A comparative evaluation of serum lipid profile and blood pressure measurements in adult hypertensive patients consuming Moringa stenopetala herbal tea and non-consuming groups as control, South East Ethiopia, 2021

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Abstract

Background

Noncommunicable diseases, such as cardiovascular diseases, continue to be the leading cause of morbidity and mortality around the world. Hypertension and dyslipidemia appear to be the two most important modifiable risk factors contributing to the global rise in cardiovascular disease. Several plant preparations are currently being touted as having benefits for such cardiovascular risk factors. African moringa, Moringa stenopetala, is one of these plants used in Ethiopia. Therefore, this study aimed to assess and compare the serum lipid profiles and blood pressure measurements of *Moringa stenopetala* herbal tea drinkers and non-drinker hypertensive patients attending chronic care follow-up at Bale zone hospitals.

Methods

A comparative cross-sectional study, involving 128 blood samples (64 each of *Moringa stenopetala* herbal tea drinkers and nondrinkers), was conducted on hypertensive patients who were on chronic care follow-up from July 1 to August 30, 2021. A face-to-face interview was used to collect data, and serum LDL-c, HDL-c, TG, and TC levels were measured using a clinical chemistry analyzer. Data were analyzed using SPSS version 25, Chi-square (X^2) was used to compare the relationship between categorical variables, and an independent sample t-test and one-way ANOVA were used to compare the mean of the groups. Generalized linear regression was used to study the association between continuous variables and *Moringa stenopetala* herbal tea consumption groups. The statistical significance was declared at $p < 0.05$.

Results

Moringa stenopetala herbal tea drinkers have showed statistically significant lower values than non-drinkers for LDL-c ($p < 0.001$), TG ($p = 0.001$), TC ($p < 0.001$), TC/HDL-c ratio ($p < 0.001$), and LDL-c/ HDL-c ratio ($p < 0.001$). The mean SBP, DBP, and MAP were significantly lower among the *Moringa stenopetala* tea drinkers group ($p < 0.001$, $p = 0.002$, and $p < 0.001$ respectively).

Conclusions

Interestingly, *Moringa stenopetala* herbal tea consumption has a significant health benefit by lowering blood pressure, LDL-c, TG, TC, and the ratios TC/HDL-c and LDL-c/HDL-c, which have the potential risk of developing CVDs.

Introduction

Non-communicable diseases (NCDs) are the leading cause of death worldwide and one of the 21st century's major health and development challenges [1]. In 2016, about 41 million (71%) of the 57 million deaths which occurred globally were due to NCDs. Among these deaths, cardiovascular disease (CVD) related mortality was responsible for 17.9 million deaths (44% of all NCD deaths and 31% of all global deaths) [2].

Hypertension has long been globally recognized as the most prevalent NCD, which is a long-term medical condition, characterized by a persistently increased state of resting systemic blood pressure [3]. Clinically, it is defined as systolic blood pressure (SBP) equal to or above 140 mmHg and/or diastolic blood pressure (DBP) equal to or above 90 mmHg based on an average of up to three blood pressure measurements [4].

Globally, the prevalence and absolute burden of hypertension are increasing, in particular in low and middle-income countries. In 2019, about 1.28 billion (33%) people had hypertension globally, of which the majority, over one billion (82% of all people with hypertension in the world) were in low and middle-income countries [5]. Moreover, hypertension is responsible for approximately 10.8 million deaths per year worldwide [6]. The prevalence of hypertension is estimated to be 30.8 percent across Africa, and 30.0% -31.1% in Sub-Saharan Africa [7–9]. In Ethiopia, approximately 21.8% of the population is estimated to have hypertension [10].

High blood pressure is among the most important modifiable risk factors for CVD, chronic kidney disease, progression to end-stage renal disease, and premature death worldwide [11–13]. It has been reported that the majority of hypertensive patients have additional cardiovascular risk factors such as dyslipidemia [14]. The presence of this additional risk factor increases morbidity and mortality from hypertension and hypertension-related cardiovascular and renal complications.

In adults with hypertension, controlling blood pressure to non-hypertensive levels could reduce CVD and chronic kidney disease, improve the quality of life of patients, and reduce the burden of disease significantly. Varieties of medications are found to be effective in correcting high blood pressure and lipid profile abnormalities in patients with hypertension [15, 16].

However, this approach is associated with potential adverse drug interactions, scarcity, discomforts, increased economic costs, and decreased quality of life [17–19]. Therefore, the use of locally available and scientifically approved herbal preparation is an alternative strategy for correcting high blood pressure and lipid profile abnormalities [20].

Several herbal preparations (i.e. herbal tea) have been claimed to have advantages for hypertension and dyslipidemia [21]. One of those herbs (plants) used in Ethiopia is African Moringa, *Moringa stenopetala*. This plant grows abundantly in the southern part of Ethiopia (Gamo-Gofa, Konso, Bale, Kaffa, Borena, Dherashe, Burji, Amaro, and Sidama) where the leaves are consumed as vegetables and teas besides its medicinal use [22]. The plant is called "Shiferaw" (in Amharic), "Aleko" (in Gamugna and Wollayetegna), and "Cabbage tree" (in English) [23].

Several studies have reported that *Moringa stenopetala* has hypotensive, antihyperlipidemic, and also has nutritional value [24–27]. Similarly, moringa extract has also shown a protective effect on the liver and kidney due to its protective action against lipid peroxidation and reactive oxygen species [28, 29]. The observed effects of *Moringa stenopetala* are thought to be due to a wide variety of polyphenols (phenolic compounds), as well as flavonoids, saponins, terpenoids, tannins, phytosterols, glucosinolates, and possibly alkaloids found in *Moringa stenopetala* [26, 30, 31].

