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Effectiveness of Trans-Theoretical Model-Based Health Education Intervention in the Promotion of Lifestyle Changes among Adults with Metabolic Syndrome: A Randomized Controlled Trial

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Abstract

Background: Evidence revealed that, 60% of deaths in the underdeveloped nations are linked to adoption of unhealthy lifestyles. The Trans-theoretical Model (TTM) has been considered a useful interventional approach in smoking cessation, drug addiction and weight control. However, its effectiveness in improving changes in dietary pattern, physical activity and alcohol consumption has not been reported.

Purpose: The study aimed at evaluating the effectiveness of the TTM-based health education intervention in the promotion of lifestyle changes among adults with metabolic syndrome.

Methods: This was an experimental design where 352 participants with metabolic syndrome were allocated to intervention and control groups. The participants were randomly assigned to receive either standard CVD care or a TTM stage-based lifestyle modification intervention for 12-months. Lifestyle patterns were assessed at baseline and endpoint. The mean difference of the subtotal TTM concept scores between pre and post intervention was evaluated using paired *t*-test. The chi-square test of independence was used to detect between group differences in the categorical data.

Results: Most of the participants were in the pre-action stage of change for their dietary intake patterns and physical activity habits at the baseline assessment with no difference between the groups. The intervention group's total level of change toward adopting a healthy lifestyle was markedly ($p < 0.001$) improved than the control group at the endpoint. The mean scores for the intervention group's stage of change, self-efficacy, and pros and cons of decisional balance all improved significantly ($p < 0.001$) from the baseline. The mean scores for the control group's pros and cons of decisional balance and stage of change also considerably ($p < 0.05$) improved from baseline to the endpoint.

Conclusion: The TTM- based health education intervention was effective in improving the participants' lifestyles that includes diet and physical activity. Health care providers, particularly nurses should implement TTM staged-matched educational intervention for individuals who are at risk for cardiovascular diseases.

Keywords

Trans-theoretical model, lifestyle changes, metabolic syndrome

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1. Introduction

Metabolic syndrome (MetS) is a group of health maladies namely: central obesity, elevated fasting blood sugar (FBG), increased level of blood pressure (BP), elevated serum triglycerides (TGs), and low levels of high density lipoprotein cholesterol (HDL-C) (Alberti et al., 2009). It is a main precursor for type-2 diabetes and cardiovascular disease (CVD) (Cantiello et al., 2015; Mendonça et al., 2015). Evidence show that, those with MetS are around five times more likely than people without the syndrome to develop type-2 diabetes, two times as likely to pass away from it, and three times as likely to have a heart attack or

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stroke (Van Namen et al., 2019). The four main behavior-based risk factors for CVD include excessive alcohol intake, poor diet, tobacco use, and physical inactivity (Bull et al., 2020).

If individuals with MetS are timely identified and properly informed to change their lifestyles, the risk of developing CVD can be greatly reduced (IDF, 2015; Peikani et al., 2018). Given that one of the World Health Organization key strategies for the prevention of CVD is to adopt a healthy lifestyle (Al-Qahtani, 2015), design and implementation of lifestyle interventions is critically important. One of the most relevant approaches of interventions for promotion of healthy lifestyles is the use of the Trans-theoretical Model (TTM) (Sousa et al., 2015). According to the model, people are at different stage of readiness to change their current behaviors towards diseases prevention, and interventions to promote positive behavior are more effective when matched with the individual's readiness (Prochaska & DiClemente, 2003). Hence, the TTM stage-based intervention considers the readiness of each individual to adopt a new behavior. Stages of change, self-efficacy, and pros & cons decisional balance are the three main components of the model.

Stage of change: This is referred to as a progressive process in five steps (Spellman, 2009). According to the TTM, people's intentions to modify or retain their behavior are integrated with their existing behavior in five stages. According to Spellman (2009) and Glanz et al. (2008), the five stages of changes are:

Pre-contemplation: A lack of awareness of the existed behavior and a lack of motivation to act. At this stage, a healthier lifestyle is not yet being contemplated for the upcoming six months. Due to ignorance or inadequate knowledge of the effects of a certain behavior, many people at this stage are oblivious of or under aware of their problems. **Contemplation:** People are at the stage of contemplation when they are thinking about making a change and intend to act within the next six months. Although they are aware of the issue and are considering it seriously, they have not yet committed to taking action. **Preparation:** An individual is in the stage of preparation when they are planning to act in the upcoming month. The individual has made plans for taking action, such as seeing a counselor, speaking with a doctor, purchasing equipment. **Action**: Within the last six months, there has been a brief change in behavior. **Maintenance**: Long-term behavior modification in which people have been using their new habits for at least six months.

The two primary behavioral determinants are self-efficacy and decisional balance. **Decisional balance**: It is the equilibrium between the benefits of forming a new habit (the pros) and the drawbacks (the cons) of doing so (Koyun & Eroglu, 2014). The TTM states that change happens when benefits outweigh costs (Yasin et al., 2011). **Self-efficacy**: This is the sense of assurance people have in their capacity to carry out a specific behavior successfully (Koyun & Eroglu, 2014). The TTM is successfully used in a range of health education initiatives, including weight control (Carter et al., 2013), drug addiction rehabilitation and quitting smoking (Stanton & Grimshaw, 2013). Self-regulatory actions involving the adoption of health-improving activities can help remove health damaging behaviors. According to studies, tailored interventions are more successful than conventional therapy at promoting long-lasting behavior change (Celis-Morales et al., 2017; Do Amaral e Melo et al., 2017). Hence, we aimed at determining the efficiency of the TTM-based health education intervention in encouraging lifestyle changes among individuals with metabolic syndrome.

1.1. Literature Review

CVD is a severe public health burden in the less developed nations, where awareness level and diagnostic rates are still poor (Bigna & Noubiap, 2019). The risk of type-2 diabetes and CVD is significantly increased by MetS. As a result, diabetes, coronary heart disease, hypertension, and stroke are all becoming more commonplace globally (Van Namen et al., 2019). In the less developed nations, CVDs are expensive to identify and treat, leading to premature death among the most productive individuals in the society. CVD is becoming more common in the Sub-Saharan African (SSA) nations (Hamid et al., 2019) and the prevalence is anticipated to double by 2030 due to population growth and lifestyle choices (Ndejjo et al., 2020). In Kenya, the major CVD risk factors such as alcohol misuse, unhealthy diets and overweight are high and rising (Kimani et al., 2019; Okube et al., 2020). In Kenya, CVD account for 26% of all NCD-related fatalities (Wekesah et al., 2020).

New approaches for maintaining a healthy lifestyle are required to address the rising CVD risk factors and help communities to attain improved cardiovascular health outcomes in the less developed nations. A recent meta-analysis discovered that lifestyle change interventions significantly improved the majority of MetS indicators (Van Namen et al., 2019). However, adherence to the recommended lifestyle changes is a major challenge for the prevention and treatment of lifestyle-related diseases. The TTM, which has been used to several health disorders such as smoking, drug addiction, and obesity, was proposed to encourage behavioral changes (Stanton & Grimshaw, 2013). Despite the evidence, little is known about the effectiveness of TTM-stage-based health education intervention in promotion of lifestyle changes among adults with MetS. This study looked at how well a TTM-based health education intervention affected adults with metabolic syndrome's ability to change their lifestyles.

1.2. Difference Between the Trans-Theoretical Model and Motivational Interviewing

In the literature, there is a correlation between interventions based on the Motivational Interviewing (MI) and the

Trans-theoretical Model (TTM) of Behavior Change (Miller & Rollnick, 2013). Understanding what triggers behavior change and how it could happen is possible using the TMM of Behavior Change (Prochaska & DiClemente, 1984). Conversely, MI is a unique counseling strategy that maximizes the person's motivation for change (Hoy et al., 2016; Martinasek et al., 2021). The goal of MI as an intervention is to facilitate the TTM of change's stages of progression. According to Miller and Rollnick (2009), MI is a cooperative, person-centered method of leading that elicits and strengthens motivation for change.

Four basic processes—engaging, focusing, evoking, and planning—are involved in MI, according to Miller and Rollnick (2009). Engaging refers to a method that understands the client's challenge toward behavioral adjustments by using a person-centered counseling strategy demonstrated by active listening. By establishing an agenda and finding out what matters to the client, focusing involves assisting the client in reaching a desired behavior. Focusing involves assisting the client in reaching a desired behavior by establishing a specific agenda and finding out what matters to the client. Evoking is the transition to MI where the therapist or counselor engages in selective eliciting, responding and summaries. Building a bridge to client change is the process of planning. Together, the client and the therapist develop a strategy for change and strengthen the client's resolve to make the necessary changes. In particular, clients who are pre-contemplative or contemplative stage of the TMM about their conduct benefit the most from MI. However, MI style is less appropriate for clients in the action stage, who have already surmounted the main obstacles to change. To sum up, the TTM provides an understanding of the broader process involved in altering a challenging habit, while MI is a particular intervention that falls into a particular phase of the TTM process.

1.3. Success of Motivational Interviewing on MetS Components

Following exercise intervention employing motivational interviewing, a recently completed randomized controlled trial study found that majority of the components of MetS were less prevalent among the intervention group compared to the control group (Suire et al., 2022). Another study also discovered that the telephone-based motivational interviewing group significantly improved their weekly physical activity and metabolic syndrome status when compared to a usual care control group (Lin et al., 2016).

