Effects of 8-week Aerobic exercise and Garlic-ginger mixture on body mass index, blood sugar, and waist circumference of type 2 diabetic patients

Kassa, M. D.[1], Umeta, B. T.[1] and Abinet Wolde, A. A.[2]

[1]*Department of Sport Science, Sports Academy, Jimma University, P.O.Box 378, Jimma, Ethiopia*
[2]*Department of Sport Science, Sport Science Academy, Haramaya University, P. O. Box 138, Dire Dawa, Ethiopia*

***Corresponding author:** melkamu.dugassa@ju.edu.et **Phone Number:** +251912202224

ABSTRACT

Background: *Type 2 diabetes mellitus is a prevalent metabolic condition that predisposes to atherosclerotic cardiovascular disease, and 6.28 % of the global population was living with diabetes in 2021. Objectives: This study aimed to determine the effects of aerobic exercise and garlic-ginger mixture on body mass index, fasting blood sugar, and waist circumference in patients with type 2 diabetes at Jimma University Medical Centre.*

Methods: *The experimental study involved 40 patients divided into four groups: garlic-ginger mixture group (GGG), aerobic exercise group (AG), garlic-ginger mixture and aerobic exercise group (GGAG), and control group (CG). A randomized parallel-group clinical trial was conducted from 1st February 2023 to 30th March 2023 among people diagnosed with type 2 diabetes (T2DM). Data were analyzed using paired sample t-test and Post-hoc multiple comparisons one-way ANOVA analysis.*

Results: *The results showed that the garlic-ginger mixture combined with aerobic exercise was more effective in controlling BMI: Mean Difference (ΔM) =1.121; P <.001, FBS: ΔM =35.8 P <.001, and WC: ΔM =1.887 P <.001 among T2DM patients than the garlic and ginger mixture alone BMI: ΔM = .74; P=. 000, FBS: ΔM =21.2; P <.001, and WC: ΔM =.957; P <.001.*

Conclusions: *Garlic-Ginger combined with aerobic exercise was more effective in controlling BMI, FBS, and WC in T2DM patients than Garlic-Ginger alone. Hence, it is recommended to use the combination of Garlic-Ginger with aerobic exercise in their T2DM self- management. The study recommends further research on Garlic-Ginger mixtures' effects on metabolic conditions and their potential role in managing T2DM.*

Keywords: Aerobic exercise, Garlic-Ginger mixture, Lipid Profile, Type 2 Diabetics, Waist Circumference

Doi: https://dx.doi.org/104314/njns.v46i1.12.

INTRODUCTION

Type 2 diabetes mellitus (T2DM) is a prevalent metabolic condition that predisposes to atherosclerotic cardiovascular disease and 6.28 % of global population are living with diabetes in 2021[1]. Currently, large numbers of morbidity across the globe are due to cardiovascular disease (CVD) [2]. Type 2 Diabetes mellitus (T2DM) is a common metabolic syndrome that predisposes to atherosclerotic CVD and is presently causing the most morbidity in the World [3]. Globally, certain groups of T2DM patients are particularly vulnerable to obesity, in addition to having elevated fasting blood glucose levels; for instance, more than half of the World's T2DM patients have shown the majority of metabolic syndrome (MetS) components which include abnormality of fasting blood sugar (FBS), body mass index (BMI) and waist circumference (WC) [4]. In Sub-Saharan Africa, one-third of T2DM patients have MetS components which include BMI, FBS, and WC [5], and the top ▪ve countries for escalating number of people with diabetes (20– 79 years) in Africa includes South Africa, Nigeria, Republic of Tanzania, Ethiopia and Democratic Republic of the Congo with 4.2, 3.6, 2.9, 1.9, and

1.9 million people respectively [6]. Speci▪cally, the prevalence abnormality of BMI and WC in Jimma town T2DM patients is one among ▪ve from each tested patients [7].

Cardiovascular disease is controlled strategically through different techniques, for instance, to control BMI, WC, and FBS, people use techniques such as lifestyle modi▪cation, physical activity, meal planning, behavioural change, and risk assessment [8]. Plant medicines are increasingly being used for the management of CVD [9]. Sometimes plant supplements can be a substitute for drug therapy for some diseases since ingesting plant supplements have fewer side effects than arti▪cial ones [10]. Among plant sources medicines, ginger and garlic have been known in traditional and modern society as their remedies against CVD [11]. Ginger which is Zingiberaceae plant family, and garlic from the Alliaceae family, have been known in Ethiopia since 13th century and communities have been using these herbs for the treatment of various diseases due to the presence of antioxidant properties [12].

Existing shreds of evidence suggest that diabetes patients need continuous surveillance and treatment for lipid pro▪les to prevent premature mortality associated with these factors [13,14]. Among the cost-effective methods of preventing lipid pro▪les that lead to T2DM, lifestyle changes, including diet and exercise, are crucial for reducing the risk of macro vascular complications [15,16]. Factors like body mass index, blood glucose, and hypertension are associated with diabetes mellitus. However, if used properly and regularly, physical exercise and dietary supplements such as ginger, garlic, fruits, and vegetables play a key role in mitigating these modi▪able risk factors of T2DM [17–20].

Among other treatment strategies used by health professionals for metabolic disturbances is physical exercise; many studies have shown that exercise can control weight, and obesity and make a person healthier [19-21].

Studies speci▪cally conducted on ginger, garlic, and aerobics exercises have shown their signi▪cant effect on BMI, WC, and FBS [22]. Up-to-date, studies investigating the combined effects of exercise with a garlic-ginge mixture on BMI, WC, and FBS of a T2DM are scarce, and no conducted study compared the effects. Therefore, this study investigated the combined effects of aerobic exercise with a mixture of garlic and ginger supplements on the lipid pro▪le of people undergoing T2DM treatment at Jimma University Medical Center (JUMC).