The Ethiopian government is currently focused on *Moringa stenopetala* due to the medical and nutritional claims made for it, as well as promising early results obtained from numerous scientific experiments [32]. Even though *Moringa stenopetala* is widely cultivated and consumed in the southern part of Ethiopia and got attention from the government, there is a gap in elucidating the association between *Moringa stenopetala* consumption and serum lipid profiles and blood pressure measurements in human subjects.

Therefore, this study was designed to assess and compare the serum lipid profile tests and blood pressure measurements of hypertensive patients consuming *Moringa stenopetala* herbal tea and hypertensive patients not consuming *Moringa stenopetala* herbal tea. Moreover, this study also aimed to assess the association between *Moringa stenopetala* consumption and serum lipid profiles and blood pressure measurements in human subjects.

Thus, the findings from this study may provide new insight to see the problem (hypertension and dyslipidemia) for better prevention and management and help to shape clinical as well as public health care of the patients and the general population. In addition, it may also help point out the research gap regarding the association between *Moringa stenopetala* consumption and serum lipid profiles and blood pressure measurements.

Methods

Study Design, Area, and Period

A hospital-based comparative cross-sectional study was carried out among 128 hypertensive patients (64 of them were *Moringa stenopetala* tea drinkers) attending Bale zone hospitals from July 1 to August 30, 2021 GC. Bale zone is situated in the southeastern part of Ethiopia in the Oromia region. Robe, the Zonal city, is located 435 km far from Addis Ababa the capital of Ethiopia. The zone has five functional hospitals namely; Goba Referral Hospital, Robe General hospital, Dello Mena General Hospital, Madda Walabu primary hospital, and Goro primary hospital.

Population and Eligibility criteria

The source population for this study was all hypertensive patients attending chronic care follow-up at three public hospitals who were willing to participate in the study and were able to give informed consent during the study period. Patients with a history of cardiac heart failure, liver disease, hypothyroidism, hyperthyroidism, pregnant women, postmenopausal women, patients on religious fasting and lipid-

lowering, antiobesity, and contraceptive medications, and patients who are smoking cigarettes and drinking alcohol were excluded from the study. All participants were on common Ethiopian food and did not engage in any strenuous physical activity. The participating individual was on treatment for hypertension using a single type of antihypertensive drug. Moreover, patients with mental or legal incapacity that prevented them from giving valid consent or hindered them from full participation in the study process will also be excluded.

Sample size determination and Sampling technique

A sample size of 128 was calculated using G*Power statistical analysis software considering an effect size of 0.5 (medium), the alpha error probability of 0.05, power of 80%, and an allocation ratio of N2/N1 of 1, dividing into two groups on basis of the *Moringa stenopetala* herbal tea-drinking habit, having a sample of 64 each representing *Moringa stenopetala* herbal tea drinkers and non-drinkers. Goba Referral Hospital, Robe General hospital, and Dello Mena General Hospital were selected using a lottery method out of the five hospitals in the zone. The sample was allocated proportionally to the three hospitals based on the annual frequency of deliveries. To select the study subjects, a systematic random sampling of every 4th case was used and the lottery method was used to select the first patient.

Operational definitions

Moringa stenopetala herbal tea drinkers

The participant is considered a *Moringa stenopetala* herbal tea drinker if he/she drinks at least one cup (200ml) of *Moringa stenopetala* herbal tea per month.

Infrequent (monthly) drinker

The participant is considered an infrequent drinker if he/she drinks less than one teacup per week or one to three teacups per month.

Weekly drinker

The participant is considered a weekly drinker if he/she drinks one to six teacups per week.

Daily drinker

The participant is considered a daily drinker if he/she drinks daily or greater than or equal to seven teacups per week.

Data collection procedure

Assessment of Moringa stenopetala herbal tea consumption

Information concerning *Moringa stenopetala* herbal tea intake in the past year was collected using an interviewer-administered questionnaire. In the study region, a cup of tea used by the study participants was estimated to be equal to 200ml. The subjects were asked to indicate the frequency and the number of teacups of *Moringa stenopetala* herbal tea intake to estimate the total consumption of *Moringa stenopetala* herbal tea in the last month. Based on the frequency of intake of *Moringa stenopetala* herbal tea the participant was categorized as: almost never (< 1 teacup per month), infrequent or monthly drinker (< 1 teacup per week or one to three teacups per month), weekly drinker (1–6 teacups per week), and daily drinker (≥ 7 teacups per week or drink tea every day). Other characteristics of the study population were documented from an interviewer-administered structured questionnaire.

Anthropometric measurements

Body weight was measured to the nearest 0.1 kg using a calibrated scale, with subjects wearing light clothing and no shoes. Height was measured to the nearest 0.5 cm using a height scale with subjects barefoot. BMI (kg/m^2) was calculated by dividing the individual's weight (Kg) by the squared height in meters. Waist circumference (WC) was measured with a measuring tape placed at the midpoint between the lower margin of the last palpable rib and the top of the iliac crest (hip bone) with the patient standing and the end of a normal expiration.

Blood pressure measurements

Blood pressure was measured three times on the arm resting on the table with mid-arm at heart level at 1-minute intervals, after keeping participants in a sitting position for 30 minutes using appropriate cuff size blood pressure apparatus. The average value of the last two readings was used for analysis.

Blood Collection and Processing

Five milliliters (5ml) of venous blood was collected from each study participant by a laboratory technologist after overnight fasting or after 8–12 hours of fasting (no food or drink, except water). The drawn blood specimen was allowed to stay for 20–30 minutes for clot formation and then centrifuged at 4000 revolutions per minute (rpm) for 10 minutes to separate the serum from the whole blood. The serum was then transferred to a clean, sterile container and kept at – 80°C until it was examined. Following the completion of the data collection, the extracted serum was transported to Melka Oda General Hospital and used to determine the levels of lipid profile tests (LDL-c, HDL-C, TC, and TG) using a calibrated fully-automated clinical chemistry analyzer (COBAS C311), as directed by the manufacturer.