2. Methods

2.1 Study Setting

The participants were recruited from the outpatient department of St. Mary's Mission Hospital in Nairobi, and they were followed in the community for 12-month period. The hospital is situated in the adjacent Kibera shantytown. It is a facility founded on the Christian faith that is committed to giving low-income slum dwellers access to quality healthcare service at a reasonable cost. The Kibera slum is the largest and poorest in all of Africa, with an average household monthly income of USD 39 (Desgroppes & Taupin, 2011). Indeed, the population of Kibera is disproportionately affected by poor socioeconomic determinants of health, including limited access to healthcare services, unemployment and job insecurity, housing, and clean water. People with low socioeconomic status have a higher risk of developing CVDs due to exposure to unhealthy behaviours, stress related to their psychosocial environment, and lack of access to high-quality healthcare resources (Van de Vijver et al., 2015). According to a study conducted in the Kibera slum, Nairobi, there are high rates of the main risk factors for CVDs, such as smoking, poor dietary patterns, and excessive alcohol consumption (Hulzebosch et al., 2015).

2.2. Design, Sampling Procedures, and Study Respondents

The study was a two-arm randomized controlled trial design comparing a TTM stage-based health education intervention with standard CVD care to promote lifestyle changes among adults with MetS for a period of 12 months. Individuals who visited the outpatient clinic of the study hospital were screened and evaluated for MetS using the revised International Diabetes Federation criteria, which considers gender and race-specific waistline measurement cutoffs (Alberti et al., 2009). Accordingly, central obesity (a waist measurement greater or equal to 80 cm for women and greater or equal to 94 cm for men) plus at least two of the major four CVD risk factors are considered for the presence of MetS in Sub-Saharan African nations. These are; (**1**) raised level of triglycerides (TGs) greater or equal to 1.7 mmol/L; (**2**) low level of high-density lipoprotein cholesterol (HDL-C) less than 1.29 mmol/L in females and less than1.03 mmol/L in males; (**3**) raised BP: systolic BP of greater or equal to 130 mm Hg and/or diastolic BP of greater or equal to 85 mm Hg or known hypertensive; (**4**) elevated fasting blood glucose (FBG) level of greater or equal to 5.6 mmol/L or known type-2 diabetes.

Age 18–64 and presence of MetS were the inclusion criteria at the baseline. Women who were pregnant or nursing, and those who had major illnesses like cancer, cardiovascular events, mental illnesses, or physical disabilities, were excluded from the study. Using a block stratified randomization technique, participants who met the inclusion criteria were recruited and randomly assigned to receive either standard CVD care ($n = 176$) or a TTM stage-based lifestyle modification intervention ($n = 176$). The procedure entailed grouping the participants into blocks of, on average, 16 subjects each. A written piece of paper was used to randomly

place people from each block into the intervention or control group. Two research assistants handled participant recruitment, while the primary investigator determined the randomization of the groups. During the randomization, the research assistants and the subjects were blinded. Measurements were made in laboratories, clinical settings, and physically by experts who had no knowledge of the groups. Those who live together and are members of the same family were allocated to the same group in order to reduce treatment contamination between intervention and control participants.

2.3 Intervention

2.3.1 Standard Care. The participants in the control arm received their screening results and standard CVD care at the baseline and second visit (month 6). Clinical/laboratory investigations, medication-assisted therapy, and post-discharge general health education are all included in standard CVD care, which is delivered by medical staff in accordance with hospital policy. For instance, if someone is identified as having hypertension, the person gets prescription for anti-hypertension medication and general guidance. No TTM stage-based suggested food intake patterns (vegetables, fruits, salt, sugar, etc.), use of alcohol, and physical activity was provided at baseline and halfway, which was reserved for participants in the intervention arm. However, after the evaluation phase (endpoint), the participants in the control group received a thorough TTM stage-based targeted lifestyle change intervention, together with a health education package and brochures. Unaware participants but found with diabetes (FBG greater or equal to 7.0 mmol/L) and/or high BP (greater or equal to 140/90 mmHg) were advised to visit the hospital's clinic for additional testing and follow-up.

2.3.2 TTM Stage-Based Lifestyle Modification Intervention. The TTM was utilized to offer stage-based individualized intervention for dietary, alcohol intake, physical activity, and smoking cessation modifications. The intervention group received TTM stage-tailored intervention in addition to standard CVD care at baseline, six and twelve months to increase intake of physical activity, intake of vegetables, fruits, legumes, nuts, cereals, and control intake of alcohol, saturated and processed foods, sugar and salt. Hence, the total period for the intervention was 12 months. The intervention was administered by determining the individuals' present stage of change with reference to their readiness to modify their lifestyle and the extent of their lifestyle modifications. The ideas of the stages of change, self-efficacy, and the pros and cons of decisional balance were rearranged based on the assessment results in order to provide stage-matched interventions. Three face-to-face contact sessions and at least two online coaching sessions through email, Whatsapp, or direct phone call took place during the 12-month intervention period.

2.4 Measurements

Two nurse research assistants who had been trained in research protocols collected the primary data. A healthy lifestyle practice (dietary and alcohol intake patterns, cigarette smoking, and physical activity) was examined at baseline and endpoint using three major TTM components (self-efficacy, the benefits (pros) and drawbacks (cons) of decisional balancing and stages of change).

2.4.1. Assessment of Stages of Change Towards Lifestyle Modification. Questionnaire on the stages of change for fruits and vegetables intake designed by Ma et al. (2002) and level of physical activity by Marcus et al. (1992) were used to evaluate the respondents' stages of change. Nine behavioural patterns including intake of vegetables, fruits, processed foods, sugar, salt, follow the Dietary Approaches to Stop Hypertension (DASH) diet, use of alcohol, smoking, and level of physical activity, were used to measure respondents' stages of change toward lifestyle characteristics. Participants indicated their present intentions to change for each of the nine behavioral patterns by selecting one of five statements. Pre-contemplation received a score of 1, contemplation a score of 2, preparation a score of 3, action a score of 4, and maintenance a score of 5. After the data had been gathered, the first three components of the model (preparation, contemplation and pre-contemplation) were combined together as a pre-action stage.

Then, pre-action respondents were given "**1 score**," action respondents were given a "**2 scores**," and maintenance respondents were given a "**3 scores**". The maximum score for the stage of change for the aforementioned 9 variables was 27. Their total score was transformed into percentages to evaluate the overall level of commitment to adopt a healthy lifestyle. The respondents' total degree of adherence to a healthy lifestyle was classified as low (< 50%), moderate (50–74%) and high (≥75%) after translating the total score into a percentage.

2.4.2. Determination of Self-Efficacy in Relation to Lifestyle Modification. Nine factors were used to measure self-efficacy in relation to patterns of dietary intake (salt, sugar, follow the DASH diet, vegetables, fruits and processed food), alcohol use, cigarette smoking, and degree of physical activity. A 3-point Likert scale that has undergone validity and reliability testing was used to rate the respondents for each variable (Louangrath & Sutanapong, 2018). The respondents were asked to rate their confidence in following the suggested healthy lifestyle on a scale of 1 to 3, with 3 denoting "extremely confident," 2 denoting "somewhat confident," and 1 denoting" not at all confident". Consequently, 27 was the highest possible self-efficacy score.

2.4.3. Determination of Pros and Cons of Decisional Balance in Relation to Lifestyle Modification. A valid questionnaire established by Nigg et al. (1998) was used to evaluate decisional

balance with reference to lifestyle adjustment. This was evaluated by asking the respondents what weight they assigned to each of the benefits and drawbacks in making the decision to lead a healthy lifestyle. This was measured using 11 cons to evaluate obstacles to adopting a healthy lifestyle and 15 pros to evaluate perceived benefits. A 3-point Likert scale was used to rate each item. Scores for pros ranged from 1 for disagree, 2 for somewhat agree and 3 for agree. The cons scores were 3 for agree, 2 for somewhat agree, and 1 for disagree. The pros and cons were given a maximum score of 45 and 33, respectively.

2.5 The Questionnaire's Validity and Reliability

The questionnaires were adopted from literature on the stage of change for fruits and vegetables intake designed by Ma et al. (2002) and level of physical activity by Marcus et al. (1992) which were tested for their Validity and reliability. Additionally, experts in the fields of nutrition and cardiovascular disease examined the tools' content validity to ensure their completeness and relevance. The final questionnaire included the suggestions and recommendations. A test-retest method was utilized to assess the questionnaire's reliability. After three weeks, a duplicate pre-test was administered to determine the degree of agreement between the two results. The duplicate pre-test produced a kappa score of 0.91, indicates its reliability.

2.6 Ethical Consideration

An Ethical Review Committee (ERC) board constituted by the University of Nairobi and Kenyatta National Hospital approved the study (Reference number: P430.07/2017). Prior to being enrolled in to study, all the participants gave their written informed permission. In order to safeguard the participants' privacy, all of the data obtained remained anonymous and was handled with absolute confidentiality.

3.7 Statistical Analyses

The SPSS software (Ver.22) was utilized to analyse the data. Significant difference for categorical variables between the two groups was established using the Pearson chi-square test of independence. The participants' mean differences in subtotal TTM concept scores between before and after intervention was tested using a paired *t*-test. At *p*-value <0.05, the results were deemed statistically significant.

3.8. Participants' Recruitment and Follow-up

Four hundred and four persons who had central obesity were examined for the presence of MetS; 352 were determined to be affected. Participants with MetS were randomly assigned to either standard CVD care group or a TTM stage-based health education intervention group over a 12-month period. Of the 352 participants, 294 (control =138; intervention = 156) completed the study period. Fifty eight individuals (control = 38; intervention = 20) left the study mostly due to poor compliance and lost follow-up. A few left the program due to residence relocation, travel to other counties, and pregnancies of two women. There was no noticeable difference in terms of sociodemographic and lifestyle patterns between those who left the study and those who completed it (Figure 1).

