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Comparative Assessment of Vegetarian and Non-Vegetarian Diets with Physical Fitness on Body Composition and Lipid Profiles among Students at School of Medicine, College of Health Sciences, Addis Ababa University

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Authors' contributions

This work was carried out in collaboration between all authors. Author TSE wrote the protocol and the manuscript; managed the statistical analyses and the literature searches of the study. Author WM was advisor and also designed the study. Author HD managed laboratory part of the study. All authors read and approved the final manuscript.

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ABSTRACT

Background: Overweight and obesity are significant health problems all over the world in all ages.
Objective: To compare the effect of vegetarian and non-vegetarian diets with physical fitness on body composition and lipid profiles of students at Addis Ababa University, College of Health Sciences.
Methodology: A comparative cross-sectional study design was carried out on 75 study participants (males= 41 and females=34) with age range of 19-29: mean 24.6 ± 7.23 years. The data were collected twice after participants consumed vegetarian (V) and non-vegetarian (NV) diets for 7-weeks each. After each dietary habit, a structured questionnaire was used to obtain socio-demographic, dietary habits and general health of the participants. Following this, anthropometric

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measurements were taken. Percentage of body fat (%BF) was determined using skinfold caliper at: abdomen, suprailiac region and triceps. VO2 max (maximum oxygen uptake) was estimated by Queen's College Step Test (QCT).
Results: Compared to a non-vegetarian diet, a vegetarian diet consumption was significantly associated with lower body weight, BMI, %BF, and FM (fat mass) ($P<0.05$). However, height, waist/hip ratio, blood pressure, and fat-free mass did not significantly differ between the two diet groups. As compared to non-vegetarian diet, vegetarian diet had significantly higher HDL-C and lower TC and TC/HDL-C values. VO2 max was significantly higher in males than in females ($P<0.05$) in both dietary patterns.
Conclusion: The use of vegetarian diet for at least 7-weeks was associated with optimal body composition and lipid profiles when compared to non-vegetarian diet consumption in healthy individuals.

Keywords: Vegan; omnivores; lipid profiles; body composition; VO2 max.

1. INTRODUCTION

Obesity is a significant health problem all over the world for all ages. Eating a healthy diet and daily physical activity are ways for combating obesity [1]. Previously conducted studies suggest that compared with non-vegetarian, vegetarian diets are considered as healthier [2,3]. Following a vegetarian diet, people have lower levels of body mass, blood pressure, and incidence of cardiovascular events as compared to non-vegetarian diet [4].

Traditionally, vegetarianism is interpreted as the avoidance of meat, however, different types of vegetarian diets exist [5]. The lacto-ovo-vegetarian diet is characterized by the avoidance of meat, poultry, and fish; and allowance of dairy products and eggs. Other subsets of vegetarian groups include pesco-vegetarian, or those who include fish, and vegan, those who abstain from all foods of animal origin, including dairy products and eggs in addition to meat, poultry, and fish [6]. Non-vegetarians are those individuals who do not have any dietary restriction [5].

On the other hand, a number of studies demonstrated that physical inactivity increased worldwide [7,8]. Physical inactivity is independent factor for being overweight or obese [7]. Worldwide, at least 2.8 million people die each year as a result of being overweight or obese [9]. Furthermore, physical inactivity has been an international issue among university and college students [10,11].

Anthropometric parameters which include subcutaneous fat (skinfold thickness), body mass index (BMI), waist-to-hip ratio (WHR), waist circumference (WC), and percentage of body fat (%BF) were single most easily obtainable, inexpensive, and non-invasive methods for assessing body composition [12].

Body composition refers to the relative proportions of body weight in terms of lean body mass and body fat. Lean body mass represents the weight of muscle, bone, internal organs and connective tissue. Body fat represents the remaining fat tissue [13]. On the other hand, body composition is categorized as a health-related component of physical fitness [14].

In 2016, the American Heart Association (AHA) published a scientific statement recommending that assessment of individuals' VO_2 max should be regularly assessed and utilized as a clinical vital sign [15]. The VO_2 max is defined as the maximal oxygen uptake during an exercise intensity [16]. The VO_2 max can be easily estimated using submaximal exercise tests (Step tests) which require little practice and are usually of short duration using the established prediction equations [17]. Submaximal exercise tests assume that a steady-state HR is achieved and is consistent for each exercise work rate. Steady-state HR usually achieved in 3 to 4 minutes, at constant submaximal work rate [18]. Using maximal exercise testing to determine VO_2 max is that subjects required to exercise to the point of volitional fatigue, thus potentially requiring medical supervision and the availability of emergency equipment [17].

The association of vegetarian diet with health is well documented in the literature nationwide. The most well-known include the Adventist Health Studies amongst Seventh Day Adventists in California. However, very few studies have quantified the relationship between physical activity and dietary habits among Africans, and no such studies exist in Ethiopia.

Therefore, the intension of the present study was to investigate the effect of consuming vegetarian and non-vegetarian diet with physical fitness on body composition and lipid profiles in a group of male and female university students.

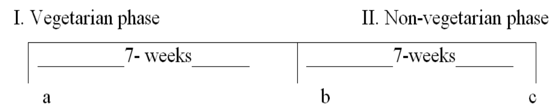
2. MATERIALS AND METHODS

The study conducted on apparently healthy, 41 males and 34 females volunteer medical and post graduate students with age range of 19-29 years who follow vegetarian diet consumption during Ethiopian orthodox church 'Abiy Tsom' (Lent fast) at Tikur Anbesa Specialized Teaching Hospital, College of Health Sciences, Addis Ababa University between March and May, 2017.

The study used a repeated measures of cross sectional study design and purposive sampling techniques. To determine sample size, the study used GPower Version 3.1.9.2 [19] as a tool for the study design.