Data Quality Control and Management

Data collection tools were prepared to meet the highest quality and monitored at the time of sampling. The blood sample was collected under aseptic techniques following standard operating procedures. The instruments used for physical measurement (blood pressure and anthropometry) and biochemical analysis were checked for their consistency. Professional laboratory technologists handled all the experimental procedures starting from specimen collection and all instruments were operated according to the manufacturer's instructions.

Data processing and analysis

Data obtained from the questionnaire, anthropometric measurements, blood pressure measurements, and laboratory analysis were entered using Epi-Data statistical software version 4.6 and exported to SPSS version 25 for analysis. The Kolmogorov-Smirnov test was used to assess the distribution of the data with the level of significance set at $p < 0.05$. Normally distributed data included age, SBP, DBP, MAP, LDL-c, HDL-c, TG, and TC. Descriptive statistical analysis such as mean, standard deviation, frequency, and the percentage was performed to describe the characteristics of the participants with and without *Moringa stenopetala* herbal tea-drinking habits. The characteristics of participants with and without *Moringa stenopetala* herbal tea-drinking habits were compared using an independent sample t-test for continuous variables and the chi-square test for categorical variables. One-way ANOVA and Tukey post hoc tests were also used to see the difference in the mean values of continuous variables among the groups of hypertensive patients consuming *Moringa stenopetala* herbal tea (non-drinkers, infrequent or monthly-drinkers, weekly-drinkers, and daily-drinkers). Generalized linear regression was used to study the association between continuous variables and *Moringa stenopetala* herbal tea consumption groups. The P-values of less than 0.05 at a 95% confidence level were considered statistically significant. Finally, the results were compiled and presented using tables, graphs, and texts.

Ethical consideration

The study was carried out after ethical clearance (with a reference number 636/06/2021) was obtained from the Institutional review board (IRB) of the School of Medicine, College of Medicine and Health Science, University of Gondar. A formal collaboration letter for data collection was obtained from Goba Referral Hospital, Dello Mena General Hospital, and Robe General Hospital. Both verbal and written consent was also obtained from the study subjects after explaining the objectives, significance, procedures, risks, and benefits of the study. Subjects' right to participate or withdraw from the study at any time was assured. For this purpose, a one-page consent letter was attached to the cover page of each questionnaire.

Result

Socio-demographic characteristics of the study participants

A total of 128 study participants were interviewed and blood pressure and lipid profile levels were measured. Among the participants, 50% were *Moringa stenopetala* herbal tea drinkers and the other 50% were non-drinkers.

The mean ± SD of ages among the study participants was 52.56 ± 10.20 and 55.56 ± 11.91 years for the *Moringa stenopetala* herbal tea drinkers and non-drinkers respectively. Sixty-four percent (64.1%) of *Moringa stenopetala* herbal tea drinkers and 56.3% of non-drinkers were found to be females. Among *Moringa stenopetala* herbal tea drinkers, 81.3% were married, 4.7% were divorced/separated, and 14.1% were widowed. Likewise, of nondrinkers, 82.8% were married, 7.8% were divorced/separated, and 9.4%

were widowed. More than 57% of *Moringa stenopetala* herbal tea drinkers were urban dwellers. Of nondrinkers, 73.4% were urban dwellers. There was no statistically significant difference between *Moringa stenopetala* herbal tea drinkers and non-drinkers group regarding socio-demographic characteristics like age, gender, marital status, residence, educational status, occupation, monthly income, duration of hypertension, and type of medication ($P > 0.05$; Table 1). Our socio-demographic data, duration of hypertension, and types of medication reflected an ideal match between the study participants.

Table 1: Socio-demographic and clinical characteristics of the study participants attending Bale zone hospitals, South East Ethiopia, 2021 (n = 128)

Variables	M. stenopetala herbal tea drinkers (n=64)	Non-drinkers (n=64)	*P*-value
Age (years)			0.128
Mean ± SD	52.56 ± 10.20	55.56 ± 11.91	
Range	35-73	28-80	
Gender			0.367
Male	23 (35.9%)	28 (43.8%)	
Female	41 (64.1%)	36 (56.2%)	
Marital status			0.574
Married	52 (81.3%)	53 (82.8%)	
Divorced/separated	3 (4.7%)	5 (7.8%)	
Widowed	9 (14.1%)	6 (9.4%)	
Residence			0.063
Rural	27 (42.2%)	17 (26.6%)	
Urban	37 (57.8%)	47 (73.4%)	
Educational level			0.630
Never attended	23 (35.9%)	20 (31.3%)	
Can read and write	1 (1.6%)	3 (4.7%)	
Primary (1-8)	15 (23.4%)	11 (17.2%)	
Secondary (9-12)	11 (17.2%)	11 (17.2%)	
College and above	14 (21.9%)	19 (29.7%)	
Occupation			0.375
Government employee	10 (15.6%)	14 (21.9%)	
Merchant	18 (28.1%)	12 (18.8%)	
Farmer	20 (31.3%)	15 (23.4%)	
Pensioner	6 (9.4%)	11 (17.2%)	
Housewife	10 (15.6%)	12 (18.8%)	
Monthly income (ETB)			0.172
<1,400	7 (10.9%)	7 (10.9%)	
1,4013,500	40 (62.5%)	31 (48.4%)	
3,5015,000	11 (17.2%)	11 (17.2%)	
>5,000	6 (9.4%)	15 (23.4%)	
Duration of			0.293

hypertension			
Mean ± SD	7.03 ± 4.61	8.08 ± 6.46	
Range	1-20	1-30	
Types of medication			0.929
Hydrochlorothiazide	43 (67.2%)	45 (70.3%)	
Amlodipine	12 (18.8%)	11 (17.2%)	
Enalapril	9 (14.1%)	8 (12.5%)	

Key: SD, Standard Deviation; % = percentage; ETB, Ethiopian birr; Categorical variables are presented in frequency and percentage while continuous variables are presented as mean ± (SD) and range; Variables were statistically significant at $P < 0.05$; P-values were got from the chi-square test except for the age and duration of hypertension which is obtained from the independent sample t-test.

