735)	0.739	-4.578	(-11.580, 2.423)	0.200
Diastolic BP	0.001	(-4.200, 4.203)	0.999	-0.239	(-3.733, 3.253)	0.893	-4.556	(-9.035, -0.077)	0.046
HDL Cholesterol	-0.007	(-0.103, 0 0.089)	0.887	0.048	(-0.044, 0.141)	0.308	0.139	(0.015, 0.262)	0.028
Triglycerides	-0.115	(-0.433, 0.203)	0.479	-0.073	(-0.340, 0.193)	0.592	-0.100	(-0.442, 0.243)	0.568
Fasting blood glucose	0.031	(-0.341, 0.279)	0.846	0.170	(-0.093, 0.434)	0.205	-1.012	(-1.553, -0.470)	$p < 0.0001$
Waist circumference	0.703	(-2.969, 4.376)	0.707	-1.087	(-4.971, 2.796)	0.583	-2.910	(-8.151, 2.331)	0.276
Body weight	0.946	(-2.704, 4.597)	0.611	0.693	(-2.547, 3.932)	0.675	-5.418	(-9.211, -1.625)	0.005
Body mass index	0.398	(-1.000, 1.795)	0.577	0.127	(-1.057, 1.312)	0.833	-2.245	(-3.756, -0.733)	0.004

*Exponentiated coefficient [exp(b)]

Coefficients and 95%CI of Coefficients adjusted for age

Table 7 Mixed effects generalised linear model (GLM) analyses of lifestyle behaviours

Variable	Group: Intervention			Time: Endline			Group (Intervention) x Time (End-line		
Lifestyle behaviours	**Coefficient**	**(95% CI)**	***p*-value**	**Coefficient**	**(95% CI)**	***p*-value**	**Coefficient**	**(95% CI)**	***p*-value**
Dietary habits (OR) *									
Fruit and vegetable intake (≥ 5 servings consumed per day)	0.526	(0.163, 1.695)	0.282	1.333	(0.387, 4.592)	0.648	6.310	(1.18, 33.637)	0.031
Food groups (≥ 5 food groups consumed per day)	0.669	(0.325, 1.376)	0.275	1.75	(0.784, 3.905)	0.172	2.356	0.754, 7.3610	0.140
Alcohol intake (Past 30 days)	0.904	(0.373, 2.187)	0.823	0.666	(0.241, 1.839)	0.433	1.044	(0.254, 4.296)	0.952
Cigarette smoking status (current smoker)	1.000	(0.135, 7.383)	0.999	0.547	(0.478, 6.253)	0.628	1.000	**#**	**#**
Physical Activity (PA) (minutes per week) (Coeff.)									
Moderate intensity PA	-118.738	(-400.851, 163.373)	0.409	17.028	(-255.292, 289.348)	0.902	161.839	(-211.438, 535.117)	0.395
Vigorous intensity PA	58.824	(-107.658, 255.305)	0.489	61.110	(-145.689, 267.910)	0.562	20.117	(-241.524, 281.758)	0.880
Moderate-intensity recreational activity	-0.513	(-84.131, 83.106)	0.990	96.875	(4.277, 189.473)	0.040	155.662	(19.107, 292.217)	0.025
Vigorous-intensity recreational activity	494.311	(173.158, 815.464)	0.003	274.506	(273.193, 275.818)	$p < 0.001$	-212.505	(-296.428, -128.582)	$p < 0.001$
Transport-related PA	33.291	(-155.334, 221.916)	0.729	51.355	(-99.141, 201.852)	0.504	3.088	(-240.318, 246.493)	0.980
Sedentarybehaviour (minutes per day)	9.804	(-22.012, 41.620)	0.546	9.027	(-22.426, 40.480)	0.574	-43.939	(-87.751, -0.127)	0.049

OR*- Exponentiated coefficients [exp(b)] were computed for fruit and vegetable intake, food groups, alcohol intake and cigarette smoking

Coeff. - Coefficients were estimated for moderate-intensity, vigorous-intensity physical activity, and recreational activity

OR* (Odds Ratios*), Coeff's (Coefficients), and their 95% CI (Confidence Intervals) were adjusted for age

PA– Physical activity

#- No values returned

Discussion

This study assessed the effects of community-based nutrition education, physical activity, and motivational interviewing interventions on metabolic syndrome (MetS) among women of reproductive age in Wakiso district, central Uganda.

The findings from the group x time interaction in the Generalised Linear Model showed that the three month intervention had a positive impact on MetS and its components over time, with marked improvements noted throughout the study. It showed reduced prevalence of metabolic syndrome, mean diastolic blood pressure, fasting blood glucose levels and increased HDL cholesterol levels (Table 6). Additionally, the group x time interaction also showed increased fruit and vegetable intake, increased moderate recreational physical activity, and reduced sedentary time. The intervention significantly improved vigorous-intensity recreational activity levels (Table 7).