Ethical clearance was obtained from Ethical Review Committee of the Department of Medical Physiology. For the purpose of data collection, informed consent was obtained from the study participants before administering the questions/collecting blood sample and objectives of the study was explained to the participants by the data collectors. Blood sample was drawn by trained health professional. Study participants were indirectly benefited from this study through early identification of their body composition and physical activity level as risk factors for non-communicable diseases and advised for further maintenance or improvement. Physical measurement was done by performing measurements at an area that has been screened off from other people within the household. Students who were self-restricted from eating animal derived foods and its by-products during the 'Abiy Tsom' (Lent fast) were included. Any participants with musculoskeletal deformity, history of any acute or chronic illness and/or on any medication, under-going regular physical fitness training were excluded from the study.

The physiological and biochemical tests were made twice – during vegetarian diet (phase I) and 1- week later during non-vegetarian diet (phase II). In both cases, that is during both vegetarian and non-vegetarian phases, duration of each dietary practice took seven weeks.



Where:

- a- Beginning of vegetarian diet consumption.
- b- Ends of vegetarian diet consumption and 1st phase of data collection.
- c- 2nd phase of data collection.

A self-administered questionnaire was used to obtain data about the general socio-demographic composition and types of dietary adaptation over. The questionnaire was first written in English, then translated into Amharic and back to English for its consistence, and was tested prior to use.

Following five-minute rest, two BP measurements were taken for subject using sphygmomanometer while the subject seated in chair relaxed with leg uncrossed and arm positioned at heart level and rested on desk. Normal blood pressure is 120/80 mm Hg. Hypertension was defined a BP reading of 130/80 mm Hg or higher [20].

2.1 Anthropometric

Weight: weight in kilogram was measured using Tanita HD-313 Digital Weight Scale, with a capacity of 150 kg, with divisions of 100 grams was used and the subject was standing wearing the minimum of clothing and as few accessories as possible.

Height: height in meter was taken using a non-stretchable measuring tape, with volunteer standing erect with feet together. An average of two consecutive measurements that did not vary more than 0.2 cm was used for analysis.

Body mass index (BMI): BMI was calculated by dividing body weight (kg) by the square of height (m). Normal weight was defined as BMI 18.5 to ≤ 22.9, Underweight as BMI < 18.5, Overweight as BMI 23 to ≤ 24.9 and Obesity as BMI ≥ 25 kg/m^2.

Hip and waist circumferences: for waist circumference, the measurement was made at the midpoint between the last rib and the iliac crest, with the abdomen relaxed, at the end of expiration using non-elastic measuring tape without exerting any pressure on the participants. Hip circumference was measured at the gluteus maximum extension with non-elastic measuring tape. All circumferences were performed in triplicate and an average of two measurements that did not vary more than 0.5 cm was used for analysis. All measures of the circumferences were performed by the researcher.

Waist-to-hip ratio (WHR): WHR was calculated by dividing the waist circumference by the hip circumference. Values of less than 1.00 for men and less than 0.85 for women are considered a desirable indicator of disease.

Percentage of body fat (%BF): skinfold thicknesses were measured at the right side of the body to the nearest 0.5 mm with a Harpenden caliper (Fig. 1) at the abdomen, triceps, and suprailium. Landmarks for the skinfold measurement were defined according to Nieman [21].

The fold of the skin was firmly grasped between the thumb and forefinger and lifted up approximately one-half inch. The contact surface of the calipers was placed below the thumb and forefinger while continuing to hold the skinfold firmly. The reading, in millimeters, on the dial of the Harpenden caliper was taken after the full spring pressure of the instrument had been applied. Care was taken to insure that sufficient time was allowed for the full pressure of the caliper to take effect, but without the fat being over compressed.

Skinfold sites used in this study were:

- Abdominal: a vertical fold taken 2 cm lateral to the umbilicus (Fig. 2).
- Suprailium: a diagonal fold taken above the iliac crest along an imaginary line extended from the anterior axillary line (Fig. 3).
- Triceps: A vertical fold on the rear midline of the upper arm, halfway between the lateral projection of the acromion process and the inferior part of the olecranon process with the arm hanging loosely at the side (Fig. 4).

This procedure was repeated at least twice at each location with 20 seconds intervals for a body turn-back. An average of two consecutive pinches that did not vary more than 0.5 mm was used to calculate %BF using the following equation [22].

For males:

$$\%BF = 0.39287(X_1) - 0.00105(X_1)^2 + 0.15772(X_2) - 5.18845 = \underline{\qquad\qquad}\%$$

For females:

$$\%BF = 0.41563(X_1) - 0.00112(X_1)^2 + 0.03661(X_2) + 4.03653 = \underline{\qquad\qquad}\%$$

Where;

X_1= the sum of average value of each site
X_2 = age

Fat mass (FM)= (% BF * weight (kg)) / 100
Fat- free mass= weight (kg) – FM (kg)

Fig. 1. Skinfold caliper (Harpenden, Barty International, CE 120, England)

Fig. 2. Measuring skinfold thickness at abdomen

Fig. 3. Measuring skinfold thickness at supraillium

Fig. 4. Measuring skinfold thickness at triceps

VO_2 max (maximum oxygen consumption)

Queen's College Step Test protocol was used for estimating maximum oxygen consumption (VO_2 max).

Equipment (Fig. 5) used for the test were:

- A stool of 41.3 cm (16.25 inch) height (Fig. 6)
- Metronome software set for cadence: 22 steps per minute for females and 24 steps per minute for males.
- Chest strap
- Heart rate monitor
- Stop watch
- Calculator

Prior to starting the test:

- Resting heart rate was recorded
- 85% of HR max (220-age*.85) of each subject was calculated.
- Demonstration on how to perform and keeping in time with the beat of the metronome.
- Demonstration on how to lead with either foot and were able to change the leading leg during testing, but must stay in time with the metronome.

- Cautions for not to have uneven weight bearing between left / right legs, use of hands on thighs for support, forward flexed posture, signs of fatigue.

While conducting the test:

- The HR was checked at least 3 times
- At the end of the 3 minutes the subjects were told to stop stepping and were rested for 20 minutes. Then the recovery heart rate (RHR) was recorded.
- The RHR was then used to calculate VO_2 max using following equation [23].

For males:

VO_2 max= 111.33 – [0.42 RHR beats/min] = _________ mL/kg/min.

For females:

VO_2 max= 65.81– [0.1847×RHR beats/min] =_________mL/kg/min.