METHODS

Study area

The study was conducted at Jimma University Medical Center (JUMC), located in the city of Jimma, the capital of Jimma Zone, which is 346 km from Addis Ababa in the southwest and 852.44 km in the southwest from Haramaya University and located at 7°40'N latitude and 36°50'E longitude. This institution now serves as a medical referral Centre for patients from Jimma, Ilu Ababor, Buno Bedele, Southern Nations and Nationalities and part of Wallagga. The town where this medical center is located has a population of 159,009 according to the 1998 National Statistics Authority estimates and currently 207,573 people according to the 2022 population hub [23].

Study design and sample selection

A randomized parallel-group clinical trial was conducted from 1st February 2023 to 30th March 2023 among people diagnosed with type 2 diabetes (T2DM). The JUMC was selected purposefully, as the hospital provides tertiary medical care for patients with T2DM. A single- arm, randomized experimental design was used. The study adhered to the consortium guidelines for randomized controlled trials. In this study, participants served as their controls by comparing their baseline and post-intervention results. Forty self-reported inactive T2DM patients (43.1 ± 6.153 years) participated in this experimental design and used a pretest and posttest with control and experimental groups. The sample was generally representative of the overall population of T2DM patients of JUMC. After giving a complete description of the issue, the volunteers ▪lled out the consent form and general health checklist. None of the individuals had a history of supplement use for treatment, smoking, and regular sports activities. Initial suitability for the study was determined by the completion of a simple lifestyle questionnaire. Subjects with any physical exercise phobia, pregnancy, allergy, and intolerance of supplements (Garlic and Ginger), using the supplement and exercise as a therapeutic strategy in addition to metformin, were excluded from the experimental trial. The participants were advised to be free from taking any additional supplements to avoid factors that may affect the relation of variables during the time of the study.

Pre Intervention

At the beginning of the experimental period, subjects were randomly divided into 4 groups including

1) the Garlic-ginger and Aerobic exercise group (GGAG),
2) the Garlic-ginger group (GGG),
3) the Aerobic Exercise Group (AG), and
4) the Control Group (CG).

Then, the pre intervention anthropometric characteristics -BMI and WC- were calculated and measured and the biochemical result of FSB was recorded. For measuring BMI, an SH-300 coin-operated weight and height scale was used.

Measurement was collected without shoes and heavy clothes at a machine scale with the nearest mass of 0.00 kg and the nearest height of 0.00 cm, and), the patient's BMI was calculated using their body weight and height. Waist circumference (WC) was measured using a flexible measuring tape. For WC measurement, the patient stood upright while the tape was positioned around the natural waist (midway between the lowest rib and the top of the hip bone). Measurements were taken immediately after the patient exhaled, and the average values of the two attempts were recorded. A biochemical test was performed at baseline and on the day after the end of treatment to determine FBS measurements. This test was administered following an overnight fast, and after collecting 2 mL of blood from the arm veins of subjects, centrifuging took place to differentiate serum from plasma, and at the end, using the cobas machine, FBS results were recorded by laboratory professionals and researchers.

Inclusion criteria

Forty patients who completed a health and exercise prescription questionnaire had no allergies and intolerances to the dietary supplement, and were willing to participate in the study were selected as respondents' for the study. Intolerance to dietary supplement was determined through participants' clinical history and self-reported information from participants. The study included people diagnosed with T2DM for more than six months, aged between 30 and 64 years old, undergoing treatment with oral antidiabetic drugs and glycated haemoglobin (HbA1c) between 6.0% and 10.0% in the baseline. The cut-off point established for HbA1c is justi▪ed since, with levels below 6.0%, people with T2DM already have good control of this biomarker; and, above 10.0%, and these patients would already have important dysregulation, making the research unfeasible.

Exclusion criteria

People using alcohol or tobacco, using any natural product to control diabetes, on insulin therapy, with the presence of chronic changes (cardiovascular, liver, kidney, gastric, or mental disorders diagnosed), and pregnant or lactating women. Chronic changes and mental disorders were assessed through information provided by the participants themselves, during the assessment of the eligibility criteria, and con▪rmed with the health professionals in the JUMC where they were monitored. The individuals could be discontinued from the study if they experienced any adverse events. All the data was previously checked during the nursing appointments. The study had as its primary outcome the reduction in body mass index (BMI), blood sugar levels (fasting glucose), and waist circumference (WC) of people with T2DM. In Jimma, there were no records on the number of people with T2DM and HbA1c levels between 6.0% and 10.0%, monitored in the JUMC.

In total, 137 people were recruited and, of these, 97 were excluded after applying the eligibility criteria (16 did not have HbA1c between 6.0% and 10.0%; 13 had alcohol consumption, 19 did not use antidiabetic drugs, 15 had tobacco consumption, 12 on insulin therapy, ▪ve had cardiovascular problems, and 17 had kidney problem). The randomization sequence was generated using computer software and strati▪ed by JUMC, with a random allocation into four parallel groups based on HbA1c levels. A numerical list was created, with even numbers corresponding to the Experimental Group (EG) and odd numbers to the Control Group (CG).

Intervention

During the intervention period, subjects in the GGAG and GGG groups received 4g of supplement powder 3 times per week for 8 weeks. In addition to supplements, subjects in the GGAG performed a progressive aerobic exercise program, while the AG performed exercise training only. The study involved a three-day, eight-week training program for GGAG and AG, varying intensity levels from low to high. Aerobic exercises included treadmill running, stationary bicycle riding, skipping rope, and jogging, with cool activities after each session. The training schedule was adapted from previous research. The CG was out of both interventions for eight weeks. The CG was out of both ginger-garlic and aerobic exercise interventions for eight weeks. The GGAGs were given a mixture of powder after aerobic exercise on each training day while they ate their dinner. The other groups performed the same aerobic exercise at the same time without supplementation. The training was scheduled and exercised three days (Tuesday, Thursday, and Saturday) per week for eight weeks for both GGAG and AG based on the training schedules of the prior researchers. The session started with a 15-minute general and speci▪c warm-up, followed by a main workout for 30, 45 and 50 minutes of low, moderate and high intensity respectively. Selected aerobic exercises were treadmill, running, bicycle stationary riding, skipping rope, and jogging as main activity exercise; then the session lasted 5 minutes of cool-activities, and this was performed with low intensity in the ▪rst three weeks, moderate intensity in the next three weeks and high intensity in the last two weeks. The supplement was homemade garlic-ginger powder which was prepared by the researcher and research assistant. To prepare the supplement, the purchase was made, and then the peeled supplements were cut into thin slices. The thin slices were dried in the sun to maintain their natural mineral content and flavor for ▪ve days. After drying, it was ground and mixed again after grinding by

