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Research Article

Blood Lipid Fractions Following a Vegan Diet in Ethiopian Society: A Study from a Developing Nation

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Abstract

Background: Dyslipidemia is a risk factor for the development of cardio-metabolic diseases. Limited information exists from developing countries like Ethiopia concerning the health effects of a vegan diet in optimizing blood lipid profiles.

Objective: This study compared the effect of short-term (7-week) intake of a vegan diet with an omnivorous diet with regards to blood lipid profiles in a group of male and female Ethiopian subjects.

Methods: 97 subjects (52 females and 45 males), who consumed strict vegetarian (vegan) diets for 7 weeks participated in the study. Following a gap of one week, participants shifted to consuming an omnivorous diet for an equal period of 7 weeks. After the end of each dietary period, height (cm), weight (kg), and BMI ($kg \cdot m^{-2}$) were recorded. Serum total (TC), high-density lipoprotein (HDL), and low-density lipoprotein (LDL) cholesterol, as well as triglyceride (TG) concentrations, were analyzed. Mean ± SD values obtained from the two diets were compared by paired t-tests, using $p < 0.05$ for significant differences.

Results: The vegan diet resulted in significantly lower TC, LDL-C, and HDL-C concentrations compared with the omnivorous diet. The values in $mg \cdot dL^{-1}$ for TC were (157.64 ± 41.89 vs. 166.86 ± 48.63, $p < 0.003$), for LDL-C (107.95 ± 39.97 vs. 113.21 ± 42.68, $p < 0.044$), for HDL-C (42.21 ± 9.22 vs. 45.68 ± 9.20, $p < 0.001$), and for BMI were (21.22 ± 3.12 vs. 21.27 ± 3.13, $p < 0.015$), respectively. Comparisons between genders showed significantly lower lipid values in males as compared to females ($p < 0.05$), with men experiencing a greater percent decrease in TC and LDL-C following the vegan diet as compared to women.

Conclusion: Short-term intake of a vegan diet compared with an omnivorous diet resulted in lower TC and LDL-C levels, which may potentially be linked to improved cardio-metabolic health. Men responded to a greater extent than women. The small decrease in HDL-C with the vegan diet, however, is unwelcome and requires consideration if adopting a vegan approach solely for purposes of improving cardio-metabolic health.

Keywords: Vegetarian; Vegan; Omnivorous; BMI; Lipoproteins; Cholesterol

Abbreviations

BMI: Body Mass Index; TC: Total Cholesterol; LDL-C: Low Density Lipoprotein-Cholesterol; HDL-C: High Density Lipoprotein-Cholesterol; TG: Triglyceride

Introduction

It is known that blood lipoprotein profiles, including total (TC), high-density lipoprotein (HDL), and low-density lipoprotein (LDL) cholesterol, as well as triglyceride (TG), have been shown to be differently altered by the consumption of plant and animal foods. Previous work has indicated that long-term consumption of a vegetarian diet, as opposed to short-term vegetarian diet consumption, leads to lower TC and LDL-C levels in blood compared with omnivorous diets [1-4]. These reductions in TC and LDL-C may have health benefits, as elevated blood lipids have been associated in some studies with the development of cardio-metabolic disease risk such as hypertension, stroke, and diabetes [5-7].

Results regarding blood HDL-C levels following a vegetarian diet are conflicting. Some work supports the notion that a vegetarian diet increases HDL-C concentration in the blood [8], while other studies document decreases following a vegan diet [9] or no change in HDL-C following a standard vegetarian diet [10]. Likewise, randomized controlled trials show that TG may increase [11],

decrease, or remain unchanged [12] when switching from an omnivorous diet to a plant-based vegetarian diet. In addition to blood lipids, intake of a plant-based diet may result in a lower body mass index (BMI) [3,10,11], further justifying the benefits of a vegetarian diet on overall health.

In reference to vegetarian diets, there are multiple forms, some of which are more stringent than others. For example, the most stringent appears to be vegan, which involves the consumption of no animal products (and the use of no animal products in any form). Other forms include lacto-vegetarian (do not eat meat, poultry, fish, or eggs, but consume dairy products), lacto-ovo-vegetarian (do not eat meat, poultry, or fish, but eat eggs and dairy products), pescatarian (do not consume meat, but eat fish, sea-foods) and others [3,9,10]. The present study has focused exclusively on vegans, who do not consume any type of animal products in their daily calories [3,4]. To the best of our knowledge, no previous study has assessed the effects of a vegan diet on blood lipid profiles in Ethiopians. Therefore, this study has aimed to determine the short-term (seven-week) effect of consuming a vegan diet on blood lipid profiles in male and female Ethiopians. It was hypothesized that similar to long-term effects, the short-term (7-week) vegan diet would cause relevant reductions in TC and LDL-C, when compared to an animal-based omnivorous diet.