Fig. 5. Beurer-heart rate monitor with chest strap-PM235

Fig. 6. Participant stepping on a stool of 41.3 cm height wearing chest strap and heart rate monitor

2.2 Lipid Profiles

After an overnight fast (8–12hrs), 5 ml of venous blood samples was drawn into serum separator tubes (from the antecubital space of the forearm) by a qualified person. The drawn sample stayed for 30 minutes and then centrifuged by 4000 revolutions per minute for 10 minutes. Then serum was taken and stored under -80 degree Celsius of temperature till it was taken for diagnostic laboratory. After all the specimens are collected, serum is packed with ice and was transported to the Addis Ababa University, College of Health Sciences, Tikur Anbessa Specialized Teaching Hospital for analysis. The serum levels of glucose, TC, HDL-C, LDL-C and TG were measured and analyzed using MINDRAY, BE-2000, CHINA, random access full automated auto analyzer.

2.3 Statistical Analysis

The data obtained from laboratory results and anthropometry measurements were checked for completeness and double entered into SPSS version 21 for analysis. After complete entry of all the data, soft copy was checked with its hard copy to see the consistency. The data entry system was programmed in such a way that outlier entries were not accepted. A paired t-test was used to compare mean level of body composition and lipid profiles between a vegetarian and a non-vegetarian dietary patterns. Chi-square was used to determine the strength of relationship between dependent variables. Pearson's correlation test was used to assess the association between body composition parameters and VO_2max. Statistical significance was accepted at the 5% level ($p<0.05$). Quantitative data were summarized as percentage, means, and standard deviation. Summary of results was displayed in graphs, tables and narrative forms.

3. RESULTS

3.1 Characteristics of Study Participants

Three participants who did not complete their end status measurement because of various reasons were excluded from the total population. The result of this study was therefore, based on 75 study participants (45% female and 55% male) with age range 19-29: mean 24.6 ± 7.23 years. The participants consumed vegetarian and non-vegetarian diet for 7-weeks each, but during vegetarian diet, participants were self-restricted from meat, dairy and its by-products, eggs and fish consumption. Sixty-one percent of the participants were under graduate and 39% were post graduate students. All the participants (N=75; 100%) were smoker and alcoholic (Table 3.1).

3.2 Physical Measurements

As shown in Table 3.2, body composition and blood pressure parameters of the 75 participants were compared after consumption of vegetarian and non-vegetarian diets for 7-weeks each. Results indicated that compared to non-vegetarian diet, vegetarian diet consumption had significantly lower body weight (56.57±8.58 vs. 57.69±8.92 kg), BMI (19.96 ±2.13 vs. 20.73 ± 2.16 kg/m^2), %BF (16.67± 6.11 vs. 18.43 ± 5.90 %), and FM (9.33 ± 3.36 vs. 10.55 ± 3.52 kg). However, height, HC, WC, WHR, BP, and FFM did not significantly differ between the two diet groups.

As shown in Table 3.3, BMI, WHR, %BF, FM, and FFM were compared between male and female participants based on dietary patterns. In both vegetarian and non-vegetarian diets, significantly higher %BF and FM, but lower WHR and FFM were observed in females than in males ($p<0.05$).

Table 3.1. Characteristics of study participants (N=75)

Characteristics		Frequency (N)	Percentage (%)
Gender	Male	41	55
	Female	34	45
Age	Years, (mean ±SD)	24.6 ± 7.23	
Educational status	Post graduate	29	39
	Under graduate	46	61
Physically active	Yes	75	100
	No	0	0
Smoking status	Yes	0	0
	No	75	100
Alcohol consumption	Yes	0	0
	No	75	100

Table 3.2. Statistical value of t-test results for physical measurements of study participants after intake of a vegetarian and a non-vegetarian diet for 7 weeks each.

Characteristics	V (N=75) Mean ± SD	NV (N=75) Mean ± SD	Mean difference	P-Value
HC (CM)	88.92±6.31	89.95 ± 6.24	-1.03	0.213
WC (CM)	70.69±7.175	70.72 ±7.16	-0.03	0.968
WHR	0.79 ±0.07	0.78 ± 0.05	0.01	0.096
HEIGHT (M)	1.67 ± 0.08	1.66 ± 0.12	0.01	0.321
WEIGHT (KG)	56.57±8.58	57.69±8.92	-1.12	0.011*
BMI (KG/M^2)	19.96 ±2.13	20.73 ± 2.16	-0.76	0.000*
%BF	16.67± 6.11	18.43 ± 5.90	-1.76	0.000*
FM (KG)	9.33 ± 3.36	10.55 ± 3.52	-1.22	0.000*
FFM (KG)	47.25 ± 8.49	47.28 ± 8.70	- 0.03	0.998
DBP (MM HG)	76.87 ± 6.88	76.20 ±5.83	-0.67	0.063
SBP (MM HG)	110.8 ±3.8	112.3 ± 3.10	-1.50	0.059

**Significance at p< 0.05; V, Vegetarian diet; NV, non-vegetarian diet; HC, hip circumference; WC, waist circumference; %BF, percentage of body fat; FM, fat mass; FFM, fat-free mass; DBP, diastolic blood pressure; SBP, systolic blood pressure.*

Table 3.3. Shows gender differences in body composition parameters participants after intake of a vegetarian and a non-vegetarian diet for 7-weeks each

Variables	V		NV	
	Females (N=34) Mean± SD	Males (=41) Mean± SD	Females (N=34) Mean± SD	Males (=41) Mean± SD
BMI (kg/m^2)	20.40 ± 2.34	19.66 ± 1.95	21.32 ± 2.55	20.33 ± 1.62
WHR	0.74 ± 0.05	0.84 ± 0.05*	0.75 ± 0.04	0.86 ± 0.04*
%BF	21.57 ± 4.98	12.76 ± 3.12*	22.94 ± 4.89	14.97 ± 3.64*
FFM (kg)	39.75 ± 4.84	53.67 ± 5.49*	40.31 ± 6.17	54.65 ± 5.56*
FM (kg)	11.00 ±3.06	8.08 ± 2.90*	9.67 ± 3.43	5.67 ± 3.17*

