Effect of Behaviour Change Communication on Metabolic Syndrome and Its Markers among Ethiopian Adults: Randomized Controlled Trial

Makeda Sinaga (✉ makedasinaga@gmail.com)

Jimma University

David Lindstrom

Brown University School of Public Health

Melese Sinaga Teshome

Jimma University

Tilahun Yemane

Jimma University

Elsah Tegene

Jimma University

Tefera Belachew

Jimma University

Research

Keywords: Metabolic syndrome, behaviour change communication

Posted Date: April 2nd, 2020

DOI: <https://doi.org/10.21203/rs.3.rs-20451/v1>

License: © ⓘ This work is licensed under a Creative Commons Attribution 4.0 International License. [Read Full License](#)

Abstract

Background: Metabolic syndrome is a global public health problem affecting both developing and developed countries with major consequences on human health, social and economic development. In Ethiopia although there is an increase in the prevalence of metabolic Syndrome due to epidemiologic transition, there is no study that evaluated the effect of interventions. This study aimed to assess the effect of nutrition behaviour change communication on metabolic syndrome and its markers.

Method: A individually randomized controlled trial was conducted among Ethiopian adults working in Jimma University from mid of September 2015 to December 30, 2015. A total of 224 participants were randomly allocated into intervention (n=112) and controls (n=112) groups. The list of administrative and academic staff involved in the baseline survey was used as a sampling frame. Data on socio-demographic, anthropometric, biochemical and clinical parameters were collected using trained data collectors. Difference in the differences in metabolic syndrome and its components between baseline and end line were compared by the intervention status. Multivariable logistic and linear regression models were used to isolate independent predictors of metabolic syndrome and its components, respectively.

Results: Overall, there was significant difference ($P<0.001$) in the prevalence of metabolic syndrome between intervention (11.6%) and control groups (37.5%) on the end line survey. On multivariable logistic regression analyses, control groups were 8.5 times more likely to have metabolic syndrome compared to intervention groups (AOR=8.53, 95%CI: 3.60, 20.21, $P<0.001$). There was a significant mean difference in differences in most components of metabolic syndrome and other lipid profiles except HDL ($P=0.717$) in the intervention group. The mean difference in differences in waist circumference was 6.3 cm ($P<0.001$), while that of systolic blood pressure (BP) and diastolic BP were 6.1 mmHg ($P<0.001$) and 3.6 mmHg ($P=0.001$), respectively. Likewise the difference of differences between intervention and control groups was 30.7 mg/dl ($P<0.001$) for T.Cholesterol, 55.5 mg/dl ($P<0.001$) for triglycerides, 21.9 mg/dl ($P=0.015$) for LDL and 22.2 mg/dl ($P<0.001$) for fasting blood sugar. Further multivariable linear regression analyses showed that after adjusting for many variables, there was a significant difference in difference between intervention groups in components of metabolic syndrome. For the intervention group the mean difference in differences was 6.1cm ($\beta=6.1$, $P<0.001$) for waist circumference and 4.2 mm Hg ($\beta=4.2$, $P<0.05$) for diastolic blood pressure and 6.5 mmHg ($\beta=6.5$, $P<0.001$) for systolic blood pressure compared with controls. Similarly, the mean difference in differences was higher in the intervention group by 19.9 mg/dl ($\beta=19.9$, $P<0.05$) for FBS, 57.5 mg/dl for TG ($\beta=57.5$, $P<0.05$), 24.40 mg/dl for LDL ($\beta=24.4$, $P<0.05$) and 30.9mg/dl for T.Cholesterol ($\beta=30.9$, $P<0.001$). This trial is retrospectively registered on Pan African Clinical Trial Registration with unique identification number of PACTR202003465339638.

Conclusion: There was strong positive effect of behaviour change communication on metabolic syndrome and its components. The results imply the need for enhancing behaviour change interventions using various strategies at the community and health facility levels to curb the emerging burden of chronic non-communicable diseases in Ethiopia. Future research should examine the sustainability of such behaviour changes using a community based study.

Introduction

Since few decades back, the burden of metabolic syndrome and chronic non-communicable diseases is emerging in developing countries at an alarming rate (1–2). Recent evidence shows that consequent to the globalization, change in dietary pattern and decline in physical activity levels, the magnitude of overnutrition is up surging on top of high prevalence of undernutrition leading to a double burden in sub-Saharan Africa (3–4).

The global prevalence of non-communicable diseases (NCDs) is on the rise, with the majority of the increase occurring among populations in developing countries (5). In Sub-Saharan Africa (SSA) where Ethiopia is situated although infectious diseases still cause the majority of mortality (69% of deaths), chronic non-communicable diseases such as cardiovascular disease, diabetes mellitus (DM), chronic respiratory disease and cancers, contribute around a quarter of deaths (6). This picture is changing as SSA is undergoing an epidemiological transition with a rapidly increasing burden chronic non-communicable diseases and associated mortality. In SSA, NCDs are projected to surpass infectious diseases (which are typically endemic to developing countries) by 2030 (5). As the prevalence of chronic non-communicable diseases is increasing, the interface between CNCDs and infectious diseases is becoming clearly apparent implying the need for health intervention strategies that can address both problems. For instance, an increasing prevalence of diabetes may hinder efforts for tuberculosis control, increasing the number of susceptible individuals in populations where tuberculosis is endemic, and making successful treatment harder (3–4). On the other hand, the high prevalence of HIV infection in developing countries, especially in sub-Saharan Africa and concomitant anti-retroviral therapy leads to an upsurge of metabolic syndrome (7–8).

Evidence shows that Ethiopia is having burden of metabolic syndrome and mortality from chronic non communicable diseases that are linked to over nutrition and life styles changes. Prevalence of MetS was reported to be 14.0% in men and 24.0% in women using IDF criteria; while individual components are prevalent among an apparently healthy working population in Ethiopia (9–10).

These findings indicate the need for evidence-based health promotion and disease prevention programs. Several studies in different countries demonstrated that varying levels of life style change interventions can reduce/reverse metabolic syndrome (11–12). Another study showed that delivery of a structured group education programme to individuals with MetS improved management of cardiovascular and diabetes risk factors (11). However, these issues were not documented in Ethiopia in particular and in Sub-Saharan Africa in general.

Although the magnitude of metabolic syndrome and chronic non communicable diseases is increasing in Ethiopia, there is no any organized public health intervention to prevent the occurrence of these problems and their risk factors. The health care system has limited itself to treating full-blown cases of metabolic syndrome and its components. There no intervention that is underway to address this emerging problem. Studies elsewhere, had demonstrated that dietary intervention can prevent metabolic syndrome (13–14). The effectiveness of interventions on metabolic syndrome has not been evaluated in Ethiopian set up. The aim of this study was to evaluate the effect of nutrition and life style behaviour change communication (BCC) intervention on metabolic syndrome and its markers.