seven star POE999 machine. It was then packaged in 4 grams as it was a daily dose. Also, the powdered garlic-ginger mixture was extracted by 50ml of water, Acetone and Methanol for 24 hours at room temperature from methanol, water, and acetone extracted from the supplement the phytochemical screening was conducted and the presence of Tannin, Terpenoids, Phenolic, Flavonoids, and Saponin was con▪rmed.

Post Intervention

At the conclusion of the experimental period, post-intervention measurements were conducted among all subjects: 1) the Garlic-ginger and Aerobic Exercise Group (GGAG), 2) the Garlic-ginger Group (GGG), 3) the Aerobic Exercise Group (AG), and 4) the Control Group (CG). Anthropometric characteristics, including BMI and WC, were reassessed, and post-intervention biochemical results for fasting blood sugar (FBS) were recorded. BMI was measured using an SH-300 coin-operated weight and height scale. Measurements were taken without shoes and heavy clothing, with the results recorded to the nearest 0.00 kg for mass and 0.00 cm for height. Among the outputs (height, mass, and BMI), the BMI value was recorded. For WC measurement, a flexible measuring tape was used. Subjects stood upright while the tape was wrapped around the natural waist (between the lowest rib and the top of the hip bone). Measurements were taken immediately after exhalationandrecordedatbothtimes.

Similarly, biochemical testing for FBS was performed at the end of the intervention period. Following an overnight fast, 2 mL of blood was drawn from the arm veins of subjects, and the sample was centrifuged to separate serum from plasma. FBS levels were then measured using the Cobas machine, with laboratory professionals and researchers recording the results. The purpose of post intervention measurement is to determine the extent of changes attributable to the intervention. Comparing pre and post-intervention data helps identify whether and to what degree the treatment influenced the variables of interest.

Data analysis

The data collected through biochemical, and anthropometric tests were analyzed, interpreted, and tabulated into meaningful ideas; and expressed as Means ± Standard Deviations to show the change in pre and post- test. Both intragroup and intergroup comparisons were made using the one-way ANOVA followed by Paired sample T-test, Multiple comparison post hoc, and Mean plot bar graph were used to identify the more effective variable. All statistical analyses were performed using the SPSS-26. A threshold cut point was set at $p< 0.05$ with a 95% margin of error. The Mann-Whitney U test was used to analyze the characteristics of the groups, and the Wilcoxon test was used to con▪rm the behavior of the numerical variables. The data was analyzed according to a protocol, with continuous variables presented as mean and standard deviation or median, minimum, and maximum. Categorical variables were exposed in frequency and prevalence rate to investigate associations between risk factors and disease. Pearson's chi-square test and Fisher's exact test were used to examine the relationship between the categorical variables. Statistical analyses were conducted using the SPSS statistical program, version 26.0 (USA). Thestudy was carried out following Ethiopian National Ministry of Health proclamation numbers 231/15 and 471/2015, and it was approved by Jimma University Sports Academy's Research Ethics Review Committee (Ref. No. JUSA MT043/2023). The indicators of metabolic syndrome among the Ethiopian population include an optimal body mass index (BMI) cut-off of 22.2 kg/m² for males and 24.5 kg/m² for females. Additionally, waist circumference measurements signify obesity, with cut-offs set at 83.7 cm for males and 78.0 cm for females. Furthermore, a fasting blood sugar (FBS) level of 100 mg/dL or greater is recognized as a risk factor for metabolic syndrome in both males and females [24].

RESULTS

Characteristics of Participants

The results of the study in Table 1 show the Mean±Standard Deviation (mean ± SD) of pre-test participants' age, BMI, FBS, and WC. The participants were (n=18) females and (n=22) males with a mean age of 44.83 and 41.73 respectively.

Pre and Post intervention difference of Anthropometric and Metabolic Parameters

Table 2 presents the Mean ± Standard Deviation (mean ± SD), Mean difference (ΔM), and P-value of the BMI, FBS, and WC at baseline (week 0) and after 8 weeks of intervention. According to the indicated result, GGAG patients exhibited signi▪cant differences ($P<.001$) in each variable by ΔM of 1.121, 35.8, and 1.887 in BMI, FBS, and WC respectively after intervention aerobic exercise and taking garlic-ginger mixture. AG has shown decrement by ΔM of 1.040, 18.3, and 1.067 in BMI, FBS, and WC respectively by the intervention and the difference was signi▪cant at ($P<.001$) in BMI, ($P<.002$) in FBS and ($P<.001$) in WC. GGG patients showed decrement after the intervention of two months Supplement by ΔM of .74, 21.2, and .957 in BMI, FBS, and WC respectively and the decrement at the end of 8 weeks compared to baseline was statistically signi▪cant ($P<.001$) for each variable. Contrary to the three groups in CG patients BMI and WC were not decreased, and FBS is signi▪cant ($P=.027$) which maybeduetothe metformin drug they used.