**Significant at p<0.05; V, vegetarian diet; NV, non-vegetarian diet; WHR, waist/hip ratio; FFM, fat free mass; FM, fat mass; %BF, percentage of body fat.*

Table 3.4. Shows characteristics of study participants based on a vegetarian and a non-vegetarian diet (N=75)

Characteristics	Dietary patterns		P-value
	V N (%)	NV N (%)	
BMI (kg/m^2)			
Normal weight	69 (92)	67 (89)	0.035*
Over weight	6(8)	8 (10)	
%BF			
Normal fat	56 (74)	54 (72)	0.017*
Over fat	19 (25)	21 (28)	
WHR			
Females <0.85	64 (85)	67 (89)	0.051
Males < 1			
Females >0.85	11 (14)	8 (10)	
Males >1			
VO_2 max (ml/kg/min)			
Normal range	34 (45)	36 (48)	0.036
Above range	41(54)	39 (52)	

**significance at P<0.05. V, vegetarian diet; NV, non-vegetarian diet; %BF, Percentage of body fat; WHR, waist/hip ratio; VO_2 max, volume of maximum oxygen uptake.*

A chi-square was used to observe the association of body weight status and VO_2 max with dietary patterns (Table 3.4). Results showed that significantly higher proportion of the participants categorized as overweight/overfat after non-vegetarian diet consumption were compared to vegetarian diet. According to Heyward [24], normal range for VO_2 max for non-athletic adults: 27-31 ml/kg/min for females and 35-40 ml/kg/min for males; above average: >31 ml/kg/min for females and > 40 ml/kg/min for males.

According to Kaminisky et al. (2006), normal range for %BF of non-athletic adults of age 20-29 for %BF: 12-15% for males and 22-25% for females; above range:>15% for males and >25% for females.

As shown in Fig. 7, VO_2 max was significantly higher in males than females during both vegetarian (43.81 ± 3.71 ml/kg/min and 30.81± 3.05 ml/kg/min, respectively, for males and females) and non-vegetarian (42.02 ± 2.32 ml/kg/min and 31.29 ± 3.73 ml/kg/min, respectively, for males and females) diet consumption.

3.3 Lipid Profile Measurements

The FBG, HDL-C, LDL-C, TC, TG, TC/HDL and LDL/HDL were compared between a vegetarian and a non-vegetarian diet groups (Fig. 10). The result of this study indicated that compared to non-vegetarian diet, significantly higher of HDL and lower TC and TC/HDL ($p<0.05$) values were observed in vegetarian diet consumption. However, there were no significant differences in the mean levels of FBG, TG, LDL, and LDL / HDL ($p>0.05$) between the two diet groups.

4. DISCUSSION

4.1 Body Composition and Blood Pressure

Epidemiological studies often reported that people who follow vegetarian diet consumption are thinner than those who eat non-vegetarian diets [2,25]. Similarly, a study conducted by Barnard [26] on 35 women who consumed strict vegetarian diet for five weeks also found significantly lower BMI as compared to non-vegetarian group. In the present study, although the participants consumed a vegetarian and a non-vegetarian diet for 7-weeks each, BMI was significantly lower in vegetarian diet as compared with non-vegetarian diet.

In addition, there was a significant difference in %BF and FM between consuming vegetarian and non-vegetarian diet ($P<0.05$).

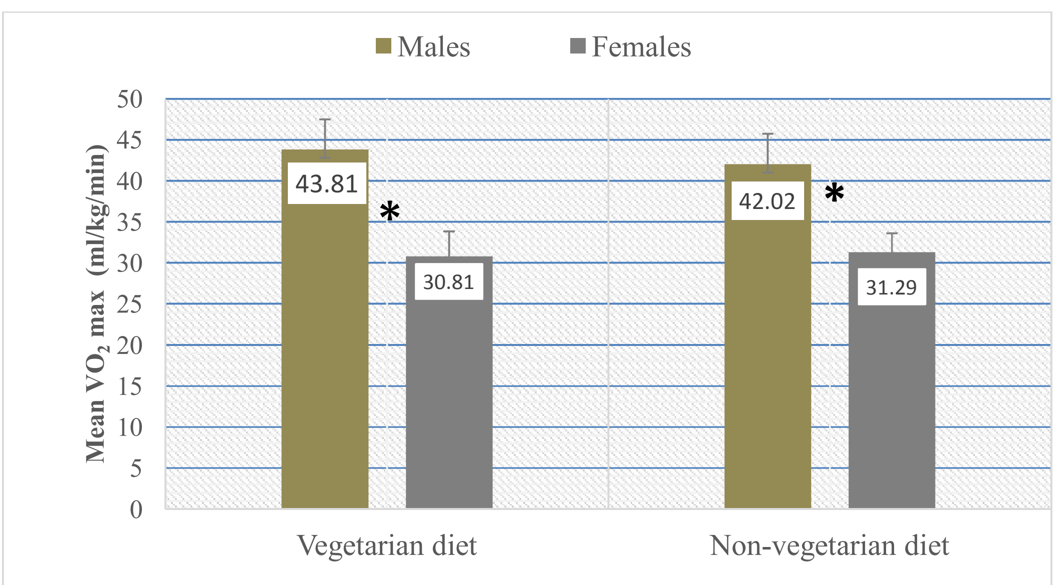


Fig. 7. Shows mean (±SD) of VO_2 max of male and female study participants after consumption of vegetarian and non-vegetarian diet for 7-weeks each
** Significance at $P<0.05$; VO_2 max, maximum oxygen uptake.*