Anthropometric characteristics of the study participants

The current study showed that the mean value of weight had a significant difference between the *Moringa stenopetala* herbal tea drinkers and non-drinkers which is higher among the non-drinkers with a mean difference of -9.33kg (p = 0.000). The mean±SD height (cm) of study participants was 161.91 ± 5.53 and 163.69 ± 7.54 in *Moringa stenopetala* herbal tea drinkers and non-drinkers, respectively, and was not significantly different (P = 0.130). The mean±SD body mass index (BMI) of the *Moringa stenopetala* herbal tea drinkers (21.87 ± 3.33Kg/m^2) was significantly lower (P = 0.000) by 12.03% than the non-drinkers (control) group (24.86 ± 4.10Kg/m^2). The mean±SD waist circumference (WC) of the *Moringa stenopetala* herbal tea drinkers and non-drinkers were 81.86 ± 7.48cm and 88.59 ± 10.81cm respectively. There was also a statistically significant difference between *Moringa stenopetala* herbal tea drinkers and the non-drinkers group regarding WC with a p-value of 0.000 (Table 2).

Table 2: Anthropometric measurements of study participants attending Bale zone hospitals, South East Ethiopia, 2021

Variables	Mean ± SD		Mean difference	%	*P*-value
	Moringa stenopetala herbal tea drinker (n=64)	Non-drinkers (n=64)			
Weight (Kg)	57.37 ± 9.17	66.70 ± 11.91	-9.33	-13.99	**0.000***
Height (m)	161.91 ± 5.53	163.69 ± 7.54	-1.78	-1.09	0.130
BMI (Kg/m^2)	21.87 ± 3.33	24.86 ± 4.10	-2.99	-12.03	**0.000***
WC (cm)	81.86 ± 7.48	88.59 ± 10.81	-6.73	-7.60	**0.000***

Key: BMI, body mass index; WC, waist circumference; % = percentage of change; (-) = Decreased from controls; (+) = Increased from controls; * = statistically significant, P-values were obtained by independent samples t-test.

Moringa stenopetala herbal tea consumption-related conditions

Of the participants, 50% were non-drinkers, while 28.1%, 14.8%, and 7.1% reported monthly, weekly, and daily *Moringa stenopetala* herbal tea intakes, respectively. The majority (79.7%) of the *Moringa stenopetala* herbal tea drinkers were beginning to drink *Moringa stenopetala* herbal tea due to the perception that *Moringa stenopetala* is entirely safe and effective in managing high blood pressure. Positive previous experience (12.5%) and dissatisfaction with conventional medicine (7.8%) were also among the other reasons given by the participants. All *Moringa stenopetala* herbal tea drinkers sweeten their *Moringa stenopetala* tea with sugar.

Lipid profile of *Moringa stenopetala* herbal tea drinkers and non-drinkers

The lipid profiles that were assessed in this study included low-density lipoprotein cholesterol (LDL-c), high-density lipoprotein cholesterol (HDL-c), triglyceride (TG), and total cholesterol (TC). The serum concentration of LDL-c in *Moringa stenopetala* herbal tea drinkers was significantly lower (P <0.001) by 28.50% than in the non-drinkers group. There was an 8.51% increment of serum HDL-c level in *Moringa stenopetala* herbal tea drinkers compared to non-drinkers, but the difference was not statistically

significant (P = 0.077). The serum TG level in *Moringa stenopetala* herbal tea drinkers was decreased by 20.89% from controls (P = 0.001). The serum concentration of TC of *Moringa stenopetala* herbal tea drinkers and non-drinkers had a Mean ± SD value of 149.88 ± 28.93 mg/dL and 188.78 ± 47.43 mg/dL respectively (P <0.001) (Tables 3).

Table 3: Mean serum level and mean percent differences of LDL-c, HDL-c, Triglyceride, and Total cholesterol of study participants attending Bale zone hospitals, South East Ethiopia, 2021

Variables	Mean ± SD		Mean difference	%	*P*-value
	Moringa stenopetala herbal tea drinker (n=64)	Non-drinkers (n=64)			
LDL-c	83.08 ± 28.87	116.19 ± 40.83	-33.11	-28.50	**<0.001***
HDL-c	42.06 ± 11.80	38.48 ± 10.93	+3.58	+8.51	0.077
Triglyceride	129.60 ± 42.43	163.83 ± 72.20	-34.23	-20.89	**0.001***
Total cholesterol	149.88 ± 28.93	188.78 ± 47.43	-38.90	-20.61	**<0.001***

Key: SD, standard deviation; LDL-c, low-density lipoprotein cholesterol; HDL-c, high-density lipoprotein cholesterol; % = percentage of change; (-) = Decreased from controls; (+) = Increased from controls; values (Mean ± SD) are represented as (mg/dL); ***** = statistically significant; P-values were obtained by student's independent t-test

Lipid ratios for *Moringa stenopetala* herbal tea drinkers and non-drinkers

Recent data have shown that Castelli's risk index I and II (estimated as TC/HDL-c and LDL-c/HDL-c ratios) are more accurate predictors of cardiovascular risk than individual lipid parameters such as serum TC, TG, HDL-c, and LDL-c. Castelli's risk index-I is produced from the ratio of two important lipid parameters, TC and HDLc, whereas Castelli's risk index II, is calculated as the ratio of LDL-c and HDL-c [33]. There was a statistically significant difference (p <0.001) between the mean ratio of LDL-c to HDL-c for *Moringa stenopetala* herbal tea drinkers (2.23 ± 1.28) and non-drinkers (3.28 ± 1.69). Similarly, the

mean ratio of TC to HDL-c was significantly lowered (p <0.001) for *Moringa stenopetala* herbal tea drinkers than non-drinkers (3.87 ± 1.49 vs 5.27 ± 2.13) (Figure 1).