3. Results

3.1 Participants' Stages of Changes in Relation to Adoption of a Healthy Lifestyle Before the Intervention

The demographic profiles of the two groups were well elaborated in our recently published work (Okube et al., 2023). At baseline, most of the participants were at pre-action stage of change for intake of the required amounts of salt, sugar, fruits and vegetables, use of the DASH diet, and alcohol with no significant difference between the groups. At baseline, there was no discernible ($p = 0.456$) variance between the two groups regarding overall commitment to adopt a healthy lifestyle (Table 1).

3.2 Stages of Change Leading to the Eventual Goal of Adopting a Healthy Lifestyle at the Endpoint

In general, both groups' lifestyle patterns improved at the endpoint in comparison to the baseline. At the study's endpoint, however, significantly ($p < 0.001$) more members of the intervention group than the control group had reached the maintenance stage of change with regard to eating fruits and vegetables, adhering to the DASH diet, reducing processed food intake, limiting salt and sugar, and engaging in the recommended amount of physical activity. Overall, the intervention group (68.6%) had a significantly ($p < 0.001$) higher level of change leading to adoption of a healthy lifestyle than the control group (25.4%) at the endpoint (Table 2).

3.3 Participants' Perceptions of the Pros of Acquiring a New Behavior Before the Intervention

Approximately, one-third of the participants (36.5% from the intervention and 31.9% from the control groups) felt that fruits and vegetables provide a good alternative to junk food. The majority of participants concurred that eating at least five servings of vegetables & fruits each day could aid in preventing diabetes and high blood pressure. Nearly half (44.9%) of the intervention group and a third (37.7%) of the control group thought that consuming vegetables and fruits regularly could help them lose extra weight. The majority of respondents, however, concurred that they were unable

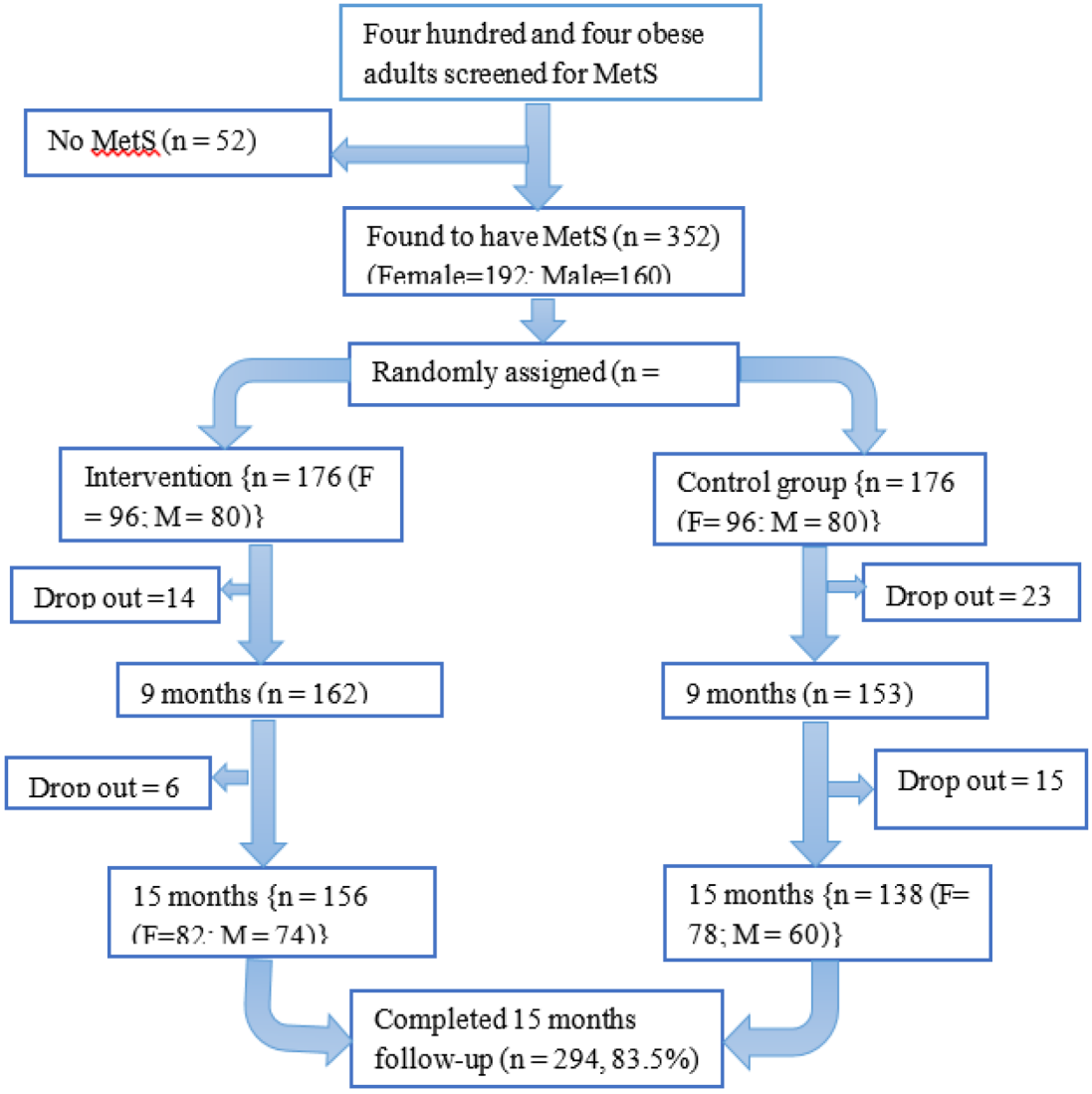

Figure 1. Consort Flow Diagram of the Study Participation (F = Female; M = Male).

to find fairly priced vegetables and fruits in their neighborhood markets. The majority of the participants in both groups agreed that consuming the suggested amounts of sugar and salt, cutting back on processed foods and fast food, exercising for at least 30 min, five to seven days a week, and avoiding or limiting alcohol use could all help people prevent hypertension and diabetes. There was no discernible difference between the two groups in their perceptions of the pros of acquiring a new behavior at baseline (Table 3).

3.4 Participants' Perceptions of the Pros of Acquiring a New Behavior After the Intervention

The number of people in the intervention arm who felt that regular consumption of fruits and vegetables could help them achieve a healthy weight ($p < 0.001$), that they are a good replacement for junk food ($p < 0.001$), and that eating at least five servings of vegetables and fruits per day could help them avoid high BP and diabetes ($p = 0.001$) was significantly higher than that of participants in the control group at the endpoint. However, only a fifth (20.3%) of the control group and a third (31.4%) of the intervention group agreed that their local markets offer reasonably priced fruits and vegetables. At the end of the intervention, considerably ($p < 0.05$) more participants from the intervention arm than the control arm concurred that limiting their intake of salt to less than one tea spoon per day, sugar to less than five tea spoons per day, reducing or totally avoiding processed foods, and alcohol could help them avoid developing hypertension and diabetes. Additionally, considerably ($p = 0.001$) more participants from the intervention group than to those in the control side agreed that exercising for at least 30 min, five to seven days a week, could help them avoid developing hypertension and diabetes (Table 4).

Table 1. Stages of Changes in Relation to Adoption of a Healthy Lifestyle Before the Intervention (*n*, %).

	Stages of change towards adoption of a healthy lifestyle at the baseline						
Groups	Pre-action	Action	Maintenance	Total	Chi-square	df	*p*-value
		Stages of fruits intake					
Control	112 (81.2)	17 (12.3)	9 (6.5)	138 (100)	1.287	2	0.526
Intervention	124 (79.5)	25 (16.0)	7 (4.5)	156 (100)			
Total	236 (80.3)	42 (14.3)	16 (5.4)	294 (100)			
		Stages of vegetables intake					
Control	111 (80.4)	16(11.6)	11(8.0)	138(100)	2.535	2	0.282
Intervention	128 (82.1)	22 (14.1)	6(3.8)	156 (100)			
Total	239 (81.3)	38(12.9)	17(5.8)	294(100)			
		Stages of following the DASH diet					
Control	119 (86.2)	18(13.0)	1(0.7)	138(100)	1.448		0.517[a]
Intervention	130 (83.3)	22(14.1)	4(2.6)	156(100)			
Total	249 (84.7)	40(13.6)	5 (1.7)	294 (100)			
		Stages of processed food intake					
Control	90 (65.2)	11(8.0	37 (26.8)	138 (100)	0.998	2	0.607
Intervention	106 (67.9)	8(5.1)	42 (26.9)	156 (100)			
Total	196 (66.7)	19 (6.5)	79 (26.9)	294(100)			
		Stages of recommended salt intake					
Control	88 (63.8)	14 (10.1)	36 (26.1)	138 (100)	1.542	2	0.463
Intervention	107 (68.6)	10 (6.4)	39 (25.0)	156 (100)			
Total	195 (66.3)	24(8.2)	75(25.5)	294(100)			
		Stages of recommended sugar intake					
Control	85 (61.6)	22(15.9)	31(22.5)	138(100)	1.282	2	0.527
Intervention	99 (63.5)	18(11.5)	39(25.0)	156(100)			
Total	184 (62.6)	40 (13.6)	70 (23.8)	294(100)			
		Stages of alcohol use ($n = 110$)					
Control	29(56.9)	0(0.0)	22(43.1)	51(100)	1.216		0.752[a]
Intervention	34(57.6)	0(0.0)	25(42.4)	59(100)			
Total	63(57.3)	0(0.0)	47(42.7)	110(100)			
		Stages of engaging in the required levels of physical activity					
Control	108 (78.3)	10(7.2)	20(14.5)	138 (100)	5.280	2	0.071[a]
Intervention	133 (85.3)	3(1.9)	20(12.8)	156 (100)			
Total	241 (82.0)	13(4.4)	40 (13.6)	294 (100)			
		Overall adherence levels to a healthy lifestyle					
	Low	Moderate	High				
Control	32(23.2)	103(74.6)	3(2.2)	138 (100)	1.568		0.456[a]
Intervention	46(29.5)	107(68.6)	3(2.9)	156 (100)			
Total	78 (26.5)	210 (71.4)	6 (2.0)	294 (100)			

[a]Analyzed using Fisher's exact test.