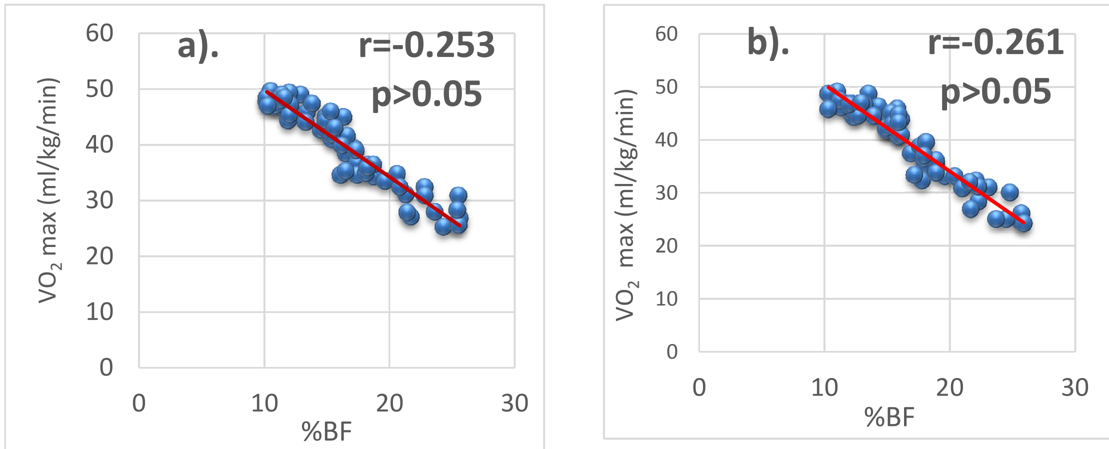


Fig. 8. Scatter diagram showing relationship between %BF and VO_2 max of the study participants after the intake of (a) vegetarian and (b) non-vegetarian diets for 7-weeks each, respectively

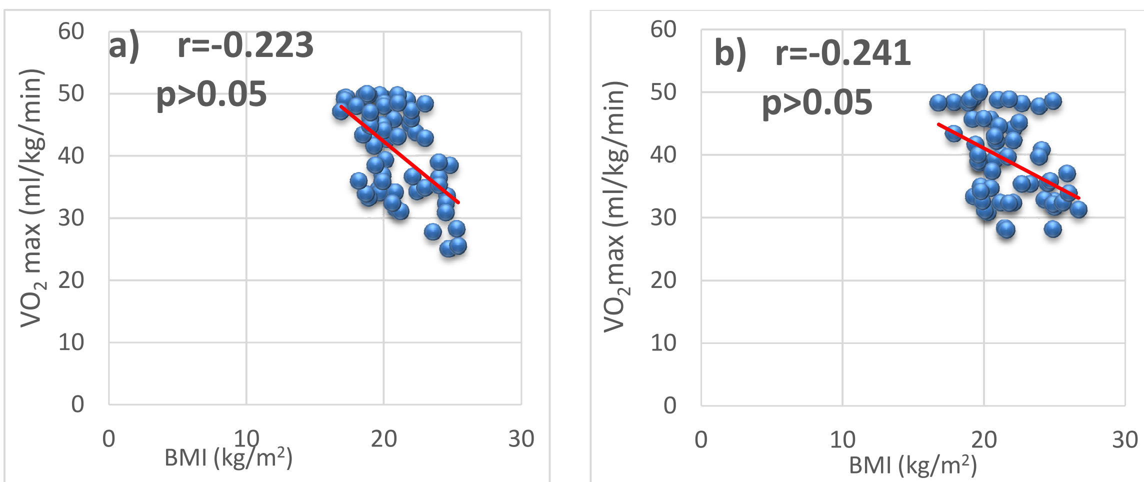


Fig. 9. Scatter diagram showing relationship between BMI and VO_2 max of the study participants after the intake of (a) vegetarian and (b) non-vegetarian diets for 7-weeks each, respectively.

The mean %BF and FM after consumption of vegetarian diet (16.67± 6.11% and 9.33 ± 3.36 kg, respectively, for %BF and FM) were significantly lower than non-vegetarian diet consumption (18.43 ± 5.90 % and 10.55 ± 3.52 kg, respectively, for %BF and FM). This finding is in agreement with previous studies [27]; (Vart, 2014).

On the other hand, other studies [28,29] reported that body composition was similar in both vegetarian and non-vegetarian diet consumption. Similarly, Kumar et al. [30] also reported that BMI did not significantly differ between vegetarian and non-vegetarian diet groups. The discrepancy may be partly attributed to different study settings, where they studied with intervention diet, lacking of homogeneous study subjects and also population samples differs with possible genetic variation lifestyle. Although this study did not observe the caloric intakes of the participants, the lower BMI, %BF and FM in vegetarian diet may be partly attributed to increased consumption of more fibers and less saturated fatty foods.

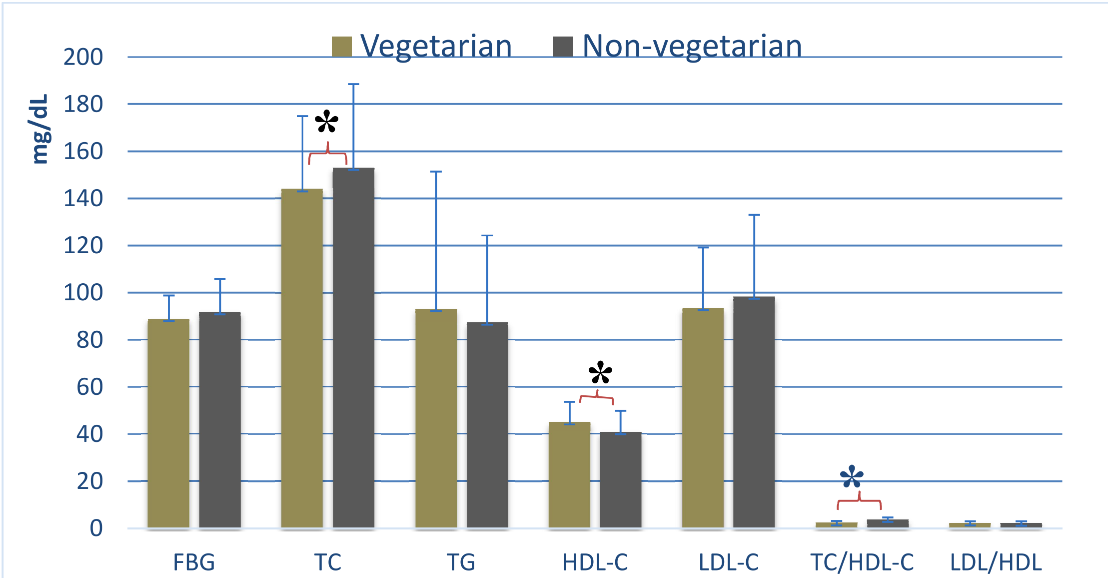


Fig. 10. Shows mean (± SD) of lipid profile of study participants after taking vegetarian and non-vegetarian diets for 7-weeks each.