Material and Methods

97 subjects (52 female and 45 male) participated voluntarily in the study. All participants were residents of the capital city Addis Ababa (~4 million citizens) and included medical students, physicians, and high school teachers. Prior to the study, risks and benefits of the study were explained to the participants, and they signed an informed consent. The Ethics Committee of the College of Health Sciences, Tikur-Anbessa Medical School, Addis Ababa University approved the study. Participants completed a questionnaire with the following personal information: name, gender, age, type of diet, alcohol consumption, and smoking habits.

All subjects were asked to maintain their normal physical activity patterns throughout the course of the study period and confirmed that this was adhered to; hence, we do not believe that changes in physical activity influenced our results. For many Ethiopians, daily physical activity is done in the form of chores and physical labor, with little time spent in formal "exercise" as might be done in developed countries. For subjects in the present study, activity was minimal and they maintained a sedentary lifestyle without being involved in any kind of formal physical activity, with time spent learning (e.g. college students), teaching (Junior high school teachers), and providing healthcare to patients within clinics (e.g. health professionals).

Although food intake was not recorded during the study period, participants were questioned about their dietary patterns and reported that they followed only a vegan diet during their seven weeks of vegan assignment. The composition of vegan diet was mainly carbohydrate, including whole grains and cereals. Plant oils, legumes, green vegetables, and fruits were also consumed. The main beverage of choice for Ethiopians is water and most Ethiopians consume three meals per day. This was confirmed for all subjects in the present study. After the end of the vegan dietary consumption and following a one-week period, participants followed an omnivorous diet for another seven weeks that included animal products.

At the end of each dietary period, height (cm) without shoes was measured by using a standard stadiometer. Body weight was measured on a standard beam scale. The ratio of weight (kg) over height in meters squared was used to calculate BMI ($kg \cdot m^{-2}$). Venous blood was collected by a phlebotomist immediately after the end of each dietary period in compliance with standard procedures for blood collection. Sample analysis was carried out at Diagnostic Laboratory of the Medical School through a working agreement with Addis Ababa University. The TC, TG, HDL-C, and LDL-C were analyzed using a direct/automated chemistry analyzer (Mindray Chemistry Analyzer BS-200E, China) using stable liquid reagent precipitation enzymatic methods. Moreover, ratio values of lipoproteins were calculated and recorded.

Statistical Analysis

All values were expressed as means ± SD. Results for BMI and lipid profiles obtained during the vegan diet were compared to the omnivorous diet using dependent paired t-tests. Further, male and female group differences for lipid profiles were compared by independent paired-t-tests. Data were analyzed using SPSS (version 21.0; IBM, Armonk, NY) software with significant differences taken at $p < 0.05$.

Results

A total of 97 subjects were enrolled in this study. However, only 72 subjects successfully completed all aspects of the study and provided the final blood sample. The specific sample size for each variable is presented within the table 1.

Table 1 describes mean ± SD values of BMI and lipoprotein concentrations measured after consumption of the vegan and omnivorous diets in all subjects (n = 97). Values for BMI ($kg \cdot m^{-2}$), TC, LDL-C, and HDL-C concentrations were significantly lower ($p < 0.05$) for subjects in the vegan compared with omnivorous diet. Mean ± SD values in $mg \cdot dL^{-1}$ for TC was (vegan, 157.64 ± 41.89 vs. 166.86 ± 48.63, omnivorous), for LDL-C it was (vegan, 107.95 ± 39.97 vs. 113.21 ± 42.68, omnivorous), and for HDL-C it was (vegan, 42.21

± 9.22 vs. 45.68 ± 9.20, omnivorous). TG and ratio values did not show a significant difference between the two dietary regimens. Table 2 indicates results of gender differences in relation to both diet types. Independent paired-t-test results showed that males were significantly lower in TC, LDL-C, and HDL-C concentrations as compared to their female counterparts. When comparing data in table 2 for men and women, the percent decrease in TC and LDL-C when consuming the vegan diet was greater for men versus women (7% vs. 4% and 6% vs. 2%, respectively).

Discussion

We compared the effects of vegan and omnivorous diets with regards to blood lipid profiles and BMI in male and female Ethiopians (a developing nation from East Africa). Our results indicate favorable effects of the vegan diet in both men and women. Specifically, the study showed that the short-term (7-week) consumption of a vegan diet induced significantly lower ($p < 0.05$) TC and LDL-C concentrations compared with omnivorous diets (Table 1). These results agree with other studies [9,12,13], meta-analyses [1,10] and reviews [8,10,14] that noted lower levels of TC and LDL-C as the result of vegan diets.

Table 1: Comparisons of serum lipoproteins including TC, TG, HDL-C, and LDL-C and their ratios measured after consumption of vegan and omnivorous diets by healthy men and women for seven weeks.