3.5 Participants' Perceptions of the Cons of Acquiring a New Behavior Before the Intervention

Most of the participants stated that eating at least five servings of vegetables and fruits in a day is too challenging due to their high price. Each group had around a third of the participants who said they were concerned about the safety of the chemicals used in vegetables and fruits. About a third of the participants (35.5% from control and 37.2% from intervention groups) expressed that it is challenging to limit one's daily sugar and salt intake. Approximately half of the participants (51.3% from the intervention and 44.9% from the control groups) felt that food with less salt or sugar or none at all has no flavor. Most of the participants (control = 58.7%; intervention = 50.0%) agreed that because processed foods are so widely available, it is challenging to limit or avoid consuming them. Of those alcohol drinkers, most concurred that it is challenging for them to restrict or avoid it at all. A small fraction (10.5%) of the control group and one-third (33.3%) of the intervention group concurred that quitting smoking is difficult for them. Of the participants, roughly one-third (control = 40.6%; intervention =

Table 2. Participants' Stages of Change Leading to Adopting a Healthy Lifestyle at the Endpoint (*n*, %).

	Stages of change towards adoption of a healthy lifestyle at the endpoint						
Group	Pre-action	Action	Maintenance	Total	Chi-square	df	*p*-value
		Stages of fruits intake					
Control	86(62.3)	24(17.4)	28(20.3)	138 (100)	22.227	2	0.000
Intervention	58(37.2)	29(18.6)	69(44.1)	156 (100)			
Total	144(49.0)	53(18.0)	97(33.0)	294 (100)			
		Stages of vegetables intake					
Control	61(44.2)	9(6.5)	68(49.3)	138(100)	14.290	2	0.001
Intervention	42(26.9)	4(2.6)	110(70.5)	156 (100)			
Total	103(35.0)	13(4.4)	178(60.5)	294(100)			
		Stages of following the DASH diet					
Control	103(74.6)	12 (8.7)	23(16.7)	138(100)	65.242	2	0.000
Intervention	43(27.6)	46 (29.5)	67(42.9)	156(100)			
Total	146 (49.7)	58(19.7)	90(30.6)	294(100)			
		Stages of processed food intake					
Control	81(58.7)	7(5.1)	50(36.2)	138 (100)	24.424	2	0.000
Intervention	48(30.8)	21(13.5)	87(55.8)	156 (100)			
Total	129(43.9)	28(9.5)	137(46.6)	294(100)			
		Stages of recommended salt intake					
Control	30(21.7)	39(28.3)	69(50.0)	138 (100)	22.280	2	0.000
Intervention	7(4.5)	40(25.6)	109(69.9)	156 (100)			
Total	37(12.6)	79(26.9)	178(60.5)	294(100)			
		Stages of recommended sugar intake					
Control	51(37.0)	24(17.4)	63(45.7)	138(100)	35.307	2	0.000
Intervention	13(8.3)	42(26.9)	101(64.7)	156(100)			
Total	64(21.8)	66(22.4)	164(55.8)	294(100)			
		Stages of alcohol use					
Control	21(41.2)	0(0.0)	30(58.8)	51(100)	2.422	1	0.120
Intervention	16(27.1)	0(0.0)	43(72.9)	59(100)			
Total	37(33.6)	0(0.0)	73(66.4)	110(100)			
		Stages of exercising to the recommended levels					
Control	82(59.4)	15(10.9)	41(29.7)	138 (100)	18.416	2	0.000
Intervention	61(39.1)	10(6.4)	85(54.5)	156 (100)			
Total	143(48.6)	25(8.5)	`126(42.9)	294 (100)			
		Level of general adherence to a healthy lifestyle					
	Low	Moderate	High				
Control	5(3.6)	98(71.0)	35(25.4)	138 (100)	56.290		0.000[a]
Intervention	2 (1.3)	47(30.1)	107(68.6)	156 (100)			
Total	7(2.4)	145(49.3)	142(48.3)	294(100)			

[a]Analyzed using Fisher's exact test.

31.4%) felt they didn't have enough time to exercise five to seven days a week. Generally, there was no discernible difference in the two groups' perceptions of the drawbacks to changing to a healthier lifestyle at the baseline (Table 5).

3.6 Participants Perceptions of the Cons of Acquiring a New Behavior After the Intervention

At the endpoint, most of the participants in both the groups felt that eating at least five servings of fruits and vegetables each day is too expensive and challenging. Approximately a third of the intervention (34.6%) and control (38.4%) groups concurred that they are concerned about the risk of chemicals used in vegetables and fruits. A significantly ($p = 0.038$) higher percentage of participants in the control (44.9%) than in the intervention (31.4%) group agreed that they have limitation for including vegetables and fruits in their meals.

Most participants in the control group (52.9%) and almost a third in the intervention group (35.9%) expressed that processed/fast meals are widely available and thus difficult to limit or avoid them, with the control group's percentage being considerably ($p = 0.001$) higher than that of the intervention group. Most of those who take alcohol concurred that limiting or avoiding alcohol use is not difficult. A

Table 3. Participants' Perceptions of the Pros of Acquiring a New Behavior Before the Intervention (*n*, %).

Groups	Level of agreement of the pros of acquiring a new behavior at baseline			Total	Chi-square	df	*p*-value
	Disagree	Somewhat agree	Agree				
	Vegetables and Fruits are a good substitute for junk food						
Control	50(36.2)	44(31.9)	44(31.9)	138 (100)	2.878	2	0.237
Intervention	63(40.4)	36(23.1)	57(36.5)	156 (100)			
Total	113(38.4)	80(27.2)	101(34.4)	294 (100)			
	Consuming fruits and vegetables could aid in weight loss or maintenance of a healthy body weight.						
Control	61(44.2)	25(18.1)	52(37.7)	138 (100)	1.588	2	0.452
Intervention	60(38.5)	26(16.7)	70(44.9)	156 (100)			
Total	121(41.2)	51(17.3)	122(41.5)	294 (100)			
	I might be able to avoid developing high blood pressure and diabetes if I eat at least five servings of veggies and fruits each day.						
Control	5(18.1)	20(14.5)	93(67.4)	138 (100)	5.669	2	0.059
Intervention	23(14.7)	40(25.6)	93(59.6)	156 (100)			
Total	48(16.3)	60(20.4)	186(63.3)	294 (100)			
	In my neighborhood markets, I can get fruits and veggies for a reasonable price.						
Control	90(65.2)	27(19.6)	21(15.2)	138 (100)	4.327	2	0.115
Intervention	86(55.1)	32(20.5)	38(24.4)	156 (100)			
Total	176(59.9)	59(20.1)	59(20.1)	294 (100)			
	I might be able to avoid developing diabetes and hypertension if I keep my daily salt intake to no more than one tea spoon.						
Control	40(29.0)	43(31.2)	55(39.9)	138 (100)	4.477	2	0.107
Intervention	55(35.3)	32(20.5)	69(44.2)	156 (100)			
Total	95(32.3)	75(25.5)	124(42.2)	294 (100)			
	I might be able to avoid developing diabetes and hypertension if I keep my daily sugar intake to no more than five tea spoons.						
Control	42(30.4)	21(15.2)	75(54.3)	138 (100)	0.477	2	0.788
Intervention	43(27.6)	22(14.1)	91(58.3)	156 (100)			
Total	85-(28.9)	43-(14.6)	166-(56.5)	294 (100)			
	I might be able to avoid getting diabetes and high blood pressure if I limit or completely avoid processed meals.						
Control	40(29.0)	41(28.3)	56(42.8)	138 (100)	4.498	2	0.106
Intervention	54(34.6)	28(17.9)	74(47.4)	156 (100)			
Total	94(32.0)	67(22.8)	133(45.2)	294 (100)			
	I might be able to avoid developing diabetes and high blood pressure if I limit or stop alcohol drinking.						
Control	55(39.9)	46(33.3)	37(26.8)	138 (100)	1.653	2	0.437
Intervention	51(32.7)	57(36.5)	48(30.8)	156 (100)			
Total	106(36.1)	103(35.0)	85(28.9)	294 (100)			
	I could achieve or maintain a healthy weight by exercising for at least 30 min, 5–7 days a week.						
Control	45(32.6)	29(21.0)	64(46.4)	138 (100)	2.460	2	0.292
Intervention	38(24.4)	37(23.7)	81(51.9)	156 (100)			
Total	83(28.2)	66(22.4)	145(49.3)	294 (100)			
	I could avoid developing diabetes and hypertension by exercising for at least 30 min, 5–7 days a week.						
Control	18(13.0)	49(35.5)	71(51.4)	138 (100)	1.779	2	0.411
Intervention	29(18.7)	53(34.2)	73(47.1)	156 (100)			
Total	47(16.0)	102(34.8)	144(49.1)	294 (100)			

Table 4. Participants' Perceptions of the Pros of Acquiring a New Behavior After the Intervention (*n*, %).