Methods And Materials

Study area and Period

The study participants were recruited from Jimma University, which is a public higher educational institution established in December 1999. Jimma Town is 357 km southwest of Addis Ababa. The university has two institutes and six colleges encompassing a total of 1341 academic and 5444 administrative staffs. Circumstantial evidences show components of metabolic syndrome such as diabetes mellitus, hypertension and cardiovascular problems are common even within the small circle of academic and administrative staff leading to morbidity and mortality tolls.

Trial design: An individually randomized controlled parallel design used to determine the effect of nutrition and life style behavior change communication (BCC) on metabolic syndrome and its components.

Participants

The baseline study recruited 704 workers of Jimma University, which was used for developing anthropometric cut-offs for detecting obesity and metabolic syndrome among Ethiopian adults (15). All administrative and academic staff of Jimma University who was actively working in the university and not away from more than one week during recruitment period was considered for inclusion in the study. Administrative and academic staff of Jimma University who have physical disability including deformity (Kyphosis, Scoliosis), pregnant women, limb deformity that prevents standing erect were excluded from inclusion into the study. The eligibility criteria include: not having any physical disability that interferes with anthropometry, being employ of Jimma University and having baseline data. Those who were not available for the total duration of the follow up were excluded.

Intervention: After giving a gap of 6 months to avoid the periods of feasting and fasting, the BCC intervention continued for three months starting from half of September, 2015 and up to December 30, 2015. The end line data were collected in the first half of September 2015 from the controls and from December 30 to January 15, 2016 for the intervention group to avoid information contamination. The intervention group was given behaviour change communication through different strategies including power point assisted sensitization, facilitated group discussion using real examples of cases with metabolic syndrome using evidences and effective dietary and life style behaviours. Each of the intervention group members was also given a two page Amharic language brochure to take home. The study subjects were also reminded about the behaviours using key mottos of the behaviour (eg. Your menu should be colourful, avoid the three whites including: fat, sugar and salt, having diversified diet, aerobic exercise, drink plenty of water, avoid sources trans fats, avoid smoking, avoid khat chewing, avoid excess intake of alcohol, have a quality and adequate sleep and avoid sitting for long time) that were emphasized during training through text messages, while the control group received nothing before data collection (Table 1). After the end line data were collected, similar information was given to the control group.

Table 1
Nutrition and life style behavior change communication (BCC): Intervention Protocol

Key action(message)	Strategy of intervention	Responsible	Frequency	Compliance Parameter
• Consumption of Diversified Diet (The six food groups) • Exercise(Moderate intensity exercise of 30 minutes at least for 3 days a week) • Life styles(no smoking, alcohol drinking, no khat chewing, getting adequate sleep of 6–8 hours, not sitting /reclining for long time) • Drinking more water • Metabolic syndrome and its risk factors, consequences	leaflet with key message(in Amharic)	Research Team members	Once	Number of intervention participants who received the leaflet
	Power point presentation and discussion of evidences on metabolic syndrome and dietary and life style behaviours	Research Team members	Once a month	Frequency & attendance
	Reminders (key mottos of the behaviours were sent by text message (Group e-mail as applicable)	Research Team Members	Every Saturday once in 15 days	Frequency

Sample size : A sample size of 230 was calculated using Gpower 3.0 software with the following assumption for the detection of the difference between two independent means with an effect size of 0.4 for fasting blood sugar (the commonest component of MetS), margin of error of 0.05, power of 81%, with an intervention to control ratio of 1. After adding 26 for loss to follow up the final sample size became 230. After excluding a total of six participants (3 interventions and 3 controls) due to differed reasons (Fig. 1) a final sample size of 224 participants was analyzed.

Randomization

Simple randomization was used to allocate the study participants into the intervention group (exposed to behaviour change communication) and the control group (group which did not receive any intervention). A baseline data were collected from a randomly selected 704 workers comprising of different ethnic groups to develop an optimal anthropometric cut-off for detecting obesity and metabolic syndrome (15). A total 230 individuals were randomly selected using their identification number as a sampling frame. Then they were randomized into intervention (n = 115) and control (n = 115) using ENA Smart software. Outcomes: Primary outcomes of the study are metabolic syndrome and its components including: waist circumference, systolic and diastolic blood pressures, fasting blood sugar, triglyceride levels, high density lipoproteins, total cholesterol and low density lipoproteins.

Measurements

This study was conducted in accordance with the WHO's Stepwise (STEPs) approach for non-communicable disease (NCD) surveillance (16). This approach is characterized by the use of questionnaires to capture data on risk factors (Step 1): simple physical measurements (Step 2): and biochemical measurements (Step 3) (16).

The STEPs questionnaire was supplemented with additional questions to gather context specific data in the study area. The questionnaire was used to collect data regarding the general socio-demographic characteristics of the population including: age, sex, and education level. Questions included in the behavioural risk factors such as tobacco, alcohol, physical inactivity, and Khat consumption (a natural stimulant with amphetamine-like effects commonly used for social recreation in Ethiopia) (17). Experienced research nurses were trained for five days on the contents of the questionnaire, ethical issues and on data collection procedure.

Body composition: Body fat percent (adiposity) was determined both at baseline and end line using different anthropometric indices: (Body Mass index (BMI) and Waist Circumference (WC). Baseline Body fat percent was measured using air displacement plethysmography (ADP) (life Measurements) following standard procedures (15). Weight was measured with a solar powered scale which was accurate to 100 grams (Model 871, Seca, Germany). Height was measured with an adjustable portable stadiometer which was accurate to 0.1 cm. Waist circumference was measured with a fixed tension tape, at the midpoint between the lower costal margin at the mid-clavicular line and anterior-superior iliac crest (18) in a private place with no clothing on the upper part of the body. To ensure the data quality, anthropometric measurement standardization was done and a coefficient of variation of < 3% was taken as acceptable.

Blood pressure, Lipid Profiles and Fasting blood Glucose: Blood pressure was measured after individuals had rested for 5 minutes. Three blood pressure measurements were taken in a difference of five minutes between successive measurements. In accordance with the WHO recommendation the mean systolic and diastolic BP measurements were considered for analyses. A five ml blood samples was collected for each individual in the morning after overnight fasting using proper sanitation and infection prevention techniques. Serum was used for the measurement of triglycerides (TG), total cholesterol (TC), high-density lipoprotein cholesterol (HDL), low-density lipoprotein cholesterol (LDL), glucose concentrations. Details of the methods are published elsewhere (15)

For the end line data, a five ml blood specimen was collected with senior medical laboratory technologist, the serum was separated from the whole blood within 30 minutes and the serum was transferred to Nunc tubes and stored in -20 °C refrigerators. After all the specimens were collected the serum was packed with ice and transported to Mettu Karl Hospital laboratory and the lipid profile tests were done at this hospital laboratory with HumaStar 80 (Germany) using standard operating procedures. Fasting blood sugar was determined using Humastar within two hours of collection in Jimma University specialized hospital (JUSH) at JUCAN project laboratory.

