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Nutrition and Lipid Profile in General Population and Vegetarian Individuals Living in Rural Bangladesh

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Abstract

Background: To examine the association between consumption of vegetable-based diets and lipid profile of aged vegetarians in rural Bangladesh.

Methodology: Cross-sectional study was conducted in the Demographic Surveillance System (DSS) area of Mirzapur sub-district, rural Bangladesh from April to September, 2010. One hundred thirty two (66 vegetarians and 66 non-vegetarians) healthy individuals, aged 40 years or more were studied through house to house visits which had been selected randomly. Overnight fasting venous blood samples were collected for estimating Fasting Blood Sugar (FBS), serum creatinine with Serum Alanine Transaminase (ALT) and serum lipid profile.

Results: The mean age of the vegetarians and non-vegetarians were 58 and 57 years respectively with normal kidney and liver function. The vegetarians had significantly lower mean serum Total Cholesterol (TC) [mean difference (95% CI)] [-0.40 (-0.74, -0.06)] and LDL [-0.47 (-0.76, -0.19)] compared to non-vegetarians. They also had lower mean levels of TC: HDL [-0.55 (-0.98, -0.13)] and LDL:HDL [-0.48 (-0.84, -0.13)]. However, triglyceride, HDL, BMI, FBS, and waist-to-hip ratio were identical. In Pearson's correlation, consumption of vegetable diet significantly correlated with serum TC, LDL and TC: HDL and LDL:HDL ratios. In multiple regression analysis, age, dietary habit, BMI, FBS, and radial pulse had positive correlation with LDL. Instead of radial pulse, for TC: HDL ratio, sex correlated along with other factors. Whereas, for LDL: HDL ratio direct correlation was found with age, dietary habit and BMI.

Conclusion: Findings of this study suggest that compared to non-vegetarians, rural Bangladeshi vegetarians had better serum lipid profile.

Keywords: Bangladesh; Lipid profile; Non-vegetarians; Rural; Vegetarians

Introduction

Diets rich in animal protein having higher amounts of fatty acids, are converted to various lipoproteins in the liver leading to increased deposition of adipose tissue, facilitating formation of atheromatous plaques inside the arteries [1]. As a result, there is narrowing of the arterial wall leading to increased risk of hypertension, stroke and coronary arterial diseases [1,2]. In addition to that, increase in age is associated with numerous health problems including altered metabolic functions and increased risk of chronic diseases such as hypertension and ischemic heart diseases [3]. In contrast, vegetarian diets have lower levels of atherogenic lipoproteins, and vegetarians have been reported to have 32% and 44% lower level of total and Low Density Lipoprotein (LDL) cholesterol respectively compared to omnivores [4]. Studies in Japan and China reported that vegetarians have lower serum total cholesterol than the non-vegetarians [5-7]. A longitudinal study reported continued increase in serum lipids with increasing age among Japanese population [8]. It is also known that consumption of vegetable-based diets not only lowers blood lipoprotein but also reduces the risk of Cardiovascular Diseases (CVD) resulting in; reduced risk of deaths [9,10], leading to higher life expectancy among vegetarians [8]. In industrialized countries, total cholesterol and non-HDL-cholesterol, as well as triglycerides increase with advancing age [11,12]. These findings suggest that dietary and life-style factors may influence the age-dependency of lipid profiles. Dietary relationship (consumption of more fat) with hypercholesterolemia (prevalence of 50%) was also observed among Indian adolescents [13].

It has already been reported that in South Asian countries including Bangladesh, CVD has become a major clinical as well as public health problem [14] and considering Ischemic Heart Disease (IHD) as an alarming problem even in the traditional rural population of Bangladesh [15]. The prevalence of dyslipidemias, high triglyceride and LDL cholesterol and low HDL cholesterol appeared to be higher in the rural individuals [16]. Although tobacco consumption and hypertension and central obesity were found to be the risk factors among rural population [17,18]; but, there is no published report on lipid profile or influence of dietary practices on lipid profile among people living in rural Bangladesh. The objectives of our study were to examine the association of vegetable-based diet with serum lipid profile among adult vegetarians and compare them with that of non-vegetarians living in rural Bangladesh.

Materials and Methods

Description of the study area

The study participants were selected from those living in the rural area of Mirzapur sub-district under Tangail district, about 40 miles north-west of Dhaka, the capital city of Bangladesh. The International

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Centre for Diarrhoeal Disease Research, Bangladesh (icddr,b) has established a Demographic Surveillance System (DSS) in this sub-district (ASG Faruque; personal communication, updated DSS information: June, 2010) with a population of over 255 thousands to collect longitudinal information on their vital events such as birth, death, marriage, and migration. About 30% of the DSS population are 40 years or older, and all have unique demographic surveillance identity. The economy of the population is mostly agriculture-based. A tertiary care hospital (750 beds) popularly known as Kumudini Hospital is located at the centre of the DSS area.