Groups	Level of agreement of the pros of acquiring a new behavior at endpoint			Total	Chi-square	df	*p*-value
	Disagree	Somewhat agree	Agree				
	Vegetables and Fruits are a good substitute for junk food						
Control	22(15.9)	46(33.3)	70(50.7)	138 (100)	15.748	2	0.000
Intervention	15(9.6)	27(17.3)	114(73.1)	156 (100)			
Total	37(12.6)	73(24.8)	184(62.6)	294 (100)			
	Consuming vegetables and fruits might assist me in achieving or maintaining a healthy weight.						
Control	24(17.4)	46(33.3)	68(49.3)	138 (100)	21.410	2	0.000
Intervention	19(12.2)	21(13.5)	116(74.4)	156 (100)			
Total	43(14.6)	67(22.8)	184(62.6)	294 (100)			
	If I consume at least five servings of veggies and fruits each day, I might be able to prevent having high blood pressure and diabetes.						
Control	25(18.1)	31(22.5)	82(59.4)	138 (100)	14.113	2	0.001
Intervention	10(6.4)	24(15.4)	122(78.2)	156 (100)			
Total	35(11.9)	55(18.7)	204(69.4)	294 (100)			
	In my neighborhood markets, I can get vegetables and fruits for a reasonable price.						
Control	69(50.0)	41(29.7)	28(20.3)	138 (100)	4.757	2	0.093
Intervention	69(44.2)	38(24.4)	49(31.4)	156 (100)			
Total	138(46.9)	79(26.9)	77(26.2)	294 (100)			
	I might be able to avoid developing diabetes and hypertension if I keep my daily salt intake to no more than one tea spoon.						
Control	22(15.9)	42(30.4)	74(53.6)	138 (100)	20.695	2	0.000
Intervention	19(12.2)	17(10.9)	120(76.9)	156 (100)			
Total	41(13.9)	59(20.1)	194(66.0)	294 (100)			
	I might be able to avoid developing diabetes and hypertension if I keep my daily sugar intake to no more than five tea spoon.						
Control	17(12.3)	36(26.1)	85(61.6)	138 (100)	10.395	2	0.006
Intervention	7(4.5)	28(17.9)	121(77.6)	156 (100)			
Total	24(8.2)	64(21.8)	206(70.1)	294 (100)			
	I might be able to avoid getting diabetes and high blood pressure if I limit or completely avoid processed meals.						
Control	21(15.2)	36(26.1)	81(58.7)	138 (100)	12.264	2	0.002
Intervention	19(12.2)	18(11.5)	119(76.3)	156 (100)			
Total	40(13.6)	54(18.4)	200(68.0)	294 (100)			
	I might be able to avoid developing diabetes and high blood pressure if I limit or stop alcohol drinking.						
Control	9(6.5)	52(37.7)	77(55.8)	138 (100)	18.057	2	0.000
Intervention	6(3.8)	27(17.3)	123(78.8)	156 (100)			
Total	15(5.1)	79(26.9)	200(68.0)	294 (100)			
	I might be able to lose weight or maintain a healthy weight if I exercise for at least 30 min, five to seven days a week.						
Control	16(11.6)	39(28.3)	83(60.1)	138 (100)	10.754	2	0.005
Intervention	16(10.3)	21(13.5)	119(76.3)	156 (100)			
Total	32(10.9)	60(20.4)	202(68.7)	294 (100)			
	I could avoid developing diabetes and high blood pressure by exercising for at least 30 min, five to seven days a week.						
Control	11(8.0)	50(36.2)	77(55.8)	138 (100)	14.871	2	0.001
Intervention	10(6.4)	27(17.3)	119(76.3)	156 (100)			
Total	21(7.1)	77(26.2)	196(66.7)	294 (100)			

Table 5. Participants Perceptions of the Cons of Acquiring a New Behavior Before the Intervention (*n*, %).

	Level of agreement of the cons of acquiring a new behavior at baseline						
Groups	Disagree	Somewhat agree	Agree	Total	Chi-square	df	*p*-value
	The cost of buying fruits and vegetables is expensive.						
Control	23(16.7)	22(15.9)	93(67.4)	138 (100)	3.436	2	0.179
Intervention	32(20.5)	35(22.4)	89(57.1)	156 (100)			
Total	55-(18.7)	57-(19.4)	182-(61.9)	294 (100)			
	It's too challenging to eat at least five servings of fruits and veggies every day.						
Control	42(30.4)	15(10.9)	81(58.7)	138 (100)	5.072	2	0.079
Intervention	42(26.9)	32(20.5)	82(52.6)	156 (100)			
Total	84-(28.6)	47-(16.0)	163-(55.4)	294 (100)			
	I have a concern about the safety of chemicals used in fruits and vegetables.						
Control	18(13.0)	74(53.6)	46(33.3)	138 (100)	4.934	2	0.085
Intervention	36(23.1)	75(48.1)	45(28.8)	156 (100)			
Total	54-(18.4)	149-(50.7)	91-(31.0)	294 (100)			
	I find it difficult to include fruits and veggies into my everyday meals.						
Control	45(32.6)	27(19.6)	66(47.8)	138 (100)	1.285	2	0.526
Intervention	49(31.4)	39(25.0)	68(43.6)	156 (100)			
Total	94-(32.0)	66-(22.4)	134-(45.6)	294 (100)			
	It is challenging to regulate one's daily intake of sugar and salt.						
Control	42(30.4)	47(34.1)	49(35.5)	138 (100)	0.859	2	0.651
Intervention	40(25.6)	58(37.2)	58(37.2)	156 (100)			
Total	82-(27.9)	105-(35.7)	107-(36.4)	294 (100)			
	Food that has less salt or sugar or neither is tasteless.						
Control	33(23.9)	43(31.2)	62(44.9)	138 (100)	5.336	2	0.069
Intervention	21(13.5)	55(35.3)	80(51.3)	156 (100)			
Total	54-(18.4)	98-(33.3)	142-(48.3)	294 (100)			
	The availability of junk foods makes it challenging to restrict or avoid them.						
Control	31(22.5)	26(18.8)	81(58.7)	138 (100)	2.273	2	0.321
Intervention	41(26.3)	37(23.7)	78(50.0)	156 (100)			
Total	72(24.5)	63(21.4)	159(54.1)	294 (100)			
	I find it challenging to restrict or stop alcohol intake.						
Control	22(43.1)	0(0.0)	29(56.9)	51(100)	0.007	1	0.936
Intervention	25(42.4)	0(0.0)	34(57.6)	59(100)			
Total	47-(42.7)	0-(0.0)	63-(57.3)	110(100)			
	I find it challenging to give up smoking.						
Control	10(52.6)	7(36.8)	2(10.5)	21(100.0)	2.982		0.250[a]
Intervention	9(42.9)	5(23.8)	7(33.3)	19(100.0)			
Total	19-(47.5)	12-(30.0)	9-(22.5)	40(100.0)			
	I believe I don't have the time to exercise five to seven days a week.						
Control	50(36.2)	32(23.2)	56(40.6)	138 (100)	3.538	2	0.170
Intervention	58(37.2)	49(31.4)	49(31.4)	156 (100)			
Total	108-(36.7)	81-(27.6)	105-(35.7)	294 (100)			

[a]Analyzed using Fisher's exact test.

quarter (28.6%) of the intervention group and a negligible percentage (10.5%) of the control group of the active smokers agreed that it is difficult for them to quit. A small percentage (9.6%) of the intervention group and about a fifth (19.6%) of the control group agreed that they lack enough time for physical activity for five to seven days per week, with the control group's percentage being considerably ($p = 0.018$) higher than the intervention group's (Table 6).

Table 6. Participants Perceptions of the Cons of Acquiring a New Behavior After the Intervention (*n*, %).