	Vegan diet	Omnivorous diet	P-value
	(Mean ± SD)	(Mean ± SD)	
Age (y) n = 97	27.47 ± 0.82	27.47 ± 0.82	
BMI ($kg \cdot m^{-2}$) n = 92	21.22 ± 3.22	21.75 ± 3.13	p = 0.015 *
TC ($mg \cdot dL^{-1}$) n = 72	157.64 ± 41.88	166.86 ± 48.63	p = 0.003 *
TG ($mg \cdot dL^{-1}$) n = 72	104.65 ± 62.24	109.83 ± 59.13	p = 0.417
HDL ($mg \cdot dL^{-1}$) n = 72	42.21 ± 9.22	45.68 ± 9.20	p = 0.001 *
LDL ($mg \cdot dL^{-1}$) n = 72	107.95 ± 39.97	113.21 ± 42.68	p = 0.044 *
TC/HDL (ratio) n = 72	3.79 ± 0.97	3.68 ± 0.96	p = 0. 060
LDL/HDL (ratio) n = 72	2.61 ± 0.97	2.51 ± 0.96	p = 0.129
TC/LDL (ratio) = 72	3.79 ± 0.97	3.68 ± 0.96	p = 0.918

* $p < 0.05$, comparisons were performed by "dependent paired-t-test" procedures.

Table 2: Comparisons of men and women consuming a vegan (V) or omnivorous (O) diet for seven weeks.

Variable	Male V	Female V	Male O	Female O
Age (y)	26.43 ± 3.19	28.38 ± 10.70	26.43 ± 3.19	28.38 ± 10.70
BMI ($kg \cdot m^{-2}$)	20.68 ± 0.40	21.91 ± 3.98	21.26 ± 3.06	22.03 ± 3.21
TC ($mg \cdot dL^{-1}$)	145.11 ± 35.15	171.16 ± 42.17*	157.00 ± 40.76	179.00 ± 54.31⸸
TG ($mg \cdot dL^{-1}$)	103.44 ± 68.22	102.27 ± 49.79	105.57 ± 53.30	114.33 ± 65.32
HDL ($mg \cdot dL^{-1}$)	38.60 ± 6.75	46.08 ± 9.63*	41.95 ±6.82	50.36 ± 9.59⸸
LDL ($mg \cdot dL^{-1}$)	98.02 ± 32.40	119.75 ± 42.28*	105.02 ± 36.46	123.66 ±47.30⸸
TC/HDL (ratio)	3.81 ± 0.99	3.78 ± 0.88	3.75 ± 1.02	3.59 ± 0.59
LDL/HDL (ratio)	2.55 ± 0.94	2.45 ± 1.00	2.55 ± 0.94	2.45 ± 1.00
TC/LDL (ratio)	1.51 ± 0.27	1.50 ± 0.21	1.54 ± 0.19	1.49 ± 0.29

* $P < 0.05$ (between men and women for Vegan diet)

⸸$P < 0.05$ (between men and women for Omnivorous diet)

One of the physiological mechanisms behind the decrease in TC and LDL-C levels relates to the presence of relatively higher fibers in plant-based diets [9,12,14]. Fibers have the capacity to slow down the absorption of cholesterol from the intestine [7,8,15]. In fact, the composition of food taken during the vegetarian diet by Ethiopians was mainly carbohydrate, which contains a greater proportion of fiber as compared to fat- and protein-rich foods. The main types of carbohydrate foods included: lentils, chickpeas, beans, pea, wheat, local loaf called "injera," potato, and the fibrous vegetables like cabbage, garlic, and carrot. In addition to fiber, vegan diets contain many health-promoting phytochemicals, which have the effect of arresting the synthesis of cholesterol in the body [10,16,17]. Phytochemicals [8,16,18] are derived primarily from fruits, vegetables, whole grains, legumes, and nuts. These are indeed the foods most often consumed by Ethiopians when following a vegan diet.

Aside from total and LDL cholesterol, we measured TG levels in our subjects. An increase in blood TG concentration above the critical level (i.e., 150 mg·dL^{-1}) is considered a risk factor for heart disease [1,19,20]. However, in our study, similar to previous observational and clinical trials [1,10], blood TG was not significantly different between the vegan and omnivorous dietary intakes (Table 1). Some previous work [10,17,21] demonstrated that people eating vegetarian diets over a long period may show lower TG levels as compared with omnivorous diets. Our subjects followed the vegan diet for a short period of seven weeks and this timeframe may not be adequate to observe significant changes in TG in the blood. Moreover, TG levels can be influenced by the carbohydrate content of the diet and our subjects certainly consumed a significant portion of their daily calories in the form of carbohydrates. Finally, our subjects had relatively low levels of TG even when adhering to the omnivorous diet; therefore, a reduction may have been unnecessary.