Statistical Analyses

Data were doubly entered into Epidata 3.1 and exported to SPSS for windows version 20 (Inc, Chicago, IL, USA) for cleaning and analyses. Student's T-tests was used to evaluate differences in mean values for study groups after checking the assumptions for normality. As the study has baseline and end line data, the effectiveness of nutrition behaviour change communication on metabolic syndrome and its markers was evaluated by comparing the mean difference in differences between the baseline and end line in the intervention and in the control groups in metabolic syndrome and its markers. End line measurements were subtracted from baseline measurements for both intervention and control groups and the differences were compared.

Multivariable logistic and linear regression models were used to isolate independent predictors of metabolic syndrome and its components, respectively. For the multivariable linear regression, all assumptions including linearity, normality, homoscedasticity and multicollinearity were checked using Q-Q plots and multicollinearity was checked using variance inflation factor. For the multivariable logistic regression, multicollinearity was checked using standard error < 2.0 and Hosmer Lemeshaw test ($P > 0.05$) was used to check model fitness. Statistical significance is set at p-values < 0.05.

Operational Definition of Terms

Intervention group – Randomly selected adults who were given nutrition and health life style behavior change communication for three months.

Control group – Randomly selected adults who were not given nutrition and health behavior change communication.

Duration of the intervention: The time during which the life style medication behavior changes communication was given to the intervention group (three months starting from the second half of September 2015 to the December 30, 2015).

Components of Metabolic syndrome:

- Raised TG level: > 150 mg/dL (1.7 mmol/L), or specific treatment for this lipid abnormality
- Reduced HDL cholesterol: < 40 mg/dL (1.0 mmol/L) in males and < 50 mg/dL (1.3 mmol/L) in females, or specific treatment for this lipid abnormality
- Raised blood pressure: systolic BP $\geq$ 130 or diastolic BP $\geq$ 85 mm Hg, or treatment of previously diagnosed hypertension
- Raised fasting plasma glucose (FPG) $\geq$ 100 mg/dL (5.6 mmol/L), or previously diagnosed type 2 diabetes If above 5.6 mmol/L or 100 mg/dL.
- Central obesity was defined as waist circumference $\geq$ 80 for women and $\geq$ 94 for men.

Metabolic syndrome (MetS) is defined in accordance with the IDF as presence of abdominal obesity (and three or more MetS components described above (19–20).

Results

Baseline background characteristics of the study participants are presented in Table 2 below. The mean ($\pm$ sd) age of the study participants were 36.9($\pm$ 10.0) years for intervention and 37.7($\pm$ 10.0) for control groups. The proportion of males and females was 50.9% and 49.1% for the intervention and 43.8% and 56.3% for control groups. The intervention and control groups were similar in terms of their baseline level of total cholesterol, triglyceride, systolic and diastolic blood pressures, body fat percent and body mass index. However, the intervention group had higher LDL (94.0 $\pm$ 43) mg/dl compared to 84.6($\pm$ 77.3) mg/dl for the controls. Likewise, the level of HDL was low in the intervention (58.7 $\pm$ 28.7) mg/dl group compared to the controls (68.3 $\pm$ 63.4) mg/dl. Conversely, fasting blood sugar was slightly lower in the intervention group (97.1 $\pm$ 21.6) mg/dl compared with the control group (102.4 $\pm$ 39.6) mg/dl.

Table 2
Baseline background characteristics of study participants

Variables	n	Intervention (n = 112)	Control(n = 112)
		Mean($\pm$ sd)	Mean($\pm$ sd)
Sex	106	63.0(50.9)	55.0(43.8)
M	118	49.0(49.1)	57.0(56.3)
F			
Age(Yrs)	224	36.9(9.0)	37.7(10.0)
FBS (mg/dl)	224	97.1(21.6)	102.4(39.6)
HDL (mg/dl)	224	58.7(28.7)	68.3(63.4)
Total Cholesterol(mg/dl)	224	182.3(38.8)	182.6(52.4)
TG (mg/dl)	224	147.8(102.3)	148.5(84.7)
LDL (mg/dl)	224	94.0(43.0)	84.6(77.3)
Systolic Blood Pressure(mm Hg)	224	117.6(11.6)	118.4(13.9)
Diastolic Blood Pressure(mm Hg)	224	77.9(9.4)	77.91(9.1)
Waist Circumference (cm)	224	86.3(12.8)	85.5(12.8)
Body fact percent (%)	224	31.4(11.2)	31.5(10.9)
Body mass index (kg/m ²)	224	24.5(4.6)	24.3(5.1)

In Table 3, comparison of levels of metabolic syndrome components and lipid profiles at baseline and end line was made and the differences of the differences between the baseline and end line values were compared by the intervention status. The results showed that there was a significant difference in differences in most components of metabolic syndrome and other lipid profiles except HDL ($P = 0.717$). The mean difference of differences in waist circumference was 6.3 cm ($P < 0.001$), while that of systolic blood pressure (BP) and diastolic BP were 6.0 mm Hg ($P < 0.001$) and 3.6 mm Hg ($P = 0.001$), respectively. Likewise the difference of differences between intervention and control groups was 30.7($P < 0.001$) for T.Cholesterol, 55.5($P < 0.001$) for triglycerides, 21.9($P = 0.015$) for LDL and 22.2 ($P < 0.001$) for fasting blood sugar.

Table 3

Differences between baseline and end line measurements of metabolic syndrome components and lipid profiles and difference in the differences between intervention and control groups

Metabolic syndrome components and lipid profile	Intervention			Control			Difference in the Differences	
	Baseline	End line	Difference (BL - EL)	Baseline	End line	Difference (BL - EL)		
	Mean($\pm$ SD)	Mean($\pm$ SD)	Mean($\pm$ SD)	Mean($\pm$ SD)	Mean($\pm$ SD)	Mean($\pm$ SD)	Mean($\pm$ SE)	P
Waist Circumference(cm)	86.3(12.8)	80.8(12.7)	5.6(7.2)	85.5(12.7)	86.2(12.8)	-0.7(5.9)	6.3(1.7)	< 0.001
Systolic BP(mmHg)	117.8(11.8)	107.8(15.0)	10.0(12.7)	118.2(13.8)	114.2(16.3)	4.0(11.9)	6.0(1.7)	< 0.001
Diastolic BP(mmHg)	77.8(9.4)	70.9(9.4)	6.9(6.2)	77.9(9.1)	74.5(9.8)	3.4(7.7)	3.6(1.1)	0.001
T. Cholesterol(mg/dl)	182.3(38.8)	139.2(35.4)	43.0(35.3)	182.6(52.4)	170.3(50.4)	12.2(70.9)	30.7(7.5)	< 0.001
Triglyceride(mg/dl)	147.8(102.3)	98.6(54.7)	49.5(83.1)	148.5(84.7)	154.4(87.7)	-6(10.6.1)	55.5(12.9)	< 0.001
HDL(mg/dl)	58.7(28.7)	42.5(11.5)	16.4(29.8)	68.3(63.4)	49.5(17.8)	18.8(64.0)	-2.4(6.7)	0.717
LDL(mg/dl)	94.0(43.0)	76.9(27.9)	16.8(43.2)	84.6(77.3)	89.7(32.4)	-5.1(83.5)	21.9(8.9)	0.015
Fasting Blood Sugar(mg/dl)	97.1(21.4)	78.8(21.9)	18.4(28.8)	102.3(38.9)	106.2(37.1)	-3.9(24.8)	22.2(3.6)	< 0.001
BL = Baseline. EL = End line, BP = Blood Pressure, SE = Standard error, SD- Standard Deviation.								