	Level of agreement of the cons of acquiring a new behavior at endpoint						
Groups	Disagree	Somewhat agree	Agree	Total	Chi-square	df	*p*-value
Groups	The cost of buying fruits and vegetables is expensive.						
Control	34(24.6)	22(15.9)	82(59.4)	138 (100)	3.246	2	0.197
Intervention	33(21.2)	38(24.4)	85(54.5)	156 (100)			
Total	67-(22.8)	60-(20.4)	167-(56.8)	294 (100)			
	Consuming at least five servings of fruits and vegetables each day is too challenging.						
Control	32(23.2)	15(10.9)	91(65.9)	138 (100)	5.953	2	0.051
Intervention	50(32.1)	25(16.0)	81(51.9)	156 (100)			
Total	82-(27.9)	40-(13.6)	172-(58.5)	294 (100)			
	The chemicals applied to vegetables & fruits worry me a lot.						
Control	30(21.7)	55(39.9)	53(38.4)	138 (100)	0.474	2	0.789
Intervention	37(23.7)	65(41.7)	54(34.6)	156 (100)			
Total	67-(22.8)	120-(40.8)	107-(36.4)	294 (100)			
	I find it difficult to include veggies & fruits into my everyday meals.						
Control	46(33.3)	30(21.7)	62(44.9)	138 (100)	6.558	2	0.038
Intervention	72 (46.2)	35(22.4)	49(31.4)	156 (100)			
Total	118-(40.1)	65-(22.1)	111-(37.8)	294 (100)			
	It is challenging to regulate one's daily intake of sugar and salt.						
Control	57(41.3)	29(21.0)	52(37.7)	138 (100)	15.722	2	0.000
Intervention	100 (64.1)	17(10.9)	39(25.0)	156 (100)			
Total	157-(53.4)	46-(15.6)	91-(31.0)	294 (100)			
	Food that has less salt or sugar or neither is tasteless.						
Control	29(21.0)	49(35.5)	60(43.5)	138 (100)	12.319	2	0.002
Intervention	61(39.1)	36(23.1)	59(37.8)	156 (100)			
Total	90-(30.6)	85-(28.9)	119-(40.5)	294 (100)			
	It can be challenging to restrict the consumption of processed foods due to their availability.						
Control	35(25.4)	30(21.7)	73(52.9)	138 (100)	13.432	2	0.001
Intervention	71(45.5)	29(18.6)	56(35.9)	156 (100)			
Total	106-(36.1)	59-(20.1)	129-(43.9)	294 (100)			
	I find it challenging to restrict or stop alcohol intake.						
Control	30(58.8)	0(0.0)	21(41.2)	51(100)	2.422	1	0.120
Intervention	43(72.9)	0(0.0)	16(27.1)	59(100)			
Total	73-(66.4)	0-(0.0)	37-(33.6)	110(100)			
	I find it challenging to give up smoking.						
Control	17(89.5)	0(0.0)	2(10.5)	19(100)	2.030[a]	1	0.241[a]
Intervention	15(71.4)	0(0.0)	6(28.6)	21(100)			
Total	32-(80.0)	0-(0.0)	8-(20.0)	40(100)			
	I don't think I have time to exercise 5–7 days a week.						
Control	69(50.0)	42(30.4)	27(19.6)	138 (100)	8.055	2	0.018
Intervention	100(64.1)	41(26.3)	15(9.6)	156 (100)			
Total	169-(57.5)	83-(28.2)	42-(14.3)	294 (100)			

[a]Analyzed using Fisher's exact test.

3.7. Mean Variations in the Study Subjects' Subtotal TTM Construct Scores Before and After the Intervention

The baseline and endpoint differences in the TTM core components are shown in Table 7. Stage of change, levels of self-efficacy, and decisional balance (pros, cons) are the three TTM domains that all significantly improved after the intervention compared to baseline in both groups. Specifically, participants in the intervention side substantially increased mean scores in the decisional balance of pros ($p < 0.001$), level of self-efficacy ($p < 0.001$), stage of change ($p < 0.001$),

Table 7. Mean Variations of Subtotal TTM Construct Scores Between Baseline and Endpoint (Mean ± SD).

Group	Max score	Baseline	Endpoint	Mean difference	Effect size (cohen's d value)	Paired *t*-test	df	*p*-value
		TTM constructs score						
	27	Stage of change						
Control		15.38(2.39)	18.57(3.27)	+3.19	1.11382654	−10.349	137	0.000
Intervention		15.13(2.42)	22.00(3.36)	+6.87	2.34633665	−22.570	155	0.000
	27	Self-efficacy						
Control		18.75(3.70)	18.86(3.22)	+0.11	0.0317157	-.264	137	0.792
Intervention		18.66(3.48)	22.03(3.33)	+3.37	0.989481	−9.341	155	0.000
	45	Decisional balance (pros)						
Control		32.62(4.69)	35.85(4.47)	+3.23	0.70503686	−10.798	137	0.000
Intervention		33.49(4.49)	39.20(4.37)	+5.71	1.28882085	−20.332	155	0.000
	33	Decisional balance (cons)						
Control		19.79(2.91)	19.13(3.06)	−0.66	−0.2210358	2.677	137	0.008
Intervention		19.33(3.03)	17.17(3.63)	−2.16	−0.6460323	8.070	155	0.000

and decreased decisional balance of cons ($p < 0.001$) at the endpoint relative to the baseline values. Similarly, participants in the control side considerably improved mean scores in the decisional balance of pros ($p < 0.001$), and stage of change ($p < 0.001$) and decreased in the decisional balance of cons ($p = 0.008$) at the endpoint relative to the baseline measurements. The level of self-efficacy construct in the control arm did not demonstrate considerable change at the endpoint when compared to baseline values.

4. Discussion

This study's primary objective was to assess the effectiveness of a TTM-based health education intervention in promoting behavioral changes in people with MetS. The study showed that, most of the participants in both the groups were in pre-action stage of change for dietary intake patterns, alcohol use (for alcohol consumers), and physical activity at the baseline. With regards to level of self-efficacy, most of the participants were either somewhat confident or not at all confident in their ability to follow a healthy lifestyle, with no discernible difference between the two groups. The baseline findings are consistent with a study performed by Holmen et al. (2016) that looked at "stages of change for physical activity and dietary habits among patients with type 2 diabetes" and revealed that the majority of the participants were in the pre-action stage of change for dietary practice at baseline. Similarly, the majority of the participants, according to Mohammadi (2013), who used the TTM to examine the exercise status of Iranian officers, were in the pre-action stage of change for physical activity.

Overall, the three TTM domains namely: stages of change, levels of self-efficacy, and pros & cons decisional balance toward adopting a healthy lifestyle were significantly improved at the endpoint compared to baseline values in both groups. At the endpoint, however, considerably a higher percentage of participants from the intervention arm had advanced to the maintenance stage of change for physical activity and most of the dietary intake patterns compared to those in control group. Individuals in the intervention group showed a considerably higher overall level of behavioral change than those in the control group at the endpoint. Moreover, the intervention group had a higher percentage of participants than the control group who were extremely confident in adopting a healthy lifestyle at the endpoint. Additionally, participants the intervention group significantly improved the overall mean scores in decisional balance pros, level of self-efficacy, and stages of change and decreased cons decisional-balance at the endpoint compared to the baseline values. Participants in the control group also showed a substantial improvement in mean scores of stage of change and decisional balancing pros and a decrease in cons decisional balance at the endpoint when compared to the baseline values. In the control group, the self-efficacy construct, however, showed no significant change. According to the findings, the TTM stage-based intervention was successful in raising participants' levels of self-efficacy, decisional balance, and readiness to adopt a healthy lifestyle. The plausible explanation for these notable changes in lifestyle modification is the comprehensive health education intervention based on the TTM framework, which supported cultivating greater efficacy of perceived benefits (pros) and decreasing the unfavorable perceptions (cons). The results lend credence to the idea that TTM can be used to prevent CVD.

The endpoint findings are consistent with a systematic review report of TTM's efficiency in managing behavioral change (Hashemzadeh et al., 2019). The findings also support a study performed by Nitzke et al. (2007) that evaluated "the efficacy of behavioral intervention to enhance fruits and vegetable intake among low-income adults. According to the report, more participants from the intervention arm consumed the recommended servings of fruit and vegetables and advanced to maintenance stage of change than those in the control arm after the intervention (Nitzke et al., 2007). Another report by Huang et al. (2013) showed that the majority of the study participants were in

the maintenance stage of change for dietary intake patterns after taking part in a TTM-based educational intervention. Similarly, a study performed in Turkey by Koyun and Eroglu (2014), revealed that progression to maintenance stage of change was considerably higher among members in the intervention arm relative to those in the control side after receiving TTM-Tailored health education intervention. According to a study by Ibrahim et al. (2017) about diet modification of antenatal mothers using the TTM framework, the participants in intervention group significantly outperformed the control group in terms of decisional-balance, level of self-efficacy, and stages of change at the endpoint compared to the baseline status.

According to our findings, perceived benefits (the pros) of acquiring a new behavior have greatly improved in the maintenance stage of change compared to the pre-action phase, while perceived drawbacks (the cons) have significantly decreased at the maintenance stage of change compared to the pre-action phase, which are in accordance to the findings of other researchers (Hashemzadeh et al., 2019; Kang et al., 2012). According to Mohsen et al.'s study (2014), which used a TTM-based intervention to promote lifestyle change, the intervention group's mean scores for the pros of decisional-balance and level self-efficacy regarding dietary management behavior were significantly higher than those of the control group, which is consistent with our findings. The two primary behavioral determinants are self-efficacy and decisional balance. Perceived benefits and drawbacks have been shown to be able to predict the stage of change, according to a study by Abbaspour et al. (2017). The model states that change happens when advantages (pros) outweigh disadvantages (cons) (Yasin et al., 2011). As a person progresses through the stages, the benefits of the new behavior are anticipated to grow, while the drawbacks are anticipated to diminish. As a result, behavioral change happens when supporters of the new conduct outweigh opponents.

The study also identified some perceived berries to adopt a healthy lifestyle among the studied population. The majority of respondents in both groups concurred that because they are so expensive to purchase, it is too challenging to consume the recommended servings of vegetables and fruits every day. They consequently have limited options for including fruits and vegetables in their regular diets. It is also interesting to note that, in each group, nearly one-third of the participants said they were concerned about the safety of the chemicals used in vegetables and fruits. According to Hromi-Fiedler et al.'s study (2016), which supports our findings, appropriate intake of fruits and vegetables is significantly hampered by the safety of the chemicals employed in producing them. Additionally, economic factors like income and cost, availability, and preferences are among the factors that have been identified as influencing the consumption of fruits and vegetables (Di Noia & Byrd-Bredbenner, 2014; Miller et al., 2016). According to a report by the Kenya Ministry of Health (2018), some of the obstacles to eating healthy diets in Kenya include poverty, social and cultural factors, urbanization, and globalization.