In this study, our participants showed significantly lower ($p < 0.05$) HDL-C concentration after consuming the vegan as compared to the omnivorous diet (Table 1), suggesting that a vegan diet may have the potential to inhibit HDL-C synthesis. Some studies are in line with ours [22], while others have noted conflicting findings of an increase [8] or no change [10] in blood HDL-C level after following a vegetarian diet. Most Ethiopians enjoy consuming raw meat (red or white raw meat) during their non-vegetarian periods. It was described in previous papers that consumption of red meat increases HDL-C concentration in the blood [12,23]. Thus, the significant increase in blood HDL-C after seven weeks of an animal-based omnivorous diet might have been caused by the increased intake of red and fatty raw meat. Though it is not advisable to decrease the concentration of HDL-C below 40 mg·dL^{-1} in the blood [10], our data on HDL-C, measured during the vegan diet (i.e., mean value, 42.21 mg·dL^{-1}) is above this level (Table 1). Thus, the relative decrease in HDL-C during the vegan diet may not imply a significant disadvantage for health, especially considering that the ratio of TC/HDL was not negatively impacted. Our study compared the mean difference in the ratios of TC/HDL and TC/LDL (Table 1) and found that both vegetarian and omnivorous diets remained in the normal ratio range of < 4, implying that our subjects were not at higher risk for cardio-metabolic disease

Aside from blood lipids, we measured BMI of our participants. Similar to several previous studies [1-3,12,23], seven weeks of vegan dietary intake by our subjects demonstrated a significantly lower BMI compared with the omnivorous diet (Table 1). This may be due to the lower fat content of vegan diets, as these diets generally contain a greater proportion of carbohydrate and fiber foods that are low in fat contents [17]. Thus, consuming a plant-based diet may help individuals control their weight and thereby be cardio-protective. This said, it should be noted that although statistically significant, the difference in BMI between the two diet groups was negligible. This small difference is likely due to the fact that subjects had extremely low BMI values and there was not a need for lowering. Differing findings may be apparent if the same experiment was performed using a sample of overweight or obese subjects.

Regarding gender differences, there is limited information in response to a vegetarian diet affecting blood lipid profiles [24]. The present study assessed the influence of age-matched gender differences in a group of females (n = 52) and males (n = 45) after consuming a vegan diet, each for 7-week periods (Table 2). Results indicated that males showed a significantly lower ($p < 0.05$) TC, LDL-C, and HDL-C levels than did their female counterparts. However, values for males were lower to begin with. That said, men did experience a greater overall percent decrease in both TC and LDL as compared to women and may respond to a greater degree (and perhaps in a shorter period of time) when exposed to a vegan diet as compared to women. Factors that may bring about changes on lipid profiles between females and males may be attributed to hormonal and metabolic differences that normally exist between the two genders. Future work is needed comparing the two genders and their response to a vegan diet.

As with all studies, we note both strengths and weaknesses. This study is the first to our knowledge to demonstrate the impact of a plant-based vegan diet on lipid profiles in Ethiopian men and women living in a developing nation. In addition, our data indicate that females may not respond to the same extent as men to the vegan diet or may require a longer period of time to do so. Limitations of our work include the fact that our study represented only those subjects living in the urban area (Addis Ababa city, nearly 4-million inhabitants), who are normally aware of their dietary intake and are educated. Our sample does not represent the rural populations who have different lifestyle and nutritional approaches. To validate our findings, we suggest a well-designed population-based study that encompasses different socio-economic and broader geographic areas of developing countries.

Moreover, we did not record the exact food values both during the vegan and omnivorous dietary intake, including a calculation of caloric intake and macronutrient breakdown. However, because of religious beliefs and strict adherence to religious fasting rules, we are confident that our participants strictly followed the vegan diet during the 7-week period. Subjects adopting a vegan diet for a long period of time may show deficiencies in some micronutrients like iron and vitamins (e.g. vitamin B-12 in the blood) [25]. The study did not investigate micronutrient status, because the follow-up

was limited to changes of lipid profiles and body weight. Therefore, it would be advisable to include micronutrient status as well, while studying effects of vegan diets on lipid metabolism. In addition, we failed to capture the precise activity profiles of our subjects, which would have helped to verify that our noted changes were due to the dietary intervention exclusively. Recording both activity and dietary intake in future studies would be recommended

Conclusion

A plant-based vegan diet consumed for a short-term (seven weeks) resulted in lower blood TC and LDL-C concentrations. Thus, for subjects who may have elevated blood lipids, consumption of vegan diets even for a short period may prove to be an effective non-pharmacologic means to optimize blood lipid profiles, possibly leading to improved cardio-metabolic health. Our study also indicates that following short-term exposure to vegan diets, men respond to a greater extent than women with regards to TC and LDL-C.

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Volume 2 Issue 7 July 2018