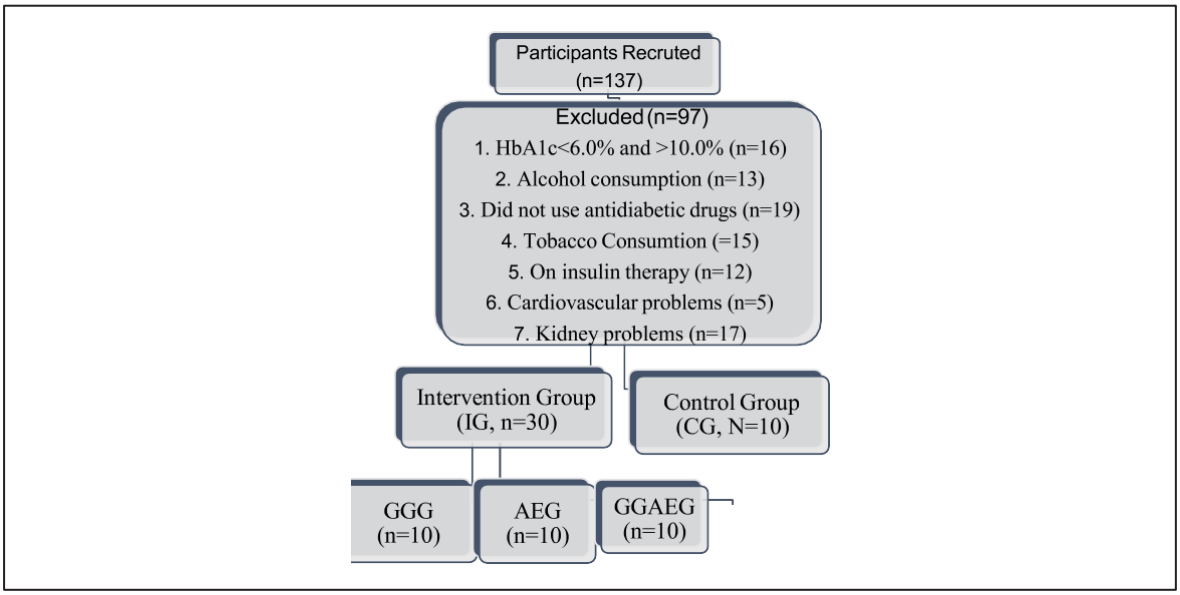

Figure 1. Recruitment of participants
Key: - GGG: Garlic Ginger Group, AEG: Aerobic Exercise Group, GGAEG: Garlic- Ginger Aerobics Group

Table 1. Pre-intervention Demographic Characteristics of Participants

Variables	Male (n=22)	Female (n=18)	Total (N=40)
	Mean ± SD	Mean ± SD	Mean ± SD
Age	41.73 ± 5.99	44.83 ± 6.08	43.13 ± 6.153
BMI	29.3 ± 2.16	28.91 ± 2.511	29.12 ± 2.302
FBS	168.18 ± 13.972	167.89 ± 15.811	168.05 ± 14.632
WC	97.91 ± 3.268	90.29 ± 2.713	94.8 ± 4.868

Table 2: The Pre and Post Test of BMI, FBS, and WC of the Four Groups

Variables	GGAG		AG		GGG		CG	
	M±SD	ΔM	M±SD	ΔM	M±SD	ΔM	M±SD	ΔM
Pre BMI	29.7±1.64	1.12*	30.7±2.21	1.04*	27.4±1.72	.74*	28.7±2.41	.25**
Post BMI	28.58±1.85		29.66±2.17		26.67±1.95		28.73±2.47	
Pre FBS	163.8±13.62	35.8*	158.20±14.42	18.83*	173.4±9.82	21.2*	176.8±13.89	5.3**
Post FBS	128.0±12.98		139.90±18.87		152.2±13.87		171.5±13.97	
Pre WC	94.37±4.97	1.89*	95.45±4.37	1.07*	93.5±5.46	.96*	94.6±5.2	.42**
Post WC	92.48±4.92		94.38±4.45		92.54±5.46		95.02±4.62	

*: ΔM is significant at 0.05, **: ΔM is not significant at 0.05

Key: *BMI: Body Mass Index, FBS: fasting blood sugar, WC: west circumference, ΔM: difference in mean, GGG: garlic-ginger mixture group, AG: aerobic exercise group, GGAG: garlic-ginger mixture and aerobic exercise group, and CG: control group, Pre: Pre-Intervention, Post: Post-Intervention.*

Post- Hoc Group Difference Analysis

Table 3 depicts a comparison between each group which was analyzed by Pre and Post-test difference Mean. Accordingly, MD of BMI GGAG has shown signi▪cant differences when compared to GGG and CG at (P=.037), and (P=.000) respectively after 8 weeks. MD of FBS in GGAG has shown a signi▪cant difference when Compared to AG (P=.012), GGG (P=.044) and CG (P=.000). MD of WC in GGAG has shown a signi▪cant difference when compared to AG (P=.050), GGG (P=.021) and CG (P=.000).

Changes in Dependent Measures

Figures 1-3 show the mean difference (MD) of BMI, FBS, and WC between pre and post-intervention among groups.

Mean Difference in Body Mass Index(Kg/M^2)

Figure 1 presents the mean differences in BMI (kg/m^2) across four groups, illustrating the effectiveness of various interventions. The Garlic Ginger and Aerobics Group (GGAG) demonstrated a signi▪cant decrease in BMI, with a mean difference of 1.21 kg/m^2. This indicates that the combination of garlic-ginger mixture and aerobic exercises effectively contributes to weight reduction. Similarly, the Aerobics Group (AG) showed a decrease in BMI with a mean difference of 1.04 kg/m^2, suggesting that aerobics alone can promote weight loss through improvements in ▪tness. In contrast, the Garlic Ginger Group (GGG) had a mean difference of 0.74 kg/m^2, which reflects a smaller impact on BMI and indicates that garlic and ginger alone are less effective than combined interventions. The CG, however, exhibited a negligible mean difference of -0.025 kg/m^2. This data emphasizes the superior effectiveness of combined interventions compared to control conditions.