4.1 Strengths and Limitations

The study's randomized controlled design and the control of the effects of potential variables on the modification of lifestyle characteristics. The large sample size and long duration (12-month) of follow-up period enabled us to evaluate changes in lifestyle characteristics towards the common modifiable risk factors of CVDs. Participants who live together were allocated to the same group in order to reduce treatment contamination between intervention and control participants. There are a number of limitations to the current study that should also be mentioned, such as the absence of objective assessments of food intake or physical activity. Because participants might have inflated exercise levels and understated nutritional intake after the intervention, the likelihood of a reporting bias cannot be completely ruled out.

4.2. Implications for Nursing Practice

A nurse-led, TTM-tailored health education intervention for behavior modification was crucial in influencing respondents' actions in the direction of a healthy lifestyle for MetS control. Nurses play a key role to facilitate cardio-metabolic risk factor reduction in higher-risk individuals and communities. Targeting adults with elevated levels of multiple CVD risk factors is necessary for preventing the onset of cardio-metabolic diseases. To reduce the burden of CVD in the community, the team advises nurses and community health workers to employ TTM stage-based health education interventions for individuals who are at risk for CVDs such as those diagnosed with MetS.

4.3 Conclusion

In conclusion, our findings show that following the TTM-based health education intervention, the majority of the intervention group moved on to the maintenance stage of lifestyle modification. Participants' decisional balance, level of self-efficacy, and stages of change toward lifestyle modification were all considerably better than baseline. There was a notably greater overall levels of change toward adopting a healthy lifestyle in the intervention group when compared to the control group. The findings show how crucial the TTM-tailored educational intervention is for encouraging adjustments and tracking respondents' progress toward adopting a healthy lifestyle. TTM-tailored lifestyle intervention is a realistic and successful approach to change the major modifiable risk factors of CVD. This calls for nurses and community health workers to implement TTM stage-based health education intervention to reduce the burden of CVD in the community. The approach could include a health education plan centered on a health facility or a community-

based awareness creation strategy like outreach initiatives, church or school-based programs. In order to promote healthy lifestyles, national health promotion programs should take into account subsidizing healthy foods like fruits and vegetables and raising prices for harmful meals like processed/fast/junk foods.

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Authors' Contributions

The study's conception was shared by OT and SK. OT and SK involved in the design of the study including the study protocol. OT drafted the manuscript, which SK carefully edited. The final manuscript was reviewed and approved by both authors.

Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Ethical Consideration

An Ethical Review Committee (ERC) board constituted by the University of Nairobi and Kenyatta National Hospital approved the study (Reference number: P430.07/2017). Prior to being enrolled into study, each participant gave their written informed permission. In order to safeguard the participants' privacy, all of the data obtained remained anonymous and was handled with absolute confidentiality.

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References

Abbaspour, S., Farmanbar, R., Najafi, F., Ghiasvand, A. M., & Dehghankar, L. (2017). Decisional balance and self-efficacy of physical activity among the elderly in Rasht in 2013 based on the transtheoretical model. *Electronic Physician*, *9*(5), 4447. https://doi.org/10.19082/4447

Alberti, K. G., Eckel, R. H., Grundy, S. M., Zimmet, P. Z., Cleeman, J. I., Donato, K. A., Fruchart, J.-C., James, W. P. T., Loria, C. M., & Smith Jr, S. C. (2009). Harmonizing the metabolic syndrome: A joint interim statement of the International Diabetes Federation Task Force on Epidemiology and Prevention; National Heart, Lung, and Blood Institute; American Heart Association; World Heart Federation; International Atherosclerosis Society; and International Association for the Study of obesity. *Circulation*, *120*(16), 1640–1645. https://doi.org/10.1161/CIRCULATIONAHA.109.192644

Al-Qahtani, M. F. (2015). Health-promoting lifestyle behaviors among nurses in private hospitals in Al-Khobar, Saudi Arabia. *Journal of the Egyptian Public Health Association*, *90*(1), 29–34. https://doi.org/10.1097/01.EPX.0000461325.97703.8a

Bigna, J. J., & Noubiap, J. J. (2019). The rising burden of non-communicable diseases in sub-Saharan Africa. *The Lancet Global Health*, *7*(10), e1295–e1296. https://doi.org/10.1016/S2214-109X(19)30370-5

Bull, F. C., Al-Ansari, S. S., Biddle, S., Borodulin, K., Buman, M. P., Cardon, G., Carty, C., Chaput, J. P., Chastin, S., Chou, R., Dempsey, P. C., DiPietro, L., Ekelund, U., Firth, J., & Friedenreich, C. M. (2020). World health organization 2020 guidelines on physical activity and sedentary behaviour. *British Journal of Sports Medicine*, *54*(24), 1451–1462. https://doi.org/10.1136/bjsports-2020-102955

Cantiello, F., Cicione, A., Salonia, A., Autorino, R., De Nunzio, C., Briganti, A., Gandaglia, G., Dell'Oglio, P., Capogrosso, P., & Damiano, R. (2015). Association between metabolic syndrome, obesity, diabetes mellitus and oncological outcomes of bladder cancer: A systematic review. *International Journal of Urology*, *22*(1), 22–32. https://doi.org/10.1111/iju.12644

Carter, M. C., Burley, V. J., Nykjaer, C., & Cade, J. E. (2013). Adherence to a smartphone application for weight loss compared to website and paper diary: Pilot randomized controlled trial. *Journal of Medical Internet Research*, *15*(4), e32. https://doi.org/10.2196/jmir.2283

Celis-Morales, C., Livingstone, K. M., Marsaux, C. F., Macready, A. L., Fallaize, R., O'Donovan, C. B., Woolhead, C., Forster, H., Walsh, M. C., Navas-Carretero, S., San-Cristobal, R., & Food4Me Study. (2017). Effect of personalized nutrition on health-related behaviour change: Evidence from the Food4me European randomized controlled trial. *International Journal of Epidemiology*, *46*(2), 578–588. https://doi.org/10.1093/ije/dyw186

Desgroppes, A., & Taupin, S. (2011). Kibera: The biggest slum in Africa? *Les Cahiers D'Afrique de L'Est/The East African Review*, *1*(44), 23–33. https://doi.org/10.4000/eastafrica.521

Di Noia, J., & Byrd-Bredbenner, C. (2014). Determinants of fruit and vegetable intake in low-income children and adolescents. *Nutrition Reviews*, *72*(9), 575–590. https://doi.org/10.1111/nure.12126

Do Amaral e Melo, G. R., de Carvalho Silva Vargas, F., dos Santos Chagas, C. M., & Toral, N. (2017). Nutritional interventions for adolescents using information and communication technologies (ICTs): A systematic review. *PLoS One*, *12*(9), e0184509. https://doi.org/10.1371/journal.pone.0184509

Glanz, K., Rimer, B. K., & Viswanath, K. (Eds.). (2008). *Health behavior and health education: Theory, research, and practice*. John Wiley & Sons.

Hamid, S., Groot, W., & Pavlova, M. (2019). Trends in cardiovascular diseases and associated risks in sub-Saharan Africa: A review of the evidence for Ghana, Nigeria, South Africa, Sudan and Tanzania. *The Aging Male*, *22*(3), 169–176. https://doi.org/10.1080/13685538.2019.1582621

Hashemzadeh, M., Rahimi, A., Zare-Farashbandi, F., Alavi-Naeini, A. M., & Daei, A. (2019). Transtheoretical model of health

behavioral change: A systematic review. *Iranian Journal of Nursing and Midwifery Research*, *24*(2), 83. https://doi.org/10.4103/ijnmr.IJNMR_94_17

Holmen, H., Wahl, A., Torbjornsen, A., Jenum, A. K., Småstuen, M. C., & Ribu, L. (2016). Stages of change for physical activity and dietary habits in persons with type 2 diabetes included in a mobile health intervention: The Norwegian study in RENEWING HEALTH. *BMJ Open Diabetes Research and Care*, *4*(1), e000193. https://doi.org/10.1136/bmjdrc-2016-000193

Hoy, J., Natarajan, A., & Petra, M. M. (2016). Motivational interviewing and the transtheoretical model of change: Under-explored resources for suicide intervention. *Community Mental Health Journal*, *52*(5), 559–567. https://doi.org/10.1007/s10597-016-9997-2

Hromi-Fiedler, A., Chapman, D., Segura-Pérez, S., Damio, G., Clark, P., Martinez, J., & Pérez-Escamilla, R. (2016). Barriers and facilitators to improve fruit and vegetable intake among WIC-eligible pregnant Latinas: An application of the health action process approach framework. *Journal of Nutrition Education and Behavior*, *48*(7), 468–477.e1. https://doi.org/10.1016/j.jneb.2016.04.398

Huang, C. M., Wu, H. L., Huang, S. H., Chien, L. Y., & Guo, J. L. (2013). Transtheoretical model-based passive smoking prevention programme among pregnant women and mothers of young children. *European Journal of Public Health*, *23*(5), 777–782. https://doi.org/10.1093/eurpub/cks177

Hulzebosch, A., van de Vijver, S., Oti, S. O., Egondi, T., & Kyobutungi, C. (2015). Profile of people with hypertension in Nairobi's slums: A descriptive study. *Globalization and Health*, *11*(1), 1–7. https://doi.org/10.1186/s12992-015-0112-1

Ibrahim, H. A. F., El Sayed, H. A. E., & Abd El-aal, E. M. (2017). Diet behavior modification of pregnant woman with iron deficiency Anemia using construct of the trans-theoretical model: A theory-based study. *IOSR Journal of Nursing and Health Science*, *6*(3), 72–85. https://doi.org/10.9790/1959-0603067285

International Diabetic Federation (IDF) (2015). Diabetes ATLAS, Seventh Edition.