Further multivariable linear regression analyses showed that after adjusting for many variables, there was a significant difference in difference between intervention and control groups in the components of metabolic syndrome that are dependent on physical measurements. For the intervention group the mean difference in differences was 6.1 cm ($\beta = 6.1$, $P < 0.001$) for waist circumference and 4.2 mm Hg ($\beta = 4.2$, $P < 0.05$) for diastolic blood pressure and 6.5 mmHg ($\beta = 6.5$, $P < 0.001$) for systolic blood pressure compared with controls. The other variable significantly associated with diastolic blood pressure was baseline body fat percent of the study participants. For a unit increase in baseline body fat percent, the mean difference in differences of diastolic blood pressure was lower by 2.0($\beta = 2.0$, $P < 0.05$) mmHg (Table 4).

The results of another multivariable linear regression analyses presented in Table 5 showed that after adjusting background variables, the intervention group had high difference of differences in LDL, Triglycerides, T.Cholesterol and fasting blood sugar (FBS). The mean difference in differences was higher in the intervention group by 19.9 mg/dl ($P < 0.05$) for FBS, 57.5 mg/dl for TG($P < 0.05$), 24.40 mg/dl for LDL ($P < 0.05$) and 30.9 mg/dl for T.Cholesterol ($P < 0.001$).

Table 5

Multivariable linear regression models predicting mean baseline to end line differences of the differences in the components of metabolic syndrome that dependent on Laboratory analyses of blood sample

Variables	Baseline end line differences of lipid profiles and Fasting blood sugar				
	FBS	HDL	TG	LDL	CHOL
	β (95%CI)	β (95%CI)	β (95%CI)	β (95%CI)	β (95%CI)
Sex Female(Ref.) Male	13.28(2.6, 24.0)*	11.9(-13.5, 37.3)	54.9(15.8, 94.1)**	-30.46(-57.7, -3.24)**	-20.6(-49.4, 8.1)
Age(Yrs)	-0.7(-1.5, 0.2)	-0.1(-1.1, 1.0)	-0.2(-3.0, 2.5)	-0.29 (-1.52, 0.94)	-0.1(-1.3, 1.1)
Monthly income High income Medium income Low(Ref.)	-6.0(-32.4, 20.4) -3.6(-23.2, 16.0)	-7.0(-40.4, 26.5) -9.1(-33.9, 15.7)	-15.4(-103.3, 72.6) 40.2(-25.2, 105.5)	45.69(7.05, 84.32)** 37.94(10.38, 65.50)**	36.19(3.6, 68.8)* 33.07(9.8, 56.3)*
Educational Status Degree and above (Ref.) Diploma High School and below	5.4(-14.0, 24.9) 14.3(-9.6, 38.2)	4.94(-0.57, 30.44) 10.8(-19.3, 40.9)	16.6(-47.9, 81.0) 23.0(-56.2, 102.2)	-0.99(-32.77, 32.79) 28.30(-6.92, 63.51)	-16.6(-44.3, 11.2) -20.0(-54.1, 14.1)
Intervention Yes Control(Ref.)	19.9(12.39, 27.40)**	-5.57(-19.9, 8.84)	57.53(30.1, 85.0)**	24.40(5.3, 43.47)*	30.87(14.8, 46.9)***
Baseline body fat percent	0.66(0.15, 1.16)*	-0.3(-1.4, 0.9)	2.12(1.28, 4.96)**	0.11(-1.17, 1.40)	-0.7(-2.0, 0.6)
Parameters adjusted for number of days of moderate intensity exercise in a week, hours of sleep in a day and Takes break after long hours of sitting					
Maximum Variance inflation factor in all models = 4.2.					
TG = Triglyceride, HDL: high density Lipoprotein. LDL: low density lipoprotein, T.Chol: Total Cholesterol, FBS: Fasting blood sugar. **P < 0.001, *P < 0.01, *P < 0.05.					

Other variables associated with LDL were sex and monthly income. The difference in differences was lower by 30.5 mg/dl ($\beta = 30.3$, $P < 0.01$) for LDL among males. Conversely, those who had high income and medium income had higher difference in differences for LDL by 45.7 mg/dl ($\beta = 45.7$, $P < 0.01$) and 37.9 mg/dl ($\beta = 37.9$, $P < 0.01$), respectively. For T.Cholesterol, those in the high income and medium income category had higher mean difference in differences by 36.2 mg/dl ($\beta = 36.2$, $P < 0.05$) and 33.1 mg/dl ($\beta = 33.1$, $P < 0.05$), respectively. Similarly, males have significantly higher difference in differences of TG by 54.9 mg/dl ($\beta = 54.9$, $P < 0.01$). Likewise, for a unit increase in base line fat mass the difference in differences of TG was higher by 2.12 mg/dl ($\beta = 2.12$, $P < 0.01$). Difference of the differences in FBS was significantly associated with sex and baseline body fat percent. Being male increased the difference in differences at the end line by 13.28 mg/dl ($\beta = 12.38$, $P < 0.05$). For a unit increase in baseline body fat percent, the difference in difference of FBS increased by 0.66 mg/dl ($\beta = 0.66$, $P < 0.001$) (Table 4).

The results showed that in both intervention and control groups small proportion of the study participants were free of any of the metabolic syndrome components (13.4% for intervention vs 5.4% for controls). Large proportion of both intervention and control groups have atleast one or two of the metabolic syndrome components. However, there was a significant difference in the proportion of intervention and control groups with three or more metabolic syndrome components (Fig. 2).

Overall, there was significant difference ($P < 0.001$) in the prevalence of metabolic syndrome between intervention (11.6%) and control groups (37.5%). This difference between intervention and control groups was consistent across the different sexes (Fig. 3).