Mean Difference in Fasting Blood Sugar (md/dL)

Figure 2 presents the mean differences in fasting blood sugar (FBS) levels between pre and post-intervention tests across different groups. The results indicate signi▪cant reductions in FBS levels post-intervention, with the GGAG group showing the most substantial decrease of 35.8 mg/dL. Following this, the AG group experienced a mean reduction of 18.3 mg/dL, while the GG group recorded a decrease of 21.2 mg/dL. In contrast, the control group (CG) exhibited only a slight reduction of 5.3 mg/dL, suggesting limited impact from the intervention. These ▪ndings highlight that the intervention was most effective in the GGAG group, while the control group revealed minimal changes, underscoring the signi▪cance of the treatment. Overall, the data suggests that the intervention effectively reduces FBS levels, particularly in speci▪c groups, emphasizing the importance of targeted strategies for managing blood sugar. Overall, the study underscores that the combination of garlic, ginger, and aerobic exercises is the most effective intervention for reducing FBS.

Mean Difference in Waist Circumference

Figure 3 illustrates the mean differences in waist circumference (WC) across the four groups, highlighting the effectiveness of the interventions in reducing abdominal measurements. The GGAG demonstrated a notable reduction in waist circumference, with a mean difference of 1.887 cm, indicating that the combination of garlic, ginger, and aerobic exercises signi▪cantly contributes to reducing abdominal fat. Similarly, the AG achieved a mean difference of 1.067 cm, suggesting that aerobic exercises alone are effective in promoting a decrease in waist size. In the GGG, the mean difference was slightly lower at 0.957 cm, indicating some bene▪ts from the use of garlic-ginger mixture, though the effect was less pronounced than that of the combined intervention. In contrast, the CG which continued with their usual lifestyle without any interventions, displayed a mean difference of -0.42 cm, reflecting no signi▪cant change. Overall, these results reinforce the conclusion that the combination of garlic, ginger, and aerobic exercises is the most effective strategy for reducing waist circumference.

DISCUSSION

The current study demonstrated that BMI, FBS, and WC decreased signi▪cantly in all three experimental groups compared to the control group of patients with T2DM after two months of intervention. This study con▪rms the result of different studies conducted on the area; for instance, a study conducted on 81 T2DM patients exhibited that 3g of ginger per day for 8 weeks decreased FBS [25]. Another study depicts that the intervention of 3 days per week of aerobic exercise coupled with 1000 mg of ginger daily for T2DM patients resulted in signi▪cant reductions in BMI and FBS. Furthermore, the study investigated the effects of 400mg of garlic on FBS and discovered that it resulted in a signi▪cant reduction in prediabetes symptoms four weeks after the intervention[26]. They discovered that allicin in garlic lowers blood glucose levels by increasing liver metabolism, increasing insulin release from pancreatic cells, and producing short-acting insulin [27].

Ginger and garlic studies have shown that spices with phytochemical components such as tannin, saponin, flavonoid, phenol, and additional have a signi▪cant influence on the metabolic syndrome and other components of CVD [28,29]. As a result, phytochemical screening was conducted on the local garlic and ginger powder that was purchased from Jimma Town, and the results indicated the presence of these substances and comparable results were observed due to the presence of the compounds on

Table 3. Post-hoc multiple comparison one-way ANOVA for comparing the difference between groups

DV	(I) Group	(J) Group	ΔM (I-J)	p
BMI	GGAG	AG	.081	.931
		GGG	.38*	.037
		CG	1.15*	.00
FBS	GGAG	AG	17.5*	.012
		GGG	14,6*	.044
		CG	30.5*	.00
WC	GGAG	AG	.82*	.05
		GGG	.93*	.021
		CG	2.31*	.00

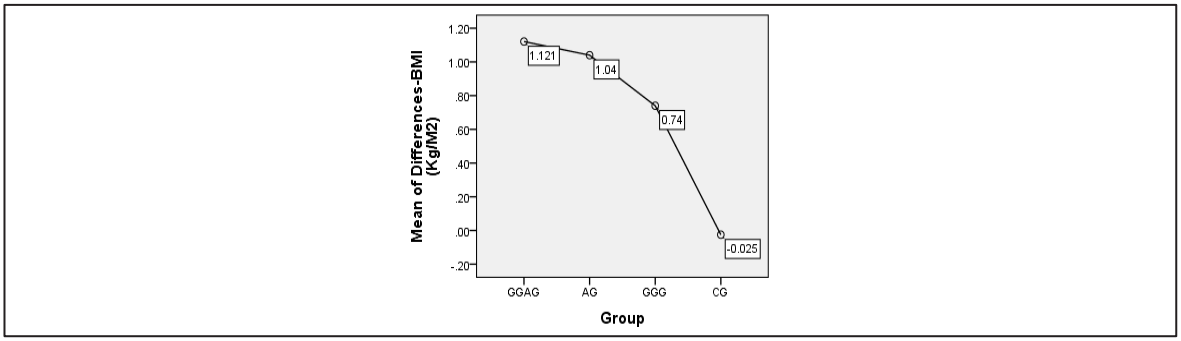

Figure 1: BMI by mean difference between Pre and Post Intervention between groups