The serum concentration of LDL-c, HDL-c, triglyceride, and total cholesterol varied according to grades of *Moringa stenopetala* herbal tea consumption. Considering individual lipid parameters, one-way ANOVA with Tukey post hoc test results indicated that there were statically significant differences (P <0.05) in mean serum LDL-c and TC level between subgroups of “daily drinkers” and “non-drinkers”. There was also a significant difference between “daily drinkers” and “monthly drinkers” in mean serum LDL-c and TC. The mean serum LDL-c and TC level of weekly drinkers was also significantly lower than monthly drinkers and non-drinkers. On the contrary, Castell’s risk index I & II showed significant differences (P <0.001) between the subgroups of *Moringa stenopetala* tea drinkers (i.e between subgroups of daily drinkers and non-drinkers; weekly drinkers, and non-drinkers) (Table 4).

Table 4: Lipid profiles of different groups of *Moringa stenopetala* herbal tea drinkers attending Bale zone hospitals, South East Ethiopia, 2021.

Variables	Mean (95% Confidence interval)				*P*-value
	Non-drinkers	Monthly drinkers	Weekly drinkers	Daily drinkers	
LDL-c	116.19 (105.99-126.39)	101.61 (93.34-109.88)	63.04 (58.16-67.92)^{ab}	51.22 (44.38-58.07)^{ab}	<0.001*
HDL-c	38.48 (35.75-41.20)	40.60 (36.35-44.86)	42.32 (38.66-45.97)	47.33 (35.57-59.09)	0.131
TG	163.83 (145.80-181.87)	134.39 (122.78-146.00)	125.11 (98.05-152.17)	119.90 (88.49-151.31)	0.113
TC	188.78 (176.94-200.63)	167.48 (158.97-175.99)^{a}	129.07 (122.47-135.67)^{ab}	123.39 (112.91-133.87)^{ab}	<0.001*
CRI-I	5.27 (4.74-5.81)	4.52 (3.97-5.07)	3.13 (2.85-3.40)^{a}	2.82 (2.16-3.48)^{a}	<0.001*
CRI-II	3.29 (2.86-3.71)	2.84 (2.37-3.31)	1.54 (1.36-1.73)^{ab}	1.24 (0.76-1.72)^{ab}	<0.001*

Key: Data are presented as mean (95% Confidence Interval); Obtained from ANOVA test for the between-group comparisons; * = statistically significant; **a** = significantly different when compared to non-drinkers (Tukey post hoc); **b** = significantly different when compared to monthly drinkers (Tukey post hoc); CRI, castell’s risk index

Blood pressure of *Moringa stenopetala* herbal tea drinkers and non-drinkers

The mean systolic blood pressure (SBP) of *Moringa stenopetala* herbal tea drinkers and non-drinkers in the study was 128.72 ± 13.71 mmHg and 139.68 ± 15.61 mmHg respectively. The mean SBP was significantly lower (P <0.001) among the *Moringa stenopetala* herbal tea drinkers than non-drinkers. On the other hand, the mean diastolic blood pressure (DBP) of *Moringa stenopetala* herbal tea drinkers and non-drinkers were 83.77 ± 9.26 and 88.63 ± 8.49 mmHg respectively. The mean DBP was also significantly lower (P = 0.002) among the *Moringa stenopetala* herbal tea drinkers than non-drinkers. The mean arterial blood pressure (MAP) of study participants was 98.76 ± 10.19 mmHg and 105.64 ± 9.90 mmHg in *Moringa stenopetala* herbal tea drinkers and non-drinkers, respectively, and was significantly different (P <0.001; Table 5).

Table 5: Blood pressure measurements of *Moringa stenopetala* herbal tea drinkers and non-drinkers attending Bale zone hospitals, South East Ethiopia, 2021

Variables	Mean ± SD		Mean difference	%	*P*-value
	Moringa stenopetala herbal tea drinker (n=64)	Non-drinkers (n=64)			
SBP (mmHg)	128.72 ± 13.71	139.68 ± 15.61	-10.96	-7.85	**<0.001***
DBP (mmHg)	83.77 ± 9.26	88.63 ± 8.49	-4.86	-5.48	**0.002***
MAP (mmHg)	98.76 ± 10.19	105.64 ± 9.90	-6.88	-6.51	**<0.001***

Key: SBP, systolic blood pressure; DBP, diastolic blood pressure; MAP, mean arterial blood pressure; % = percentage of change; (-) = Decreased from controls; (+) = Increased from controls; ***** = statistically significant; P-values were obtained by student's independent t-test

Systolic blood pressure of non-drinkers, monthly-drinkers, weekly-drinkers, and daily drinkers in the study had a mean (95% confidence interval) of 139.68 (135.78-143.58) mmHg, 131.93 (127.33-136.54) mmHg, 126.76 (120.20-133.32) mmHg, and 120.0 (111.90-128.10) mmHg respectively. Regarding DBP, the mean (95% confidence interval) was found 88.63 (86.50-90.75) mmHg, 86.61 (83.85-89.38) mmHg, 82.24 (77.37-87.11) mmHg, and 75.67 (70.94-80.39) mmHg for non-drinkers, monthly-drinkers, weekly-drinkers, and daily-drinkers respectively. One-way ANOVA with Tukey post hoc test results indicated that; daily and

weekly *Moringa stenopetala* herbal tea drinkers appeared to have significantly lower SBP, DBP, and MAP compared with non-drinkers groups (P <0.001; Table 6).