The results of multivariable logistic regression showed that variables including: intervention, sex, age base line body fat percent were independent predictors of metabolic syndrome. Control groups were 8.5 times more likely to have metabolic syndrome compared to intervention groups (AOR = 8.53, 95%CI: 3.60, 20.21, $P < 0.001$). Males were 10.2 times more likely to have metabolic syndrome as compared to females (AOR = 4.71, 95%CI: 2.60, 39.84, $P = 0.001$). Similarly for one year increase in age the likelihood of having metabolic syndrome was higher by 6% (AOR = 1.06, 95%CI: 1.01, 1.11, $P = 0.029$). Likewise, for a unit increase in baseline body fat percent, the odds of having metabolic syndrome increased by 11% (AOR = 1.11, 95%CI: 1.04, 1.18, $P = 0.001$) (Table 6).

Table 6

Multivariable logistic regression model predicting the likelihood of having metabolic syndrome among study participants, Jimma University, Ethiopia

Predictors	β	RR	95% C.I.		P
			Lower	Upper	
Sex					
Male	2.32	10.19	2.60	39.84	0.0010
Female		1.00			
Age (Years)	0.05	1.06	1.00	1.11	0.0400
Intervention					
No	2.00	7.42	3.00	18.38	< 0.0001
Yes		1.00			
Monthly income Tertile					
Low		1.00			
Medium	-0.28	0.75	0.16	3.54	0.7190
High	-0.27	0.76	0.22	2.66	0.6710
Educational Status					
Degree and above	-0.07	0.94	0.23	3.79	0.9250
Diploma	0.15	1.16	1.08	1.24	< 0.0001
High School or below		1.00			
Baseline fat percent	0.15	1.16	1.08	1.24	< 0.0001
Hosmer Lemeshaw (P = 0.068), Maximum Standard error = 0.790					
AOR- Adjusted odds ratio, CI = Confidence Interval.					

Discussion

The study demonstrated a significant positive effect of behaviour change communication implemented for three months on metabolic syndrome and its components, which is consistent with a 12 week yoga-based lifestyle intervention among Indian adults with metabolic syndrome (21) and a 12 week life style education interventional in Thai adults (22). A systematic review of randomized controlled trials in different population groups also showed positive effect of life style modification interventions starting from 10 weeks duration (23). In this study, the likelihood of having metabolic syndrome was 8.5 times higher among the control group after adjusting for background variables indicating the significance of lifestyle modification interventions in the prevention of metabolic syndrome and related non-communicable diseases. This finding is consistent with the report of meta analyses of randomized controlled trials that showed life style modification intervention were effective in resolving metabolic syndrome (MetS) and reducing the severity of related abnormalities including fasting blood glucose, waist circumference, systolic blood pressure (SBP) and diastolic blood pressure (DBP), and triglycerides in subjects with MetS (12, 13,24).

The positive results imply the need for adopting a team approach to lifestyle modification programs in the management of MetS (25). It was suggested that multidisciplinary group approach is an effective and economically feasible strategy in the control of metabolic parameters (26). It was also reported that modifying diet together with frequent physical exercise can reduce the triglycerides concentration as well as SBD and DBP (24, 27, 28). The need for implementing effective lifestyle modifications to prevent MetS and its health consequences has been indicated (24, 29).

Sex and age were other variables associated with metabolic syndrome. It was observed that males were 4.7 times more likely to have metabolic syndrome as compared to females, which is consistent with other reports (30). For one year increase in age, the likelihood of metabolic syndrome was higher by 6%, which is similar to a report from elsewhere (31). The relationship between metabolic syndrome components with older age and male sex has also been reported (32).

It was also observed that the intervention group has significantly ($P < 0.05$) higher dereference in differences between baseline and end line surveys for serum levels of FBs, Triglycerides and T.cholesterol and higher levels of HDL compared to the control group. A similar finding was reported by studies from elsewhere (24; 27, 33). Likewise, the intervention group had a significant difference in differences in waist circumference similar to reports of studies elsewhere (34–35).

The results showed that intervention group the mean difference in differences was 4.2 mmHg ($P < 0.05$) for diastolic blood pressure and 6.5 mmHg ($P < 0.001$) for systolic blood pressure compared with controls. This finding is consistent with another study which showed that the mean diastolic blood pressure (DBP) and triglycerides decreased significantly in the intervention group in both sexes (36). A positive effect of life style modification on blood pressure has also been reported among Korean adults (37, 38).

It has been documented that interventions incorporating dietary, physical activity and other life style changes exerts beneficial effects on the various components of the metabolic syndrome and improves overall survival (13, 24, 27, 28, 29,). However, interventions targeting life style changes have the potential to succeed only if they are executed early to offer strong evidence to substantiating the development of appropriate public policies (14, 23).

Baseline body fat percent of the study participants was significantly associated with diastolic blood pressure such that for one year increase in baseline body fat percent the mean difference in differences in diastolic blood pressure was lower by 2.0($P < 0.05$) mmHg. This could be related the effect of high body fat percent on the cardiovascular system which minimizes the difference in the blood pressure changes. The effect of body fat percent on increasing blood pressure has been documented by other studies (13, 38, 39,).

Multivariable linear regression analyses showed that the intervention has high difference of differences in LDL, Triglycerides, T.Cholesterol and fasting blood sugar (FBS). A similar positive effect of life style modification was reported on lipid profiles (40–41) and blood sugar level (42).

It was also observed that the difference of differences was lower by 30.5 mg/dl for LDL among males compared to females. This indicates that at the end of the follow up period, the decrease in LDL cholesterol was lower among men. The relationship between gender and Lipid profile is age dependent. At younger age men tend to have higher levels of LDL, while this relationship gets reversed during older age especially after menopause where women tend to have higher level of LDL (43) implying the need for careful interpretation of this finding.

Similarly, participants who had high income and medium income had higher difference in differences for LDL and T.Cholesterol compared with those in lower income. Evidence shows that an increase in income without change in educational status was associated with poor lipid profiles (44). However, the positive association of income with differences in differences of LDL and T.Cholesterol could be due to the fact that income is highly associated with educational status in the study population (university staff), which in turn may affect the level of adherence to the behaviour change interventions(45).

The positive findings of the behaviour change communication observed in this study have wider practical implications for Ethiopia where both modifiable and non-modifiable risk factors for chronic non-communicable diseases are increasing from time to time while the commensurate preventive intervention are lagging behind. The non-modifiable risks factors include increased life expectancy to over 64 years (46) and history of high proportion of early life stunting (47–51). Early life stunting could generate a huge potential for emergence of epidemics of chronic non-communicable diseases due to organ stunting. It has been reported that early childhood malnutrition including during the fetal period leads to occurrence of chronic non-communicable diseases later in life (52). The modifiable risk factors include dietary transitions to more processed and low fibre high calorie diet and sedentary and motorized way of life (53–55). The positive effect of the intervention documented in these modifiable risk factors implies the need for enhancing such interventions using different strategies through the involvement of different sectors to curb the upsurge of non-communicable disease and associated consequences in the years to come.