Kang, S. J., Kim, S. C., & Kim, Y. H. (2012). Korean older adult's physical activity and its related psychosocial varieables. *Journal of Sports Science and Health*, *13*(3), 89–99. https://doi/abs/10.1177/00315125221126775

Kenya Ministry of Health (2018). Accelerating cardiovascular health and care in Kenya. Roadmap to reducing cardiovascular mortality through hypertension management. A partnership of the World Heart Federation and Access Accelerated (AA) Report; 1-4. https://world-heart-federation.org/wp-content

Kimani, S., Mirie, W., Chege, M., Okube, O. T., & Muniu, S. (2019). Association of lifestyle modification and pharmacological adherence on blood pressure control among patients with hypertension at Kenyatta National Hospital, Kenya: A cross-sectional study. *BMJ Open*, *9*(1), e023995. https://doi.org/10.1136/bmjopen-2018-023995

Koyun, A., & Eroglu, K. (2014). The transtheoretical model use for smoking cessation. *European Journal of Research on Education*, 130–134. http://iassr.org/journal

Lin, C. H., Chiang, S. L., Heitkemper, M. M., Hung, Y. J., Lee, M. S., Tzeng, W. C., & Chiang, L. C. (2016). Effects of telephone-based motivational interviewing in lifestyle modification program on reducing metabolic risks in middle-aged and older women with metabolic syndrome: A randomized controlled trial. *International Journal of Nursing Studies*, *1*(60), 12–23. https://doi.org/10.1016/j.ijnurstu.2016.03.003

Louangrath, P. I., & Sutanapong, C. (2018). Validity and reliability of survey scales. *International Journal of Social Research Methodology*, *4*(4), 99–114. https://doi.org/10.5281/zenodo.2545038

Ma, J., Betts, N. M., Horacek, T., Georgiou, C., White, A., & Nitzke, S. (2002). The importance of decisional balance and self-efficacy in relation to stages of change for fruit and vegetable intakes by young adults. *American Journal of Health Promotion*, *16*(3), 157–166. https://doi.org/10.4278/0890-1171-16.3.157

Marcus, B. H., Rossi, J. S., Selby, V. C., Niaura, R. S., & Abrams, D. B. (1992). The stages and processes of exercise adoption and maintenance in a worksite sample. *Health Psychology*, *11*(6), 386–395. https://doi.org/10.1037/0278-6133.11.6.386

Martinasek, M., Tamulevicius, N., Gibson-Young, L., McDaniel, J., Moss, S. J., Pfeffer, I., & Lipski, B. (2021). Predictors of vaping behavior change in young adults using the transtheoretical model: A multi-country study. *Tobacco Use Insights*, *14*(1), 1179173X20988672. https://doi.org/10.1177/1179173X20988672

Mendonça, F. M., de Sousa, F. R., Barbosa, A. L., Martins, S. C., Araújo, R. L., Soares, R., & Abreu, C. (2015). Metabolic syndrome and risk of cancer: Which link? *Metabolism*, *64*(2), 182–189. https://doi.org/10.1016/j.metabol.2014.10.008

Miller, V., Yusuf, S., Chow, C. K., Dehghan, M., Corsi, D. J., Lock, K., Popkin, B., Rangarajan, S., Khatib, R., Lear, S. A., Mony, P., Kaur, M., Mohan, V., Vijayakumar, K., Gupta, R., Kruger, A., Tsolekile, L., Mohammadifard, N., Rahman, O., & Mente, A. (2016). Availability, affordability, and consumption of fruits and vegetables in 18 countries across income levels: Findings from the Prospective Urban Rural Epidemiology (PURE) study. *The Lancet Global Health*, *4*(10), e695–e703. https://doi.org/10.1016/S2214-109X(16)30186-3

Miller, W. R., & Rollnick, S. (2009). Ten things that motivational interviewing is not. *Behavioural and Cognitive Psychotherapy*, *37*(2), 129–140. https://doi.org/10.1017/S1352465809005128

Miller, W. R., & Rollnick, S. (2013). *Motivational interviewing: Helping people change* (3rd ed.). Guilford Press.

Mohammadi, M. (2013). Application of transtheoretical model to exercise in office staff: Array. *Electronic Physician*, *5*(1), 588–593. https://doi.org/10.14661/2013.588-593

Mohsen, M. M., Saafan, N. A., Attia, A., & El-Abassy, A. (2014). Lifestyle behavior modification of mothers of diabetic children's through application of transtheoretical model of change. *Journal of Nursing & Care*, *3*(2), 1–10. https://doi.org/10.4172/2167-1168.1000153

Ndejjo, R., Nuwaha, F., Bastiaens, H., Wanyenze, R. K., & Musinguzi, G. (2020). Cardiovascular disease prevention knowledge and associated factors among adults in Mukono and Buikwe districts in Uganda. *BMC Public Health*, *20*(1), 1–9. https://doi.org/10.1186/s12889-020-09264-6

Nigg, C. R., Rossi, J. S., Norman, G. J., & Benisovich, S. V. (1998). Structure of decisional balance for exercise adoption. *Annals of Behavioral Medicine*, *20*(suppl), 211. https://www.academia.edu/23004647/Does_the_trans

Nitzke, S., Kritsch, K., Boeckner, L., Greene, G., Hoerr, S., Horacek, T., Kattelmann, K., Lohse, B., Oakland, M. J., Phillips, B., & White, A. (2007). A stage-tailored multi-modal intervention increases fruit and vegetable intakes of low-income

young adults. *American Journal of Health Promotion*, *22*(1), 6–14. https://doi.org/10.4278/0890-1171-22.1.6

Okube, O. T., Kimani, S., & Waithira, M. (2020). Association of dietary patterns and practices on metabolic syndrome in adults with central obesity attending a mission hospital in Kenya: A cross-sectional study. *BMJ Open*, *10*(10), e039131. https://doi.org/10.1136/bmjopen-2020-039131

Okube, O. T., Kimani, S. T., & Mirie, W. (2023). Effect of a nurse-led intervention on knowledge of the modifiable risk behaviors of cardiovascular disease: A randomized controlled trial. *SAGE Open Nursing*, *9*(1), 23779608231201044. https://doi.org/10.1177/23779608231201044

Peikani, F. A., Shahgholian, N., & Kazemi, A. (2018). The effect of health-belief-model-based training on behaviors preventing peritonitis in patients on peritoneal dialysis. *International Journal of Preventive Medicine*, *9*(1), 49. https://doi.org/10.4103/ijpvm.IJPVM_444_17

Prochaska, J. O., & DiClemente, C. C. (1984). *The transtheoretical approach: Crossing traditional boundaries of therapy*. Dow/Jones Irwin.

Prochaska, J. O., & DiClemente, C. C. (2003). Stages and processes of self-change of smoking: Toward an integrative model of change. *Journal of Consulting and Clinical Psychology*, *51*(3), 390–395. https://doi.org/10.1037/0022-006X.51.3.390

Sousa, P., Gaspar, P., Fonseca, H., Hendricks, C., & Murdaugh, C. (2015). Health promoting behaviors in adolescence: Validation of the Portuguese version of the Adolescent Lifestyle Profile. *Jornal de Pediatria*, *91*(4), 358–365. https://doi.org/10.1016/j.jped.2014.09.005

Spellman, C. W. (2009). Achieving glycemic control: Cornerstone in the treatment of patients with multiple metabolic risk factors. *Journal of Osteopathic Medicine*, *109*(s51), 8–13. https://doi.org/10.7556/jaoa.2009.20003

Stanton, A., & Grimshaw, G. (2013). Tobacco cessation interventions for young people. *Cochrane Database of Systematic Reviews*, *8*, CD003289. https://doi.org/10.1002/14651858.CD003289.pub5

Suire, K. B., Peart, A., Kavookjian, J., & Wadsworth, D. D. (2022). Impact of motivational interviewing as a follow-up to an exercise intervention among women with or at risk for metabolic syndrome: A randomized controlled trial. *SAGE Open Medicine*, *10*(1), 20503121211073434. https://doi.org/10.1177/20503121211073434

Van de Vijver, S., Oti, S., Addo, J., de Graft-Aikins, A., & Agyemang, C. (2015). Review of community-based interventions for prevention of cardiovascular diseases in low-and middle-income countries. *Ethnicity & Health*, *17*(6), 651–676. https://doi.org/10.1080/13557858.2012.754409

Van Namen, M., Prendergast, L., & Peiris, C. (2019). Supervised lifestyle intervention for people with metabolic syndrome improves outcomes and reduces individual risk factors of metabolic syndrome: A systematic review and meta-analysis. *Metabolism*, *101*(1), 153988. https://doi.org/10.1016/j.metabol.2019.153988

Wekesah, F. M., Klipstein-Grobusch, K., Grobbee, D. E., Kadengye, D., Asiki, G., & Kyobutungi, C. K. (2020). Determinants of mortality from cardiovascular disease in the slums of Nairobi, Kenya. *Global Heart*, *15*(1), 33. https://doi.org/10.5334/gh.787

Yasin, S. M., Taib, K. M., & Zaki, R. A. (2011). Reliability and construct validity of the Bahasa Malaysia version of transtheoretical model (TTM) questionnaire for smoking cessation and relapse among Malaysian adult. *Asian Pacific Journal of Cancer Prevention*, *12*(6), 1439–1443. https://api.semanticscholar.org/CorpusID:17014461