Table 6: Blood pressure measurements of different *Moringa stenopetala* herbal tea consuming groups at Bale zone hospitals, South East Ethiopia, 2021

Parameters (unit)	Means (95% Confidence Interval)				*P*-value
	Non-drinker	Monthly drinker	Weekly drinker	Daily drinker	
SBP (mmHg)	139.68 (135.78-143.58)	131.93 (127.33-136.54)	126.76 (120.20-133.32)[a]	120.0 (111.90-128.10)[a]	<0.001*
DBP (mmHg)	88.63 (86.50-90.75)	86.61 (83.85-89.38)	82.24 (77.37-87.11)[a]	75.67 (70.94-80.39)[ab]	<0.001*
MAP (mmHg)	105.64 (103.17-108.12)	101.72 (98.52-104.92)	97.08 (91.93-102.23)[a]	90.44 (85.22-95.67)[ab]	<0.001*

Key: Data are presented as mean (95% Confidence Interval); Obtained from ANOVA test for the between-group comparisons; ***** = statistically significant; **a** = significantly different when compared to non-drinkers (Tukey post hoc); **b** = significantly different when compared to monthly drinkers (Tukey post hoc);

Association between *Moringa stenopetala* herbal tea consumption categories and lipid profiles, lipid ratios, and blood pressure measurements

The observed and the adjusted means of LDL-c, HDL-c, TG, TC, CRI-I, CRI-II, SBP, DBP, and MAP in the four groups are shown in Table 8. In the fully adjusted generalized linear model (M2), the mean LDL-c, TC, CRI-I, and CRI-II increased towards the higher *Moringa stenopetala* herbal tea consumption categories. In contrast, no differences were observed amongst the four groups in HDL-c and TG. Moreover, in the fully adjusted generalized linear model (M2), the mean SBP, DBP, and MAP decreased toward the higher *Moringa stenopetala* herbal tea consumption categories (Table 7).

Table 7: Associations between *Moringa stenopetala* herbal tea consumption categories and lipid profiles and blood pressure measurements among hypertensive patients attending Bale zone hospitals, South East Ethiopia, 2021.

Variables	Model	Mean (95% Wald Confidence interval)				*P*-value
		Non-drinkers	Monthly drinkers	Weekly drinkers	Daily drinkers	
LDL-c	M1	116.19 (108.43-123.95)	101.61 (91.27-111.96)	63.04 (48.80-77.28)	51.22 (30.53-71.91)	<0.001*
	M2	116.15 (108.11-124.18)	101.65 (91.25-112.04)	63.11 (48.73-77.48)	51.28 (29.56-72.99)	<0.001*
HDL-c	M1	38.48 (35.74-41.21)	40.60 (36.95-44.25)	42.32 (37.29-47.34)	47.33 (40.04-54.63)	0.115
	M2	38.58 (35.71-41.45)	40.41 (36.69-44.12)	42.12 (36.99-47.25)	47.80 (40.05-55.55)	0.171
TG	M1	163.83 (149.47-178.19)	134.39 (115.24-153.54)	125.11 (98.75-151.47)	119.90 (81.61-158.20)	0.009*
	M2	157.37 (143.51-171.24)	139.71 (121.77-157.66)	131.33 (106.54-156.13)	131.40 (93.93-168.87)	0.220
TC	M1	188.78 (179.89-197.68)	167.48 (155.62-179.34)	129.07 (112.74-145.39)	123.39 (99.67-147.11)	<0.001*
	M2	187.84 (178.68-196.99)	168.21 (156.36-180.06)	129.98 (113.60-146.36)	125.29 (100.54-150.04)	<0.001*
CRI-I	M1	5.27 (4.85-5.70)	4.52 (3.95-5.09)	3.13 (2.34-3.91)	2.82 (1.68-3.96)	<0.001*
	M2	5.19 (4.76-5.63)	4.60 (4.03-5.17)	3.19 (2.41-3.98)	2.93 (1.75-4.11)	<0.001*
CRI-II	M1	3.29 (2.94-3.63)	2.84 (2.38-3.30)	1.54 (0.91-2.18)	1.24 (0.32-2.16)	<0.001*
	M2	3.25 (2.89-3.60)	2.88 (2.42-3.34)	1.57 (0.93-2.20)	1.29 (0.33-2.25)	<0.001*
SBP	M1	139.68 (136.18-143.18)	131.93 (127.27-136.59)	126.76 (120.35-133.18)	120.00 (110.68-129.32)	<0.001*
	M2	138.84 (135.34-142.34)	132.84 (128.31-137.37)	126.10 (119.84-132.36)	123.75 (114.28-133.21)	0.001*
DBP	M1	88.63 (86.57-90.68)	86.61 (83.87-89.35)	82.24 (78.46-86.01)	75.67 (70.18-81.15)	<0.001*
	M2	88.31 (86.20-90.42)	86.74 (84.01-89.47)	82.30 (78.53-86.07)	77.26 (71.55-82.96)	0.001*
MAP	M1	105.64 (103.30-107.99)	101.72 (98.59-104.84)	97.08 (92.78-101.38)	90.44 (84.19-96.70)	<0.001*
	M2	105.15 (102.77-	102.11 (99.02-	96.90 (92.63-	92.75 (86.31-	<0.001*

		107.54)	105.19)	101.17)	99.20)	

Key: Data are presented as mean (95% Wald Confidence Interval); Obtained from generalized linear models; * = statistically significant; CRI, castell's risk index; Model 1 (M1), unadjusted; Model 2 (M2), adjusted for age, gender, weight, BMI, WC, duration of hypertension, and types of medication.

Discussion

The present study conducted in Bale zone hospitals has assessed and compared the lipid profiles and blood pressure measurements of hypertensive patients drinking *Moringa stenopetala* herbal tea and nondrinking groups. The results of this study showed that the age, gender, marital status, residence, educational level, occupation, monthly income, duration of hypertension, and types of medication of both *Moringa stenopetala* herbal tea drinkers and non-drinkers were comparable (well matched). This shows that sociodemographic characteristics, duration of hypertension, and types of medication were not determinant factors for the variation of lipid profile levels and blood pressure measurements between these two groups.