The study employed an individually randomized controlled trial to generate empirical evidence on the effectiveness of intervention approaches. However, to avoid information contamination the end line data were collected from the control group earlier than the intervention group, which is not expected to have an effect in their dietary and other behavioural factors as the data from the intervention group was also collected in the same season.

Conclusions

There was strong positive effect of behaviour change communication on metabolic syndrome and its components. The results imply the need for enhancing behaviour change interventions using various strategies at the community and health facility levels to curb the emerging burden of chronic non-communicable diseases in Ethiopia. Future research should examine how sustainable such behaviour changes are using a community based study.

Abbreviations

ADP: Air Displacement Plethysmography; BMI: Body Mass Index; ROC: Receiver Operating Characteristics Curve; WC: Waist Circumference; WHR: Waist to Hip Ratio; WHtR: Waist to Height Ratio

Declarations

Acknowledgements

We appreciate Institute of Health, Jimma University for funding the study and JUCAN project and Mettu Karl Hospital for providing body composition analyses and laboratory facilities for lipid profiles analyses, respectively. We are also grateful the study participants for their willingness involve in the study.

Funding

The study was funded by Jimma University; Institute of Health. The institute did not have a role in the design of the study and collection, analysis and interpretation of data or in writing the manuscript.

Availability of data and materials

The data used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Authors' contributions

MS and TB conceived and planned the study. MS, DL, MST, TY, TB and ET implemented the study. MS and TB did the analyses. MS drafted the manuscript. DL, MST, TY, TB and ET critically reviewed the manuscript. All authors gave input to the manuscript and read and approved the final version.

Ethics approval and consent to participate

The study protocol was ethically approved by the Ethical review board of Jimma University before the start of the study on February 5, 2015 with a reference number of: RPGC/691/07. Adequate explanation was given to each participant and informed consent was obtained before data collection. To keep anonymity of all data, no personal identifiers were used except unique ID number. So, unlinked anonymous method was used, where the study subjects and their blood samples were matched later during analyses without revealing any personal identifiers. Informed verbal consent was obtained from each study subjects prior to the administration of questionnaire after the purpose of the study was explained to respondents. The study participants were informed that they will have the right to refuse or discontinue participating in the research without any compromise in the service they are getting from the respective facilities. Finally, the study participants were given their laboratory results printed on a slip that has only their unique identifier. This trial is retrospectively registered on Pan African Clinical Trial Registration with unique identification number of PACTR202003465339638.

Consent for publication

This is not applicable as the study does not have individual person's data.

Competing interests

Authors do not have any competing interests.

The authors declare that they have no competing interests.

Author details

¹Department of nutrition and dietetics, Jimma University, South West Ethiopia.

²Population Studies Centre, Brown University, Providence, USA.

³Department of Laboratory sciences, Jimma University, South West Ethiopia.

⁴Department of Internal Medicine, Jimma University, South West Ethiopia.

References

1. Islam SM, Purnat TD, Phuong NT, Mwingira U, Schacht K, Fröschl G. Non-communicable diseases (NCDs) in developing countries: a symposium report. *Global Health*. 2014 Dec 11;10:81. doi: 10.1186/s12992-014-0081-9.
2. Jakovljevic MB, Milovanovic O. Growing Burden of Non-Communicable Diseases in the Emerging Health Markets: The Case of BRICS. *Front Public Health*. 2015 Apr 23;3:65. doi: 10.3389/fpubh.2015.00065. eCollection 2015.
3. Young F, Critchley J, LJohnstone L, Unwin Globalization and the dual disease burden in sub-Saharan Africa. *Diabetes Voice*, June 2010; 55(1).
4. Young F, Critchley JA, Johnstone LK, Unwin NC. A review of co-morbidity between infectious and chronic disease in Sub Saharan Africa: TB and Diabetes Mellitus, HIV and Metabolic Syndrome, and the impact of globalization. *Globalization and Health* 2009, 5 :9 doi:10.1186/1744-8603-5-9.
5. BeLue R, Okoror TA, Iwelunmor J, Taylor KD, Degboe AN, Agyemang C, Ogedegbe G. An overview of cardiovascular risk factor burden in sub-Saharan African countries: a socio-cultural perspective. *Global Health*. 2009 Sep 22;5:10. doi: 10.1186/1744-8603-5-10.
6. WHO: *The Global Burden of Disease: 2004 update*. Switzerland
7. Estrada V, Martínez-Larrad MT, González-Sánchez JL, de Villar NG, Zabena C, Fernández C, Serrano-Ríos M. Lipodystrophy and metabolic syndrome in HIV-infected patients treated with antiretroviral therapy. 2006 Jul;55(7):940-5.
8. Alvarez C, Salazar R, Galindez J, Rangel F, Castañeda ML, Lopardo G, Cuhna CA, Roldan Y, Sussman O, Gutierrez G, Cure-Bolt N, Seas C, Carcamo C, Castrillo M. Metabolic syndrome in HIV-infected patients receiving antiretroviral therapy in Latin America. *Braz J Infect Dis*. 2010 May-Jun;14(3):256-63.
9. Tran A, Gelaye B, Girma B, Lemma S, Berhane Y, Bekele T, Khali A, Williams MA. Prevalence of Metabolic Syndrome among Working Adults in Ethiopia. *Int J Hypertens*. 2011;2011:193719. doi: 10.4061/2011/193719. Epub 2011 May 26.
10. Nshisso LD, Reese A, Gelaye B, Lemma S, Berhane Y, Williams MA. Prevalence of hypertension and diabetes among Ethiopian adults. *Diabetes Metab Syndr*. 2012 Jan-Mar;6(1):36-41. doi: 10.1016/j.dsx.2012.05.005. Epub 2012 Jun 5.
11. Dunkley AJ, Charles K, Gray LJ, Camosso-Steinovic J, Davies MJ, Khunti K. Effectiveness of interventions for reducing diabetes and cardiovascular disease risk in people with metabolic syndrome: systematic review and mixed treatment comparison meta-analysis. *Diabetes Obes Metab*. 2012 Jul;14(7):616-25. doi: 10.1111/j.1463-1326.2012.01571.x. Epub 2012 Feb 21.
12. van Namen M, Prendergast L, Peiris C. Supervised lifestyle intervention for people with metabolic syndrome improves outcomes and reduces individual risk factors of metabolic syndrome: A systematic review and meta-analysis. 2019 Dec;101:153988. doi: 10.1016/j.metabol.2019.153988. Epub 2019 Oct 28.
13. Yamaoka K, Tango T. Effects of lifestyle modification on metabolic syndrome: a systematic review and meta-analysis. *BMC Med*. 2012 Nov 14;10:138. doi: 10.1186/1741-7015-10-138.