The intervention group showed a significant reduction in metabolic syndrome compared to the control group, with participants having 0.599 times the odds of developing metabolic syndrome by the end of the study. This finding indicates that the combined intervention effectively reduced metabolic syndrome over time, aligning with previous primary studies in Kenya [31, 36] and systematic reviews [37, 38].

In the intervention group, diastolic blood pressure significantly decreased over time compared to the control group, with an average reduction of 4.6 mmHg at the endline. This finding suggests that the combined intervention lowered diastolic blood pressure, consistent with previous studies showing the efficacy of physical activity and nutrition in reducing blood pressure [36, 39]. The mechanism through which exercise reduces blood pressure remains unclear. However, it is hypothesised to reduce peripheral vascular resistance and induce favourable changes in endothelial function, renin-angiotensin system activity, oxidative stress, the sympathetic nervous system, and insulin sensitivity [40–43]. Similarly, nutrition, particularly fruit intake, may affect blood pressure through nutrients such as fibre, potassium, magnesium, and folate, associated with favourable blood pressure effects, and phytochemicals and antioxidants that reduce oxidative stress [44].

In the intervention group, fasting blood glucose decreased by an average of 1.0 mmol/L from baseline to endline compared to the control group, likely due to increased physical activity and diet, particularly intake of fruit and vegetables (see Table 3). Studies demonstrate that interventions involving physical activity [45–47] and fruit and vegetable intake [48] reduce fasting blood glucose levels. Regular physical activity has been reported to increase glucose availability and consumption, improve insulin sensitivity [49, 50], increase glucose uptake [51], and enhance the regulation of hormones involved in glucose homeostasis [52]. Fruits and vegetables are postulated to reduce fasting blood glucose through protective elements such as antioxidants, potassium, vitamins, folate, fibre and phenolic compounds [48].

The intervention group showed a significant increase in HDL cholesterol over the study period compared to the control group, with a mean rise of 0.139 millimoles per litre (mmol/L) from baseline to endline. This increase was likely due to the combined effects of increased physical activity, reduced sedentary behaviour and fruit and vegetable intake. Studies have shown that regular aerobic exercise increases HDL cholesterol levels and reduces triglyceride levels and serum LDL cholesterol [53, 54]. Previous studies have shown a gender-related response to exercise, with women responding favourably to low- to moderate-intensity aerobic exercise, whereas men need vigorous-intensity exercise [54]. The mechanism by which exercise modulates HDL cholesterol possibly involves influencing HDL cholesterol maturation and composition [54]. Fruits and vegetables are rich in dietary fibre, antioxidants, and phytochemicals [55], contributing to improved lipid profiles. Furthermore, the PREDIMED studies [56] showed that consuming diets rich in fruits and vegetables improved lipid profiles, including HDL cholesterol and cardiovascular health.

The intervention significantly increased daily fruit and vegetable consumption, with intervention participants having 6.31 times higher odds of daily intake at endline compared to the control group at baseline (OR = 6.31, 95% CI: 1.18–33.64, $p = 0.031$). This increase is likely attributable to exposure to nutrition education and motivational interviewing. Participants received education on the benefits of consuming fruit and vegetable consumption, appropriate portion sizes, strategies for incorporating them into their daily diet and overcoming related barriers to consuming fruits and vegetables. This finding is consistent with previous studies that reported increased fruit and vegetable intake following nutrition education [57] and motivational interviewing [58]. Higher fruit and vegetable intake is linked to a reduced risk of type 2 diabetes [48], cardiovascular disease, and all-cause mortality [59].

The study found an increase in recreational physical activity, with intervention participants reporting an additional 155.65 min of moderate-intensity activity per week at the endline, compared to the control group at baseline ($p = 0.025$, 95% CI: 19.11-292.22). This surpassed the WHO's recommended weekly moderate physical activity of 150 min [27]. Several factors related to physical activity education and motivational interviewing intervention could have contributed to the increased physical activity. First, participants were encouraged to incorporate various recreational activities, including walking, jogging, or engaging in group sports, into their daily schedules as part of the intervention. Secondary physical activity education sessions emphasized the advantages of regular physical activity, including recreational activities. Additionally, motivational interviewing was used to address potential barriers to engaging in physical activity, such as limited motivation or time constraints. Thus, our study findings demonstrated the effectiveness of physical activity education and motivational interviewing intervention in improving physical activity. This aligns with similar studies conducted elsewhere [60, 61].

The intervention led to a reduction in sedentary behaviour. As indicated by the group x time interaction, participants in the intervention group experienced a decrease of 43.94 min per day in sedentary time at the endline, compared to the expected reduction based on the combined effects of group and time. The reduction in sedentary behaviour among participants in the intervention group is likely to be due to a combination of factors. The physical activity education sessions likely played a role in raising awareness of the risks associated with sedentary behaviour and highlighting the benefits of reducing sedentary time. Additionally, motivational interviewing facilitated goal setting by enabling participants to set specific, achievable objectives to reduce sedentary time, such as incorporating regular physical activity intervals into their daily routines. Furthermore, the structured support provided to engage in physical activity throughout the study period may have contributed to decreased sedentary behaviour. Our study is consistent with other research that has similarly highlighted the effectiveness of interventions targeting sedentary behaviours [61, 62]. The WHO recommends limiting the amount of sedentary behaviour to reduce the risk of poor health outcomes, including type 2 diabetes, cardiovascular disease, cancer, and the associated mortality from these conditions [27].