The finding from the present study showed that the serum LDL-cholesterol (LDL-c), triglyceride (TG), and total cholesterol (TC) levels were found to be significantly lower in *Moringa stenopetala* herbal tea drinkers than nondrinkers. The serum HDL-cholesterol (HDL-c) levels were higher in *Moringa stenopetala* herbal tea drinkers compared to nondrinkers, although statistically insignificant. Similarly, this study showed a significant decrease in Castelli's risk index I (TC to HDL-c ratio) and II (LDL-c/HDL-c ratio) in *Moringa stenopetala* herbal tea drinkers. From the present study, it was also observed that *Moringa stenopetala* herbal tea consumption was significantly associated with lower serum LDL-c, TC, TG to HDL-c ratio, and LDL-c/HDL-c ratio. However, no statistically significant association was observed between *Moringa stenopetala* herbal tea consumption and HDL-c.

Reduction in the serum LDL-c, TG, TC, TG to HDL-c ratio, and LDL-c/HDL-c ratio in the blood of *Moringa stenopetala* herbal tea drinkers may add evidence for positive effects of *Moringa stenopetala* herbal tea on lipid profile and cardiovascular health. The observed positive effects of *Moringa stenopetala* herbal tea are attributed to either a single component or mixture of phytochemicals found in the *Moringa stenopetala* plants. These phytochemicals: alkaloids, flavonoids, saponins, steroids, terpenoids, and polyphenols improve lipid profiles thereby decreasing cholesterogenesis and fatty acid synthesis through inhibition of pancreatic cholesterol esterase and pancreatic lipase activities, respectively [34]. These phytochemicals also lower cholesterol absorption by the inhibition of cholesterol micellar solubility thereby improving lipid profiles [35]. Furthermore, polyphenols can enhance lipid metabolism by activating AMP-activated protein kinase, thereby attenuating lipogenesis, promoting lipolysis, and reducing lipid accumulation by inhibiting the differentiation and proliferation of preadipocytes [36]. A

recent study showed that the consumption of beverages like herbal tea could have a beneficial effect in reducing the risk of getting CVDs [37].

The current study's findings are consistent with a recent analysis that found moringa consumption can help decrease TG, LDL-c, and TC levels while simultaneously raising HDL-c levels [38]. Similarly, the finding of the present study is in agreement with an experimental study carried out on fructose-induced hypertensive male Wistar rats, that showed a significant decrease in the concentration of TC and TG in these rats treated with aqueous and 70% ethanol crude extracts of *Moringa stenopetala* leaves compared to controls [26].

Another investigation on diabetic rats also revealed that diabetic rats fed with aqueous ethanol extract and butanol fraction of *Moringa stenopetala* had significantly lower TC and TG levels [39]. In a similar study, diabetic rats fed with aqueous ethanol extract and butanol fraction of Moringa stenopetala exhibited a significant rise in mean serum HDL-c levels, in contrast to the current study [39]. This discrepancy might be due to the difference in study design and animal model used.

Blood pressure is determined by cardiac output and peripheral vascular resistance, and it is affected by a change in either or both of these parameters [40]. The goal of any antihypertensive therapy is to bring a reduction in either or both of these parameters, preferably peripheral vascular resistance. The current study compared the mean SBP, DBP, and MAP of *Moringa stenopetala* tea drinkers and non-drinkers. The result of this study showed that the mean SBP, DBP, and MAP of *Moringa stenopetala* herbal tea drinkers were significantly lower than that of the non-drinkers, with a mean difference of 10.96 mmHg, 4.86 mmHg, and 6.88 mmHg respectively. This study also demonstrated that *Moringa stenopetala* herbal tea consumption was significantly associated with lower SBP, DBP, and MAP.

The observed blood pressure lowering effects of *Moringa stenopetala* herbal tea might be owing to the presence of bioactive compounds (i.e. polyphenols, alkaloids, flavonoids, glycosides, saponin, and antioxidants) that act on blood pressure. Previous studies indicated that the consumption of polyphenol-rich foods like moringa may induce beneficial changes in pathways related to cardiovascular health [31].

The potential mechanisms of action for the blood pressure-lowering effect of *Moringa stenopetala* were not determined in this study but have been explored by others. In vitro and animal studies show that *Moringa stenopetala* is a vasodilator [41, 42], an angiotensin-converting enzyme inhibitor [43], and a diuretic [41, 44], which ultimately leads to reduced blood pressure.

The result of the current study is in agreement with an experimental study carried out on normotensive guinea pigs that have been shown the hypotensive and antihypertensive effects of crude aqueous leaf extract of *Moringa stenopetala*, which is explained by a significant drop in SBP, DBP, and mean arterial blood pressure (MAP) [45]. Similarly, the current study is in line with another experimental study carried out on rat models using aqueous and 70% ethanol extracts of *Moringa stenopetala* that has also shown the hypotensive and antihypertensive effects of *Moringa stenopetala*, which is also explained by a significant drop in SBP, DBP, and MAP [26]. The findings from the present study are also consistent with a

systematic review that found *Moringa stenopetala* to have antihypertensive (diuretic, natriuretic, kaliuretic, and vasodilatory) properties [32]. A study carried out on human subjects demonstrated the potential lowering effect of moringa on both SBP and DBP [46].

Strength And Limitations Of The Study

To the best of our knowledge, this is the first reported study that attempted to assess and compare the serum lipid profiles and blood pressure parameters of *Moringa stenopetala* herbal tea drinkers and non-drinkers and therefore will serve as a baseline for future studies. Despite the aforementioned strengths, this study has several weaknesses. First, the study used participants selected through a non-probability sampling method and thus may affect the external validity of the findings. Second, self-reported *Moringa stenopetala* herbal tea consumption may be subject to misclassification and recall biases, thus may have distorted the effect estimates of moringa tea consumption. Third, information about the way of preparation (filtered, boiled water) was not available, though the information on frequency and amount was obtained. Fourth, potential confounders including total daily caloric intake and intake of cholesterol-rich diets were not considered. Fifth, sufficient literature was not available on the influence of *Moringa stenopetala* herbal tea consumption on lipid profiles and blood pressure. Hence, a sufficient comparison of the current study was not made. Finally, this study is a comparative cross-sectional study, hence cannot indicate a causal relationship.