14. Blackford K, Jancey J, Lee AH, James AP, Waddell T, Howat P. Home-based lifestyle intervention for rural adults improves metabolic syndrome parameters and cardiovascular risk factors: A randomized controlled trial. *Prev Med*. 2016 Aug;89:15-22. doi: 10.1016/j.ypmed.2016.05.012. Epub 2016 May 16.
15. Sinaga M, Worku M, Yemane T, Tegene E, Wakayo T, Girma T, Lindstrom D, Belachew T. Optimal cut-off for obesity and markers of metabolic syndrome for Ethiopian adults. *Nutr J*. 2018 Nov 22;17(1):109. doi: 10.1186/s12937-018-0416-0.
16. The WHO STEPwise approach to noncommunicable disease risk factor surveillance. Last Updated: 26 January 2017. Available from: https://www.who.int/ncds/surveillance/steps/STEPS_Manual.pdf. Accessed on January 2020.
17. Getahun W, Gedif T, Tesfaye F. Regular Khat (*Catha edulis*) chewing is associated with elevated diastolic blood pressure among adults in Butajira, Ethiopia: a comparative study. *BMC Public Health*. 2010; 10:390. [PubMed: 20594361]
18. Waist Circumference and Waist-Hip Ratio Report of a WHO Expert Consultation GENEVA, 8–11 DECEMBER 2008. Available from: https://apps.who.int/iris/bitstream/handle/10665/44583/9789241501491_eng.pdf;jsessionid=D3E0AACFF0CE01B24BCD3621BA528636?sequence=1.
19. Beilby J. Definition of Metabolic Syndrome: Report of the National Heart, Lung, and Blood Institute/American Heart Association Conference on Scientific Issues Related to Definition. *Clin Biochem Rev*. Aug 2004; 25(3): 195–198.
20. International Diabetes Federation. The IDF consensus worldwide definition of the Metabolic Syndrome, 2006. Available from: <https://www.idf.org/e-library/consensus-statements/60-idfconsensus-worldwide-definition-of-the-metabolic-syndrome.html>. Accessed 12 Feb 2018.
21. Yadav R, Yadav RK, Khadgawat R, Pandey RM, Upadhyay AD, Mehta N. Randomized Controlled Trial of A 12-Week Yoga-Based (Including Diet) Lifestyle vs. Dietary Intervention on CardioMetabolic Risk Factors and Continuous Risk Score in Indian Adults with Metabolic Syndrome. *Behav Med*. 2020 Jan-Mar;46(1):9-20. doi: 10.1080/08964289.2018.1538098. Epub 2019 Jan 7.
22. Chaiyasoot K, Sarasak R, Pheungruang B, Dawilai S, Pramyothin P, Boonyasiri A, Supapueng O, Jassil FC, Yamwong P, Batterham RL. Evaluation of a 12-week lifestyle education intervention with or without partial meal replacement in Thai adults with obesity and metabolic syndrome: a randomized trial. *Nutr Diabetes*. 2018 Apr 25;8(1):23. doi: 10.1038/s41387-018-0034-0.
23. Kataria I, Chadha R, Pathak R. Dietary and lifestyle modification in metabolic syndrome: a review of randomized control trials in different population groups. *Reviews in Health Care* 2013; 4(4): 209-230
24. Azizi F, Mirmiran P, Momenan AA, et al. The effect of community-based education for lifestyle intervention on the prevalence of metabolic syndrome and its components: tehran lipid and glucose study. *Int J Endocrinol Metab*. 2013 Summer;11(3):145-53. doi: 10.5812/ijem.5443. Epub 2013 Jul 1.
25. Grave RD, Calugi S, Centis E, Marzocchi R, Ghoch ME, Marchesin G. Lifestyle modification in the management of the metabolic syndrome: achievements and challenges. *Diabetes, Metabolic Syndrome and Obesity: Targets and Therapy* 2010;3. <https://doi.org/10.29328/journal.hodms.1001004>
26. Saboya PP, Bodanese LC, Zimmermann PR, Gustavo AD, Macagnan FE, Feoli AP, Oliveira MD. Lifestyle Intervention on Metabolic Syndrome and its Impact on Quality of Life: A Randomized Controlled Trial. *Arq Bras Cardiol*. 2017 Jan;108(1):60-69. doi: 10.5935/abc.20160186. Epub 2016 Dec 8.
27. Valmorbida LA, Borsatto AC, Feoli AM, Antunes MT, Breigeiron MK, Macagnan FE. Benefits of lifestyle modification on the metabolic syndrome. *Fisioter Mov*. 2013; 26(4): 835-43.
28. Ostman C, Smart NA, Morcos D, Duller A, Ridley W, Jewiss D. The effect of exercise training on clinical outcomes in patients with the metabolic syndrome: a systematic review and meta-analysis. *Cardiovasc Diabetol*. 2017 Aug 30;16(1):110. doi: 10.1186/s12933-017-0590-y.
29. Pérez-Martínez P, Mikhailidis DP, Athyros VG, et al. Lifestyle recommendations for the prevention and management of metabolic syndrome: an international panel recommendation. *Nutr Rev*. 2017 May; 75(5): 307–326.
30. Yang Y-M, Shin B-C, Son C, Ha I-H. An analysis of the associations between gender and metabolic syndrome components in Korean adults: a national cross-sectional study. *BMC Endocrine Disorders*. 2019; 19:67.
31. Bhanushali CJ, Kumar K, Wutoh AK, Karavatas S, Habib MJ, Daniel M, Lee E. Association between Lifestyle Factors and Metabolic Syndrome among African Americans in the United States. *J Nutr Metab*. 2013;2013:516475. doi: 10.1155/2013/516475. Epub 2013 Jan 31.
32. Weng C1, Yuan H, Tang X, Huang Z, Yang K, Chen W, Yang P, Chen Z, Chen F. Age- and gender dependent association between components of metabolic syndrome and subclinical arterial stiffness in a Chinese population. *Int J Med Sci*. 2012;9(8):730-7. doi: 10.7150/ijms.4752. Epub 2012 Oct 16.
33. VanWormer JJ, Boucher JL, Sidebottom AC, Sillah A, Knickelbine T. Lifestyle changes and prevention of metabolic syndrome in the Heart of New Ulm Project. *Prev Med Rep*. 2017 Mar 29;6:242-245. doi: 10.1016/j.pmedr.2017.03.018. eCollection 2017 Jun.
34. Burini RC, Kano HT, Nakagaki MS, Frenhani PB, McLellan KCP. Behavioral factors of Abdominal Obesity and effects of lifestyle changes with Fiber Adequacy. *New Insights Obes Gene Beyond*. 2017; 1: 014-022.
35. Wadolowska L, Hamulka J, Kowalkowska J, et al. Changes in Sedentary and Active Lifestyle, Diet Quality and Body Composition Nine Months after an Education Program in Polish Students Aged 11–12 Years: Report from the ABC of Healthy Eating Study. *Nutrients*. 03 Feb 2019;11(2). DOI: 3390/nu11020331 PMID: 30717465 PMCID: PMC6412996
36. Gharipour M, Sarrafzadegan N, Sadeghi M, Khosravi A, Hoseini M, Khosravi-Boroujeni H, Khaledifar A. The metabolic syndrome and associated lifestyle factors among the Iranian population. *Adv Biomed Res*. 2015 May 11;4:84. doi: 10.4103/2277-9175.156645. eCollection 2015.
37. Yang MH, Kang SY, Lee JA, Kim YS, Sung EJ, Lee KY, Kim JS, Oh HJ, Kang HC, Lee SY. The Effect of Lifestyle Changes on Blood Pressure Control among Hypertensive Patients. *Korean J Fam Med*. 2017 Sep;38(5):311-312. doi: 10.4082/kjfm.2017.38.5.311. Epub 2017 Sep 22.
38. Fazliana M, Liyana AZ, Omar A, Ambak R, Mohamad Nor NS, Shamsudin UK, Salleh NA, Aris T. Effects of weight loss intervention on body composition and blood pressure among overweight and obese women. *BMC Womens Health*. 2018 Jul 19;18(Suppl 1):93. doi: 10.1186/s12905-018-0592-2.
39. Lee SB, Cho AR, Kwon YJ, Jung DH. Body fat change and 8-year incidence of hypertension: Korean Genome and Epidemiology Study. *J Clin Hypertens (Greenwich)*. 2019 Dec;21(12):1849-1857. doi: 10.1111/jch.13723. Epub 2019 Oct 29.