Implications

Our findings add to the growing body of knowledge that recommends combining nutrition education, physical activity, and motivational interviewing to manage metabolic syndrome.

The study has shown that the intervention package improves MetS outcomes. To incorporate the intervention into current healthcare programs, it is essential to ensure the availability of qualified, multidisciplinary health professionals, provide training for existing healthcare workers, support participants in adhering to the program, and ensure the availability of infrastructure, including spaces for physical activity.

To enhance the intervention, it may be necessary to identify which components, such as nutrition education, physical activity, or motivational interviewing, have the greatest impact on the observed changes. Further research is needed to assess the long-term feasibility, scalability, and sustainability of the intervention.

Strengths of the study

This was a randomised controlled trial, which enhanced the study's internal validity. The use of an individually randomised group treatment trial (IRGT) design mitigated the contamination of control participants with the intervention due to "spill-over effects", something common in other designs such as cluster randomised controlled trials. Our study focused on females within the reproductive age range. Because of the specificity of this risk group, recommendations can be tailored specifically. The study used various intervention packages, including nutrition education, physical activity, and motivational interviewing, which provided a holistic approach to improving health. This was a community-based study, a strategy that increased its relevance and potential for use in real-world settings.

Study limitations

The study had some limitations, including the participant's loss to follow-up. This was minimised by encouraging commitment at enrolment and supporting research assistants and trainers for better tracking. The 12-week intervention was short, limiting the assessment of long-term effects. However, similar short-term interventions have shown benefits. Reporting bias was a potential limitation due to the use of self-reported physical activity and dietary intake (see Tables 3 and 5). However, this risk was minimised by using experienced research assistants for data collection. The specific focus of the study in one district alone (Wakiso) may limit the generalizability of the findings to other regions. However, future studies with diverse demographic groups and regions are recommended to validate our findings. The intensive 12-week intervention delivered weekly by a multidisciplinary team using a structured curriculum likely contributed to the positive study findings. However, its intensity may limit scalability in resource-constrained settings. Future research could examine the effectiveness of less intensive interventions in a broader setting. The inclusion of adolescents (15–18 years) was a potential limitation due to their unique developmental, physiological and psychological characteristics, which could affect the generalisability of findings. However, their minimal participation (only four adolescents in the intervention) greatly reduced their impact on the results. Hence, these factors should be considered when interpreting the findings.

Conclusions and recommendations

Community-based interventions comprising nutrition education, physical activity, and motivational interviewing led to improvements in metabolic outcomes among females of reproductive age with metabolic syndrome in Wakiso district, central Uganda.

We recommend further prospective studies to investigate the feasibility, cost-effectiveness, scalability, and long-term effects of these interventions. Furthermore, we recommend the formulation of supportive health policies that promote community-level interventions in nutrition education, physical activity, and motivational interviewing to improve the management and outcomes of metabolic syndrome.

List of abbreviations and acronyms

BMI	Body Mass Index
CHD	Coronary Heart Disease
Coeff	Coefficient
CVD	Cardiovascular disease
DBP	Diastolic blood pressure
FBS	Fasting blood glucose
GLM	Generalised Linear Model
HDL	High-Density Lipoprotein Cholesterol
MetS	Metabolic Syndrome
SBP	Systolic blood pressure
T2DM	Type 2 Diabetes Mellitus
Trigs	Triglycerides
WC	Waist Circumference
WHO	World Health Organization

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12889-025-21936-9.

Additional file 1: CONSORT checklist.doc

Additional file 2: TIDier checklist

Additional file 3: Summary Table for intervention and control groups

Additional file 4: MetS Study Information Leaflet

Additional file 5: Design and development of the training curriculum for the intervention

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Author contributions
DL conceptualised the study, participated in data collection, supervision, design of methodology, data analysis, acquisition of financial support, and wrote the manuscript. HW, RWM and CGO participated in supervision, design of methodology, data analysis, acquisition of financial support, and wrote the manuscript. All authors read and approved the final manuscript.

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Data availability
"All relevant data is provided within the manuscript or supplementary information files. The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request".

Declarations

Ethics approval and consent to participate
This study adhered to the principles of the Declaration of Helsinki. Ethical approval was obtained from the Higher Degree's Research and Ethics Committee of Makerere University School of Public Health (MakSPH HDREC Protocol 071) and the Uganda National Council of Science and Technology (UNCST - HS1281ES). Written voluntary informed consent was obtained from adult participants, while assent and parental or guardian informed consent were secured for minors prior to their recruitment into the study. Participants were compensated for their time and transportation expenses at each study visit.

Consent for publication
"Not applicable".

Competing interests
The authors declare no competing interests.

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