Conclusion

Our study proved that the blood pressure, LDL-c, TG, TC, and the ratios TC/HDL-c and LDL-c/HDL-c were found to be significantly lower in *Moringa stenopetala* herbal tea drinkers. Interestingly, HDL-c was also found to increase in *Moringa stenopetala* herbal tea drinkers compared to nondrinkers. Moreover, increasing *Moringa stenopetala* herbal tea intake is significantly associated with lower blood pressure, LDL-c, TC, and the ratios TC/HDL-c and LDL-c/HDL-c. Overall, the cumulative findings of the present study suggest the need for future in-depth human studies or randomized control trials to confirm the effects of *Moringa stenopetala* herbal tea consumption on lipid profile and blood pressure measurements and possibly identify the underlying mechanisms.

Abbreviations

ANOVA, Analysis of Variance; CVD, Cardiovascular disease; DBP, Diastolic Blood Pressure; HDL-c, High-density lipoprotein cholesterol; LDL-c, Low-density lipoprotein cholesterol; MAP, Mean Arterial Blood Pressure; mg/dL, Milligram per deciliter; mmHg, Millimeter of mercury; NCD, Non-communicable disease; SBP, Systolic Blood Pressure; TC, Total Cholesterol; TG, Triglyceride

Declarations

Data Sharing Statement

A de-identified data set can be shared without limitations, and supporting data was uploaded in the supporting information section.

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Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis, and interpretation, or in all these areas; took part in drafting, revising, or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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Disclosure

All authors declare that they have no competing interests

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Figures

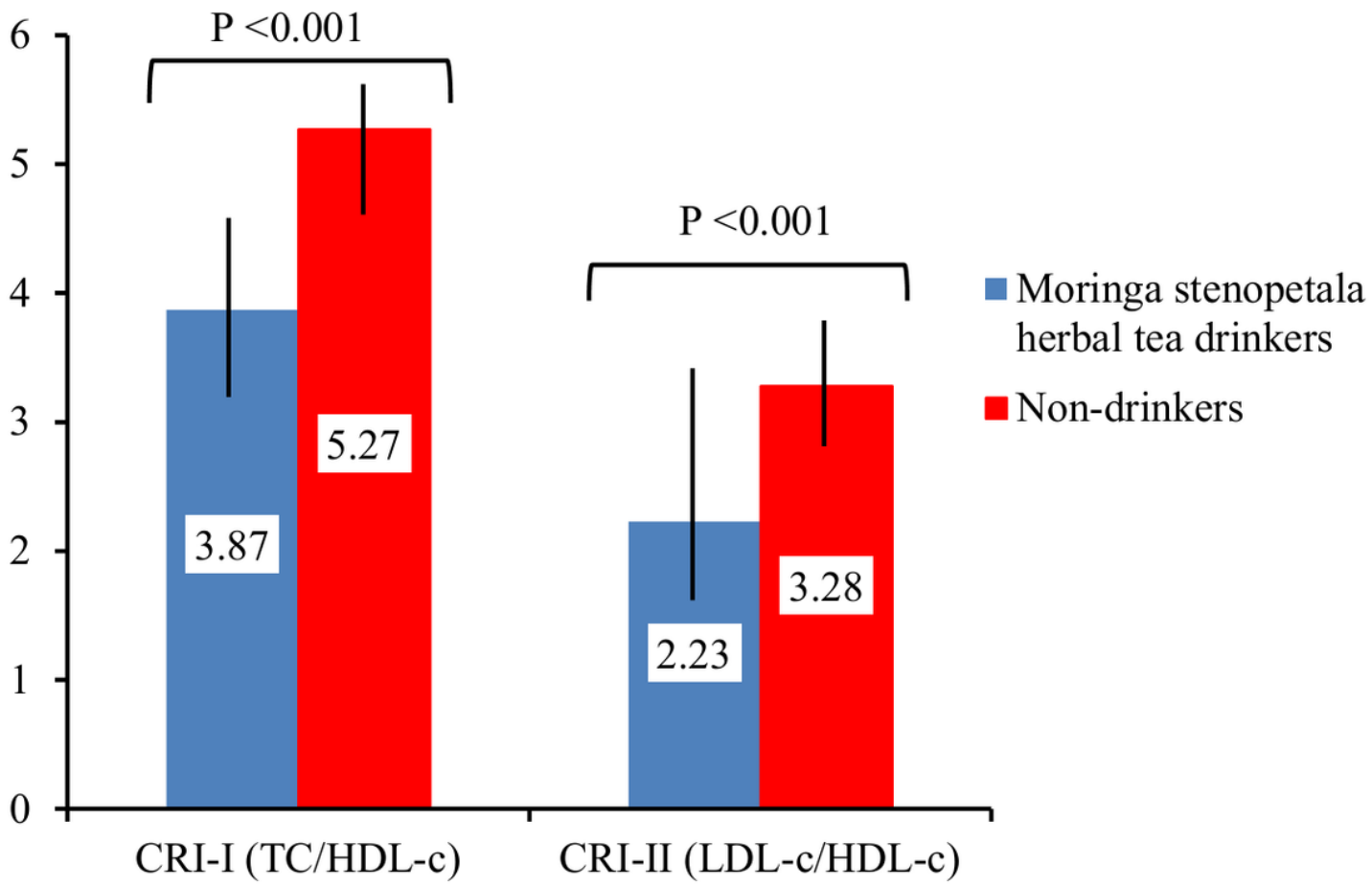

Figure 1

Castelli’s risk index I and II of *Moringa stenopetala*herbal tea drinkers and non-drinkers attending Bale zone hospitals, South East Ethiopia, 2021.