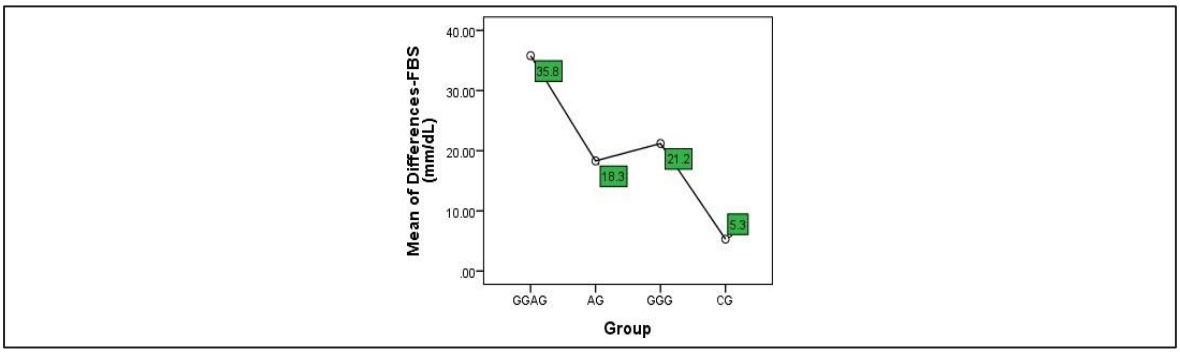

Figure 2. FBS mean difference between groups Pre and Post Intervention

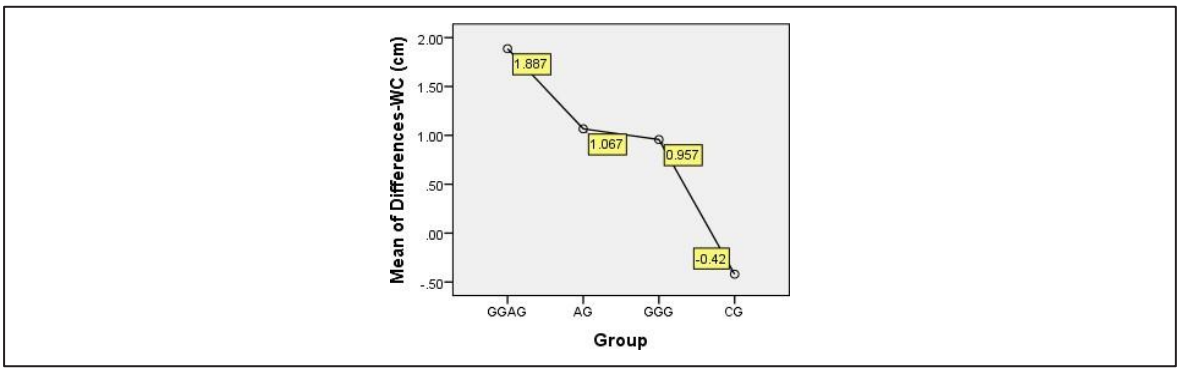

Figure 3. WC mean difference between groups Pre and Post Intervention

nearly all Sites of GGG and GGAG in the current investigation. There is some evidence that the presence of antioxidants against oxidative stress may reduce blood glucose by inspiring insulin, and studies have revealed that therapy with antioxidant herbs may increase glucose transport activity in T2DM patients [30,31].

In addition, a study conducted by giving 1000 mg of ginger supplementation showed that it signi▪cantly decreased body waist-hip ratio, waist circumference, and body mass index (BMI) in the experimental group compared to the placebo group, and other research indicates that taking a ginger supplement per day for three months can lower the mentioned components of metabolic syndrome [32,33]. Similarly, according to a systematic review of garlic's effects on cardiovascular disease, consumption of white cloves reduces WC, BMI, and blood glucose [34]. Eight-week and ten-week aerobic exercise plans were proven to be an effective adjunct therapy in T2DM participants for lowering blood glucose levels, and BMI [35,36]. Aerobic exercise stimulates insulin and enhances its function in blood glucose transfer. Because working muscles are more sensitive to insulin than resting muscles, each unit of insulin causes more glucose absorption during exercise [37]. Af▪rming the results of our study, a study conducted by [34] states that plasma glucose at 120 min following glucose load (Glu 120) was signi▪cantly reduced in the intervention group after training (Glu 120: 17.3 mmol/L to 15.0 mmol/L, < 0.05). However, Glu 120 remained unchanged in the control group (Glu 120: 16.6 mmol/L to 18.7 mmol/L). Other studies witnessed that the combined effects of aerobic and strength exercise intervention resulted in signi▪cantly lower body composition, blood pressure, and fasting blood glucose compared to the individual intervention [16]. Moreover, combining aerobic exercise with dietary supplements such as ginger and garlic is more effective in changing these parameters [38]. Furthermore, phytochemical components of the garlic-ginger mixture, saponin, phenol, and tannin, demonstrated signi▪cant hypoglycemic effects when combined with the standard antidiabetic agent ginger, via its major component, gingerol, by inhibition of key enzymes relevant to type 2 diabetes, glucosidase and amylase, which is known to inhibit T2DM [19,21,39]. Allium sativa, Zingiber of▪cinale, and Citrus limonum given for 90 days resulted in signi▪cant reductions in BMI, and waist circumference of the volunteers, and aerobic exercise is associated with less risk of both [40]. These previous results prove that the combination of aerobic exercise and a garlic- ginger mixture is signi▪cant in improving BMI, FBS, and WC in T2DM patients in the current study.

There are also studies whose results are contrary to the current study's ▪ndings. For instance, a previous clinical trial evaluated the effects of garlic on serum glucose in patients with coronary artery disease and reported no signi▪cant change in fasting and 2 hours postprandial blood glucose levels [41]. A study conducted through the intervention of aerobic exercise along with garlic for four weeks was insigni▪cant in reducing body weight which has a direct relationship with the BMI of patients [42], and this may be due to training duration differences with the current study.

CONCLUSION

This study concludes that, as a mixture, an aerobic exercise and the combination of both aerobic exercise and mixture has a signi▪cant effect on BMI, FBS, and BMI of T2DM patients. Moreover, the mixture combined with aerobic exercise is more signi▪cant than either the mixture alone or aerobic exercise alone. Therefore, it is recommended to use the combination of garlic-ginger mixture and aerobic exercise as T2DM self-management strategy.

CONFLICT OF INTEREST

The authors declare that they do not have conflicting interests.

ACKNOWLEDGEMENTS

We would like to acknowledge Haramaya and Jimma University Medical Center for allowing the study to be conducted with their patients and subjects of the study for sacri▪cing their time for the success of our work.