40. Michishita R, Tanaka H, Kumahara H, Ayabe M, Tobina T, Yoshimura E, Matsuda T, Higaki Y, Kiyonaga A (2014) Effects of Lifestyle Modifications on Improvement in the Blood Lipid Profiles in Patients with Dyslipidemia. *J Metabolic Syndr* 3: 150. doi: 10.4172/2167-0943.1000150
41. Akbari M, Lankarani KB, Naghibzadeh-Tahami A, Tabrizi R, Honarvar B, Kolaheidoz F, Borhaninejad V, Asemi Z. The effects of mobile health interventions on lipid profiles among patients with metabolic syndrome and related disorders: A systematic review and meta-analysis of randomized controlled trials. *Diabetes Metab Syndr*. 2019 May - Jun;13(3):1949-1955. doi: 10.1016/j.dsx.2019.04.011. Epub 2019 Apr 12.
42. Sheng Z, Cao JY, Pang YC, Xu HC, Chen JW, Yuan JH, Wang R, Zhang CS, Wang LX, Dong J. Effects of Lifestyle Modification and Anti-diabetic Medicine on Prediabetes Progress: A Systematic Review and Meta-Analysis. *Front Endocrinol (Lausanne)*. 2019 Jul 12;10:455. doi: 10.3389/fendo.2019.00455. eCollection 2019.
43. Swiger KJ¹, Martin SS, Blaha MJ, Toth PP, Nasir K, Michos ED, Gerstenblith G, Blumenthal RS, Jones SR. Narrowing sex differences in lipoprotein cholesterol subclasses following mid-life: the very large database of lipids (VLDL-10B). *J Am Heart Assoc*. 2014 Apr 22;3(2):e000851. doi: 10.1161/JAHA.114.000851.
44. Lara M, Amigo H. Association between education and blood lipid levels as income increases over a decade: a cohort study. *BMC Public Health*. 2018 Feb 27;18(1):286. doi: 10.1186/s12889-018-5185-3.
45. Leung AWY, Chan RSM, Sea MMM, Woo J. An Overview of Factors Associated with Adherence to Lifestyle Modification Programs for Weight Management in Adults. *Int J Environ Res Public Health*. 2017 Aug 16;14(8). pii: E922. doi: 10.3390/ijerph14080922.
46. Jembere GB, Cho Y, Jung M. Decomposition of Ethiopian life expectancy by age and cause of mortality; 1990-2015. *PLoS One*. 2018 Oct 3; 13(10):e0204395. doi: 10.1371/journal.pone.0204395. eCollection 2018.
47. Central Statistical Authority [Ethiopia] and ORC Macro. 2001. Ethiopia Demographic and Health Survey. Addis Ababa, Ethiopia and Calverton, Maryland, USA: Central Statistical Authority and ORC Macro, 2000.
48. Central Statistical Agency [Ethiopia] and ORC Macro. Ethiopia Demographic and Health Survey 2005. Addis Ababa, Ethiopia and Calverton, Maryland, US A: Central Statistical Agency and ORC Macro, 2006.
49. Ethiopian Demographic and Health Survey. Addis Ababa, Ethiopia and Calverton Maryland, USA.; 2011.
50. Ethiopian Demographic and Health Survey. Addis Ababa, Ethiopia and Calverton Maryland, USA.; 2016
51. Ethiopian Demographic and Health Survey . Addis Ababa, Ethiopia and Calverton Maryland, USA.; 2019
52. DeBoer MD, Lima AA, Oría RB, Scharf RJ, Moore SR, Luna MA, Guerrant RL. Early childhood growth failure and the developmental origins of adult disease: do enteric infections and malnutrition increase risk for the metabolic syndrome? *Nutr Rev*. 2012 Nov;70(11):642-53. doi: 10.1111/j.1753-4887.2012.00543.x.
53. Yarinbab TE, Alemseged F. Prevalence and Determinants of Modifiable Risk Factors for Chronic Non-Communicable Diseases among Adults in Mizan-Aman Town, Ethiopia: A Community Based Cross Sectional Study. *JOJ Pub Health*, 2018;3(5): 1-8.
54. Abebe SM, Andarge G, Shimekaa A, *et al*. The prevalence of non-communicable diseases in northwest Ethiopia: survey of Dabat Health and Demographic Surveillance System. Abebe SM, *et al*. *BMJ Open* 2017;7:e 015496. doi:10.1136/bmjopen-2016-015496
55. Gebreyes YF, Goshu DY, Geletew TK, Argefa TG, Zemedu TG, Lemu KA *et al*. Prevalence of high bloodpressure, hyperglycemia, dyslipidemia, metabolic syndrome and their determinants in Ethiopia: Evidences from the National NCDs STEPS Survey, 2015. *PLoS One*. 2018 May 9;13(5):e0194819. doi: 10.1371/journal.pone.0194819. eCollection 2018.

Figures

Figure 1

Trial flow diagram

Figure 2

Proportion of study participants with different components of metabolic syndrome in the intervention and control groups

Figure 3

Prevalence of metabolic syndrome between intervention and control groups at the end line by sex, Jimma University southwest Ethiopia