**significance at p<0.05; FBG, fasting blood glucose; TC, total cholesterol; TG, triglyceride; HDL-C, high density lipoprotein cholesterol; LDC-C, low density lipoprotein cholesterol.*

Furthermore, gender difference in body composition parameters: BMI, WHR, %BF, FM, and FFM was investigated in the present study. In line with the study by Yousef et al. (2015), significantly higher %BF and FM, but lower FFM and WHR were observed in females as compared with males. The gender difference in body composition parameters may be due to the fact that relatively higher amount of subcutaneous fat tissue is preset in females, while males have higher amount of FFM [31].

Concerning blood pressure parameters, several studies have reported lower blood pressure in vegetarian diet consumption as compared with non-vegetarian diet [32,33]. At least one of the studies reporting lower blood pressure in vegetarians indicated that BMI rather than diet accounted for much of the age–adjusted variation in blood pressure. Similarly, Chiu *et al*. [34] stated vegetarian diet are high in potassium and fibers which are known to reduce blood pressure. In the present study both systolic and diastolic blood pressures are lower after participants consumed vegetarian diet with mean difference of -1.50 mm Hg and -0.67 mm Hg, respectively, when compared after the participants switched to non-vegetarian diet consumption. The lack of significance in this study may be partly attributed to short duration of adherence to vegetarian diet consumption or small sample size of the study.

4.2 VO_2 Max

In the present study, the VO_2max **(**mL/kg/min**),** as assessed by QCT protocol, did not significantly differ between a vegetarian and a non-vegetarian diet consumption for 7-weeks each. Similarly, Nieman (1999) reported that a vegetarian diet, even when practiced for several decades, is neither beneficial nor detrimental to the level of individuals' VO_2 max. On the other hand, Barr and Rideout [35] reported that due to greater intake of carbohydrate in vegetarians, individuals who followed vegetarian diet are associated with obtaining better results of VO_2 max levels. The discrepancy may be due to different study settings, where they studied with intervention diet and also population samples differ with lifestyle and types of vegetarians. In addition, the gender difference in VO_2 max (mL/kg/min) was significant in both diet groups ($P<0.05$). In both vegetarian and non-vegetarian diet consumptions, mean relative VO_2 max was significantly higher in males (V, 43.81 ± 3.71 mL/kg/min and NV, 42.02 ± 3.73 mL/kg/min) as compared with females (V, 30.81± 3.05 mL/kg/min and NV, 31.29 ± 2.32 mL/kg/min). The sex difference in VO_2 max (mL/kg/min) may partly be attributed to lower blood volume [36] and lower hemoglobin concentration (female [13.9 g/dL], male [14.3 g/dL]) (Mc Ardle, 2006) in female. On comparison of VO_2 max value of this study with the standard VO_2 max classification scale, both female and male participants were fitted in the category of fair [37]. The reason for reduced VO_2 max value of study participants could be because of the decreased physical activity and unhealthy lifestyle behaviors.

Furthermore, the relationship of relative VO_2 max with %BF and BMI was assessed in the present study (Figs. 8 and 9). In both vegetarian and non-vegetarian diet, VO_2 max (mL/kg/min) was negatively correlated with BMI and %BF. However, the correlation was not significant. This finding is in conflict with the study of Sharma et al. [38]. It could be said that the lack of significant correlation of VO_2 max (mL/kg/min) with %BF and BMI may be derived from the subject's average BMI and %BF in this study. Possibly, the reason for the negative correlation between %BF and VO_2 max may be accompanied as a consequence of increase in body fat, the vascular endothelial growth factor (as the most important mitogen builds capillaries in the body), reduced. Reduction in capillary density decreases the arterial blood oxygen difference and therefore reduces the amount of VO_2 max [39]. On the other hand, the negative correction between VO_2 max (mL/kg/min) and BMI could be associated with lower FFM or higher FM, because BMI does not distinguish between FFM and FM [40].

4.3 Lipid Profile Measurements

Most epidemiological studies on the lipid profile of a vegetarian and a non-vegetarian diet concluded that consuming a vegetarian diet had favorable lipid profiles than non-vegetarian diet [41,30]. In the present study, significantly higher serum concentration of HDL-C and lower TC/HDL-C and TC were observed after the participants consumed vegetarian diets for 7-weeks than after they switched to non-vegetarian diet consumption for an exact period of 7-weeks. Although the serum concentration of LDL-C, TG, HDL/LDL, and FBG did not significantly differ between the two dietary patterns, the values were lower in vegetarian diet consumption. Therefore, results from the present study supported the hypothesis of the present study that lipid profiles would be lower in vegetarian diet consumption than in non-vegetarian diet.

With regard to TC, most related studies [42,30] were reporting significance of lower TC in vegetarian diet as compared with non-vegetarian diet.

The result of the preset study also indicated that TC was significantly ($P = 0.015$) lower in vegetarian (144 ± 31.03 mg/dl) as compared with non-vegetarian (153.14 ± 35.45 mg/dl) consumption.

On the other hand, findings from Ashavaid et al. [43] indicated a non-significant difference in TC between vegetarian and non-vegetarian diet groups. The discrepancy may be due to different study setting, where they studied with intervention diet and also population samples differs with possible genetic variation lifestyle and types of vegetarians.

The effect of vegetarian and non-vegetarian diets on TG level has been inconsistent. In this study, a higher TG level was observed in vegetarian diet with mean difference of 5.73 mg/dL as compared to non-vegetarian diet. This finding is in agreement with Chen et al. [44] and De Biase et al. [45] and inconsistent with Dourado et al. [33]. The discrepancy may be due to the study participants in the present study may be consumed more carbohydrates in various forms such as fructose, which might reflect higher serum TG. Diet rich in carbohydrates helps for synthesis of more TG [46].