REFERENCES

1. IDF. International Diabetes Federation Atlas. (2021). Vol. 10, International Diabetes Federation. 147–148 p.
2. Nascimento BR, Brant LCC, Naback ADN, Veloso G, Polanczyk C, Ribeiro ALP, et al. (2022). Burden of Cardiovascular Diseases Attributable to Risk Factors in Portuguese-Speaking Countries: Data from the "Global Burden of Disease 2019" Study. Arq Bras Cardiol. 118(6):1028–48.
3. De Rosa S, Arcidiacono B, Chiefari E, Brunetti A, Indol▪ C, Foti DP. (2018). Type 2 diabetes mellitus and cardiovascular disease: Genetic and epigenetic links. Vol. 9, Frontiers in Endocrinology. p. 1– 13.
4. Li X, Cao C, Tang X, Yan X, Zhou H, Liu J, et al. (2019). Prevalence of Metabolic Syndrome and Its Determinants in Newly-Diagnosed Adult-Onset Diabetes in China: A Multi-Center, Cross-Sectional Survey. Front Endocrinol (Lausanne). 10(661):1–9.
5. Shiferaw WS, Akalu TY, Gedefaw M, Anthony D, Kassie AM, Misganaw Kebede W, et al.

(2020). Metabolic syndrome among type 2 diabetic patients in Sub-Saharan African countries: A systematic review and meta-analysis. Diabetes Metab Syndr Clin Res Rev [Internet]. 14(5):1403–11. Available from: https://doi.org/10.1016/j.dsx.2020.07.013
6. WHO. (2023). Analytical Fact Sheet: Diabetes, a silent killer in Africa. Integrated African Health Observatory. 7(3):1–9.
7. Rajesh.P.N, Mossie A, Mezgebu Y. (2017). Prevalence of Metabolic Syndrome and Its Components in Adult Women. J Korean Biol Nurs Sci. 20(4):261–9.
8. Al-Rubeaan K, Bawazeer N, Al Farsi Y, Youssef AM, Al-Yahya AA, AlQumaidi H, et al. (2018). Prevalence of metabolic syndrome in Saudi Arabia - a cross sectional study. BMC Endocr Disord. 18(1):1–9.
9. Chaachouay N, Azeroual A, Bencharki B, Zidane L. (2022). Herbal medicine used in the treatment of cardiovascular diseases in the Rif, North of Morocco. Front Pharmacol. 13(921918):1–12.
10. Pérez-Torres I, Torres-Narváez JC, Pedraza-Chaverri J, Rubio-Ruiz ME, Díaz-Díaz E, Del Valle-Mondragón L, et al. (2016). Effect of the aged garlic extract on cardiovascular function in metabolic syndrome rats. Molecules. 21(11):1–15.
11. Okaiyeto K, Oguntibeju OO. (2021). African herbal medicines: Adverse effects and cytotoxic potentials with different therapeutic applications. Int J Environ Res Public Health. 18(11):1–20.
12. Alemu M, Asfaw Z, Lulekal E, Warkineh B, Debella A , Sisay B, et al. (2024) . Ethnobotanical study of traditional medicinal plants used by the local people in Habru District, North Wollo Zone, Ethiopia. J Ethnobiol Ethnomed [Internet].20(1):1–30. Available from: https://doi.org/10.1186/s13002-023-00644-x
13. Abagre TA, Bandoh DA, Addo-Lartey AA. (2022). Determinants of metabolic syndrome among patients attending diabetes clinics in two sub-urban hospitals: Bono Region, Ghana. BMC Cardiovasc Disord. 22(1):1–13.
14. Charkos TG, Getnet M. (2023). Metabolic syndrome in patients with type 2 diabetes mellitus at Adama Hospital Medical College, Ethiopia: a hospital-based cross- sectional study. Front Clin Diabetes Healthc. 1165015(10):1–8.
15. Amin AR, Kassab RB, Abdel Moneim AE, Amin HK. (2020). Comparison Among Garlic, Berberine, Resveratrol, Hibiscus sabdariffa, Genus Zizyphus, Hesperidin, Red Beetroot, Catha edulis, Portulaca oleracea, and Mulberry Leaves in the Treatment of Hypertension and Type 2 DM: A Comprehensive Review. Nat Prod Commun. 15(4):1–24.
16. Kaikhosro Doulatyari P, Ghahramani M, Mozaffari K. (2020). Investigating the Effect of Aerobic and Resistance Training on Insulin Resistance and Some Cardiovascular Disease Risk Factors in Type 2 Diabetes Mellitus Patients: A Systematic Review. J Clin Res Paramed Sci. 12(1):1–9.
17. Xin C, Ye M, Zhang Q, He H. (2022). Effect of Exercise on Vascular Function and Blood Lipids in Postmenopausal Women: A Systematic Review and Network Meta-Analysis. Int J Environ Res Public Health. 19(12074):1–13.
18. Iwai K, Ushigome E, Okada K, Yokota I, Majima S, Nakanishi N, et al. (2022). Usefulness of Aerobic Exercise for Home Blood Pressure Control in Patients with Diabetes: Randomized Crossover Trial. J Clin Med. 11(3):1–12.
19. Khandouzi N, Shidfar F, Rajab A, Rahideh T. (2015). The Effects of Ginger on Fasting Blood Sugar, Hemoglobin A1c , Apolipoprotein B , Apolipoprotein A-I and Malondialdehyde in Type 2 Diabetic Patients. Iran J Pharm Res. 14(1):131– 40.
20. Rahimlou M, Yari Z, Rayyani E, Keshavarz SA, Hosseini S, Morshedzadeh N, et al. (2019). Effects of ginger supplementation on anthropometric, glycemic and metabolic parameters in subjects with metabolic syndrome: A randomized, double-blind, placebo-controlled study. J Diabetes Metab Disord. 18(1):119–25.
21. Aggarwala J, Sharma S, Saroochi S, Jain A, Sarkar A. (2016). Effects of aerobic exercise on blood glucose levels and lipid pro•le in Diabetes Mellitus type ii subjects. AL Ameen J Med Sci. 9(1):65– 9.
22. Vahdatpoor H, Shakerian S, Alizadeh AA, FatemiTabatabaei SR. (2019). The combined effect of aerobic activity and ginger supplementation on blood glucose and lipid pro•le in overweight girls. Iran J Diabetes Obes. 11(1):1–8.
23. ESA. (2021). Population-of-Towns-as-of- July-2021.. https:// www.statsethiopia.gov.et/wp-content/uploads/2020/08/Population-of-Towns-as-of-July-2021.pdf. P.1-50.
24. Sinaga M, Worku M, Yemane T, Tegene E, Wakayo T, Girma T, Lindstrom D, Belachew T. (2018). Optimal cut-off for obesity and markers of metabolic syndrome for Ethiopian adults. Nutr J. 17(1):109. doi: 10.1186 /s12937-018-0416-0. PMID: 30466421; PMCID: PMC6251157.