In this study, the serum concentration of HDL-C was significantly ($P=0.001$) lower in vegetarian as compared with non-vegetarian diet, after consuming each diet for 7-weeks. This study was in agreement with Huang et al. (2014). On the other hand, few other studies did not observe significant difference in HDL-C between vegetarian and non-vegetarian diet groups [44,45,33]. The discrepancy in HDL-cholesterol may be due to different study setting, where they studied with intervention diet, genetic variation or lifestyle and types of vegetarians [47,48].

Another blood measurement compared between vegetarian and non-vegetarian diet consumption was serum glucose. Previously conducted studies [32,49] did not observe significant difference in fasting blood glucose level between consuming a vegetarian and a non-vegetarian diets. Similarly, the present study also failed to reveal significant difference after the same participants consumed a vegetarian and a non-vegetarian diet for 7-weeks each.

On the other hand, few studies reported significantly lower level of FBG in individuals who followed vegetarian diet, as compared with those who eat non-vegetarian diet [47,48]. The discrepancy may be due to unadjusted risk factor for developing diabetes such as physical activity/exercise, age range, BMI, and also types of vegetarians.

5. CONCLUSION

- In conclusion, following a vegetarian diet for at least 7-weeks did exhibit significantly lower body composition parameters such as body weight, BMI, %BF and FM when compared with consuming non-vegetarian diet for equal period of time (7-weeks) by the same participants.
- In addition, significantly higher serum concentration of HDL-C and TC/HDL-C and lower TC levels were observed after consumption of vegetarian diet.
- The VO_2 max of the participants did not significantly differ after following vegetarian and non-vegetarian diets for 7-weeks each. However, as compared to males, female participants had significantly lower VO_2 max level. And also, the greater proportion of the study participants scored VO_2 max below average value. This could be associated with poor physical activity habits in daily life.
- Generally, the findings of the present study suggested that following vegetarian diet for at least 7-weeks is associated with lower risk factors for cardio-metabolic diseases

CONSENT

For the purpose of data collection, informed consent was obtained from the study participants before administering the questions/collecting blood sample and objectives of the study was explained to the participants by the data collectors.

ETHICAL APPROVAL

Ethical clearance was obtained from Ethical Review Committee of the Department of Medical Physiology.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Burleson JM, O'bryant HS, Stone MH, Collins MA, Triplett-McBride T. Effect of weight training exercise and treadmill exercise on post-exercise oxygen consumption. Medicine and Science in Sports and Exercise. 1998;30(4):518-522.
2. Berkow SE, Bernard N. Vegetarian diet and weight status: Nutrition Review. 2006;64:175-88.
3. Leitzmann C. Vegetarian diets: What are the advantages? In Diet diversification and health promotion. 2005;57:147-156.
4. Lin CL, Fang TC, Gueng MK. Vascular dilatory functions of ovo-lactovegetarians compared with omnivores. Atherosclerosis. 2001;158(1):247-251.
5. Craig WJ, Mangels AR. Position of the american dietetic association: Vegetarian diets. Journal of the American Dietetic Association. 2009;109(7):1266-1282.
6. Le LT, Sabaté J. Beyond meatless, the health effects of vegan diets: Findings from the adventist cohorts. Nutrients. 2014; 6(6):2131-2147.
7. Blanchard CM, McGannon KR, Spence JC, Rhodes RE, Nehl E, Baker F, Bostwick J. Social ecological correlates of physical activity in normal weight, overweight, and obese individuals. International Journal of Obesity. 2005;29:720-726.
8. Conley D. and McCabe BJ. Body mass index and physical attractiveness: Evidence from a combination image-alteration/list experiment. Sociological Methods & Research. 2011;40(1):6-31.
9. Kastorini CM, Milionis HJ, Ioannidi A, Kalantzi K, Nikolaou V, Vemmos KN, Goudevenos JA, Panagiotakos DB. Adherence to the Mediterranean diet in relation to acute coronary syndrome or stroke nonfatal events: A comparative analysis of a case/case-control study. American Heart Journal. 2011;162(4):717-724.

10. Huang TTK, Harris KJ, Lee RE, Nazir N, Born W, Kaur H. Assessing overweight, obesity, diet, and physical activity in college students. Journal of American College Health. 2003;52(2):83-86.
11. Amani AR, Somchit MN, Konting MMB, LY K, Darestani SA, Ismail MY, BT Ismail N. Relationship between body fat percent and maximal oxygen uptake among young adults. Biodegradation. 2010;102:106.
12. Tarnus E, Bourdon E. Anthropometric evaluations of body composition of undergraduate students at the University of La Reunion. Advances in Physiology Education. 2006;30(4):248-253.
13. Howley ET, Franks BD. Fitness professional's handbook. 5th ed. Champaign: Human Kinetics; 2007.
14. Ruiz JR, Castro-Piñero J, España-Romero V, Artero EG, Ortega FB, Cuenca MM et al. Field-based fitness assessment in young people: The ALPHA health-related fitness test battery for children and adolescents. British Journal of Sports Medicine. 2011;45(6):518–524.
15. Ross R, Blair SN, Arena R, Church TS, Després JP, Franklin BA, Haskell WL, Kaminsky LA, Levine BD, Lavie CJ, Myers J. Importance of assessing cardio-respiratory fitness in clinical practice: A case for fitness as a clinical vital sign: A scientific statement from the American Heart Association. Circulation, 2016;CIR-0000000000000461.
16. Lobelo F. Ruiz JR. Cardiorespiratory fitness as criterion validity for health-based metabolic syndrome definition in adolescents. Journal of the American College of Cardiology. 2007; 50(5):471.
17. American College of Sports Medicine (ACSM). ACSM's Guidelines for Exercise Testing. 2010;118:353-8.
18. Heyward VH, Gibson A. Advanced fitness assessment and exercise prescription 7th edition. Human kinetics; 2014.
19. McCrum-Gardner E. Sample size and power calculations made simple. International Journal of Therapy and Rehabilitation. 2010;17(1):10.
20. Whelton PK, Carey RM, Aronow WS. Guideline for the prevention, detection, evaluation, and management of high blood pressure in adults: A report of the American college of cardiology/American heart association. Journal of American College of Cardiology. 2018;7(1).
21. Nieman DC. Fitness and sports medicine: An introduction. Bull Publishing Company. 1990;260:70-6.
22. Jackson AS, Pollock ML. Practical assessment of body composition. The Physician and Sportsmedicine. 1985; 13(5):76-90.
23. McArdle WD, Katch FI, Pechar GS, Jacobson L, Ruck S. Reliability and interrelationship between maximal oxygen intake, physical work capacity and step-test scores in college women. Medical Science Support. 1972;4(4):182-186.
24. Heyward V. Advance fitness assessment & exercise prescription. 3rd ed. 1998;48.
25. Fraser GE. Vegetarian diets: What do we know of their effects on common chronic diseases? The American Journal of Clinical Nutrition. 2009;89(5):1607s-1612s.
26. Barnard ND, Scialli AR, Bertron P, Hurlock D, Edmonds K, Talev L. Effectiveness of a low-fat vegetarian diet in altering serum lipids in healthy premenopausal women. The American Journal of Cardiology. 2000;85(8):969-972.
27. Newby PK, Tucker KL. Empirically derived eating patterns using factor or cluster analysis: A review. Nutrition Reviews. 2004;62(5):177-203.
28. Siani V, Mohamed EI, Maiolo C, Di Daniele N, Ratiu A, Leonardi A, De Lorenzo A. Body composition analysis for healthy Italian vegetarians. Diabetolical Vineger. 2003;40(1):297-298.
29. Parm Ü, Jürimäe J, Orav A, Lätt E, Sokmann S, Pedamäe K, Tamm AL. Influence of vegetarian diet to the factors associated with metabolic syndrome. Journal of Advanced Nutrition and Human Metabolism; 2015.
30. Kumar S, Syed A, Mohammed J, Shanawaz C, Mamum AD. Nutrition in lipid profile in general population and vegetarian individuals living in Rural Bangladesh. Journal Obesity and Weight loss Therapy. 2012;55:123-138.
31. Kyle UG, Genton, Slosman DO, Pichard C. Fat-free and fat mass percentages in 5225 healthy subjects ged 15 to 98 years. Applied Nutrition of Invest. 2001b;17:534-541.
32. Sarri KO, Tzanakis NE, Linardakis MK, Mamalakis GD, Kafatos AG. Effects of Greek Orthodox Christian Church fasting

on serum lipids and obesity. BMC Public Health. 2003;3(1):16.
33. Dourado KF, de Arruda Cámara F, Campos S, Shinohara NK. Relation between dietary and circulating lipids in lacto-ovo vegetarians. Nutricion Hospitalaria. 2011;26(5).
34. Chiu Y-F, Hsu C-C, Chiu THT, Lee C-Y, Liu T-T, Tsao CK. Cross-sectional and longitudinal comparisons of metabolic profiles between vegetarian and non-vegetarian subjects: A matched cohort study. British Journal of Nutrition. 2015; 114(8):1313-20.
35. Barr SI, Rideout CA. Nutritional considerations for vegetarian athletes. Nutrition. 2004;20:696–703.
36. Charkoudian N, Joyner MJ. Physiologic considerations for exercise performance in women. Clinics in Chest Medicine. 2004; 25(2):247-255.
37. Heyward VH. The physical fitness specialist certification manual. The Cooper Institute for Aerobics Research. Champaign: Human kinetics; 2007.
38. Sharma BK, Subrananian SK, Arunachalam V. Evaluation of body composition and its association with cardiorespiratory fitness in south India adolescents. India Journal of Physiopharmacol. 2013;57:399-405.
39. Chou E, Suzuma I, Way KJ, Opland D, Clermont AC, Naruse K, Suzuma K, Bowling NL, Valhos CJ, Aiello LP, King GL. Decreased cardiac expression of vascular endothelial growth factor and its receptors in insulin-resistant and diabetic status: A possible explanation for impaired collateral formation in cardiac tissue. Circulation. 2002;105(3): 373-379.
40. Cotes JE, Chinn DJ, Miller MR. Body size and anthropometric measurements. Lung Function: Physiological Measurement and Application in Medicine, six editions. 2006; 31-41.
41. Woo J, Kwok T, Suzanna C, Apprille S. Nutritional status of elderly Chinese vegetarians. Age and Aging. 1998;29:45 – 461.
42. Key TJ, Appleby PN, Rosell MS. Health effects of vegetarian and vegan diets. Proceedings of the Nutrition Society. 2006; 65(1):35-41.
43. Ashavaid TF, Todur SP, Dherai AJ. Establishment of reference intervals in Indian population. Indian Journal of Clinical Biochemistry. 2005;20(2):110-8.
44. Chen CW, Lin YL, Lin TK, Lin CT, Chen BC, Lin CL. Total cardiovascular risk profile of Taiwanese vegetarians. European Journal of Clinical Nutrition. 2008;62:138-44.
45. De Biase SG, Fernandes SFC, Gianini RJ, Duarte JLG. Vegetarian diet and cholesterol and triglycerides level. Arquivoas Brasileiros. de Cardiologia. 2007;88(1):35-39.
46. Jhala CI, Joshi PC, PC, Shah TK, B, Naik, B. Establishment of Normal lipid reference values in healthy vegetarian's population of Rural Western and Northern Gujarat and comparison with available similar data of other parts of India. Gujarat Medical Journal. 2009;64:25-30.
47. Fraser GE. Association between diet and cancer, ischemic heart disease, and all-cause mortality in non-Hispanic white California seventh-day Adventists. The American Journal of Clinical Nutrion. 1999;70(3):532s-538s.
48. Song Y, Manson JE, Buring JE, Liu S. A prospectively study of red meat consumption and type 2 diabetes in middle-aged and elderly women: The women's health study. Diabetes Care. 2004;27(9):2108-2115.
49. Yokoyama Y, Barnard ND, Levin SM, Watanabe M. Vegetarian diets and glycemic control in diabetes: A systematic review and meta-analysis. Cardiovascular Diagnosis and Therapy. 2014;4(5):37.

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