25. Zhu J, Chen H, Song Z, Wang X, Sun Z. (2018). Effects of Ginger (Zingiber of▪cinale Roscoe) on Type 2 Diabetes Mellitus and Components of the Metabolic Syndrome: A Systematic Review and Meta-Analysis of Randomized Controlled Trials. Evidence-based Complement Altern Med. 2018 (5692962):1–11.
26. Yaping X, Huifen Z, Meijing Z, Huibin H, Chunhong L, Fengfeng H, et al. (2021). Effects of Moderate-Intensity Aerobic Exercise on Blood Glucose Levels and Pregnancy Outcomes in Patients With Gestational Diabetes Mellitus: A Randomized Controlled Trial. Diabetes Ther. 12(9):2585–98.
27. Faroughi F, Charandabi SMA, Javadzadeh Y, Mirghafourvand M. Effects of garlic pill on blood glucose level in borderline gestational diabetes mellitus: A randomized controlled trial. Iran Red Crescent Med J. 2018;20(5):1–10.
28. Azimi H, Masroor D, Haghani H, Ra▪i F. (2016). Effect of Aerobic Exercise on Blood Pressure of Patients With Type 2 Diabetes: A Randomized Controlled Trial. J Client-centered Nurs Care. 2(3):169– 76.
29. Guiger E, Oshiiwa M, Otoboni A, Araujo A, Tofano R, Barbalaho S. (2022). Garlic systematic review of the effects on cardiovascular diseases. Crit Rev Food Sci Nutr. 13(2):1–10.
30. Hegazy EM, El-Sayed Khamis NH. (2014). Effect of fresh garlic and ginger on the shelf-life of Gelatin waste used for improvement of plant growth. World AppISci J. 30(1):83–8.
31. Imo C. (2019). Medicinal Properties of Ginger and Garlic: A Review. Curr Trends Biomed Eng Biosci. 18(2):1–7.
32. Park SH, Jung SJ, Choi EK, Ha KC, Baek HI, Park YK, et al. (2020). The effects of steamed ginger ethanolic extract on weight and body fat loss: a randomized, double-blind, placebo-controlled clinical trial. Food Sci Biotechnol. 29(2):265–73.
33. Wang J, Wang P, Li D, Hu X, Chen F. (2020). Bene▪cial effects of ginger on prevention of obesity through modulation of gut microbiota in mice. Eur J Nutr. 59(2):699–718.
34. Ezema CI, Omeh E, Onyeso OKK, Anyachukwu CC, Nwankwo MJ, Amaeze A, et al. (2019). The effect of an aerobic exercise programme on blood glucose level, cardiovascular parameters, peripheral oxygen saturation, and body mass index among Southern Nigerians with type 2 diabetes mellitus, undergoing concurrent sulfonylurea and metformin treat. Malaysian J Med Sci. 26(5):88–97.
35. Ambelu T, Teferi G. (2023). The impact of exercise modalities on blood glucose, blood pressure and body composition in patients with type 2 diabetes mellitus. BMC Sports Sci Med Rehabil. 15(1):1–11.
36. Yan H, Prista A, Ranadive SM, Damasceno A, Caupers P, Kanaley JA, et al. (2014). Effect of Aerobic Training on Glucose Control and Blood Pressure in T2DDM East African Males. ISRN Endocrinol. 2014(864897):1–6.
37. Kirwan JP, Sacks J, Nieuwoudt S. (2017). The essential role of exercise in the management of type 2 diabetes. Cleve Clin J Med. Jul;84(7 Suppl 1):S15-S21. doi: 10.3949/ccjm. 84.s1.03. PMID: 28708479; PMCID: PMC 5846677.
38. Al-Mhanna SB, Rocha-Rodriguesc S, Mohamed M, Batrakoulis A, Aldhahi MI, Afolabi HA, et al. (2023). Effects of combined aerobic exercise and diet on cardiometabolic health in patients with obesity and type 2 diabetes: a systematic review and meta-analysis. BMC Sports Sci Med Rehabil [Internet]. 15(1):1–15. Available from: https://doi.org/10.1186/s13102-023-00766-5
39. Ashraf R, Khan RA, Ashraf I. (2011). Garlic (Allium sativum) supplementation with standard antidiabetic agent provides better diabetic control in type 2 diabetes patients. Pak J Pharm Sci. 24(4):565–70.
40. Brellenthin AG, Lee DC, Bennie JA, Sui X, Blair SN. (2021). Resistance exercise, alone and in combination with aerobic exercise, and obesity in Dallas, Texas, US: A prospective cohort study. PLo S Med [Internet].18(6):1–17. Available from: http://dx.doi.org/10.1371/journal.pmed.10 03687
41. Bordia A, Verma SK, Srivastava KC. (1998). Effect of garlic (Allium sativum) on blood lipids, blood sugar, ▪brinogen and ▪brinolytic activity in patients with coronary artery disease. Prostaglandins Leukot Essent Fat Acids. 58(4):257–63.
42. Bashiri J. (2015). The Effect of Regular Aerobic Exercise and Garlic Supplementation on Lipid Pro▪le and Blood Pressure in Inactive Subjects. Zahedan J Res Med Sci. 17(4):1–6.