Study design, selection and sample size of study participants

A cross sectional survey was conducted from April to September 2010. We defined an individual as a vegetarian who consumed only vegetable-based diets, devoid of any animal protein, more than last 5 years. At the time of initial screening, it was difficult to get a vegetarian in rural Bangladesh. However, those who were identified, majority (92%) of them gave a history of being on vegetarian diet for more than five years. Moreover, assuming that vegetarian diet would not be able to demonstrate any impact on reduced lipid profile if it is not consumed for more than 5 years; therefore, we selected individuals who were found to be consuming vegetarian diet for more than 5 years. People on the usual Bangladeshi diets, including animal protein, were considered as non-vegetarian controls. Trained research assistants screened vegetarians through house to house visits of randomly selected villages within the DSS area. For each vegetarian, four non-vegetarians were randomly screened using locally developed computer based software within the same age stratum (± 5 years), of same sex and from the same village. Among those interested to participate in the study after explaining its details, one apparently healthy non-vegetarian, who was the first to express interest, was selected as control (non-vegetarian). After initial screening in the field, all interested participants were invited to come to the Kumudini Hospital for final selection. After excluding evidence of respiratory (no history of chronic cough or breathing difficulty) and renal impairment (individuals with regular micturition habit) from previous or recent history, potential participants were asked for their current or previous history of chronic illnesses such as hypertension (measured blood pressure), diabetes mellitus (checked fasting blood sugar level), and ischemic heart disease (based on history), in identifying 66 vegetarians and 66 non-vegetarians. Moreover, participants' optimal hepatic function (alanine aminotransferase) and renal function (serum creatinine) were also assessed. The study objectives and its methods, and its risks and benefits were described to each of the participants before their final enrollment after signing an informed consent form.

Exploration from published data [19] mean lipoprotein status among vegetarian 0.98 mmol/L and non-vegetarians 1.06 mmol/L with standard deviation of 0.52 and 80% power the estimated sample size was calculated to be 55 in each group. Therefore, our study sample size of 66 in each group had enough power to detect any statistical difference at significant level in outcome variable.

Anthropometric measurement and blood sampling

Using a pre-tested questionnaire, all events and relevant clinical information were recorded from all participants. Height and weight were measured with locally made wooden height scale and digital balance scale (TANITA–HG314). Body Mass Index (BMI) was calculated by dividing body weight expressed as kg by the square of height in meters (kg/m2). Waist and hip circumference were also measured to equate waist-to-hip ratio. Five milliliter (5.0 ml) of venous blood was collected in the Kumudini Hospital from each of the participants before 9:00 am after an overnight fast. All specimens were shifted to the central laboratory of icddr, b in Dhaka, within six hours, in cold boxes maintaining the core temperature between +4 to +8°C for the following analyses using Enzymatic Colour Method: serum total cholesterol (TC), triglyceride (TG), High Density Lipoprotein (HDL), and low density lipoprotein (LDL). Fasting blood sugar (FBS) was determined by glucometer (ACCU-CHEK, Active, Roche) at the time of blood collection and serum alanine transaminase (ALT) [20], and creatinine [21] were also assessed.

Data analysis

Data entry and analyses were done using Statistical Package for Social Sciences (SPSS) Windows (Version 15.2; Chicago, IL) and Epi Info (Version 6.0, USD, Stone Mountain, GA). For categorical variables of interest, differences in the proportions were compared by Chi-square test, and strength of association was determined by estimating odds ratios (OR) and their 95% Confidence Intervals (CI). For continuous variables of interest, the statistical significance of the differences in the group means was compared by Student's t test. In the event of non-normal distribution of data, equivalent non-parametric tests were applied. Pearson's correlation test was used to assess the correlation between different lipoproteins. Finally, backward stepwise regression analyses were performed for identifying factors that independently influenced the outcome. In the analysis, we included: age, sex, dietary habit, BMI, FBS, radial pulse, diastolic blood pressure, physical exercise and history of smoking as independent variables in the model to explore any association with LDL and TC:HDL and LDL:HDL ratio with the probability (p) for exclusion set at 0.10.

Results

Of 132 participants, half (30 males and 36 females) of them were vegetarians and other half (30 males and 36 females) were non-vegetarians. The mean ± SD age (years) of the vegetarians and non-vegetarians were 58 ± 12 (age span; 41 to 93 years) and 57 ± 9 years (age span; 43 to 85 years), respectively. All study participants were found to be identical with optimal renal and hepatic functions and they also had similar BMI and waist-hip-ratio (Table 1).

None of the study participants were alcoholic and twenty six percent of the study participants in both the groups gave history of smoking (data not presented). Mean serum TC and LDL-cholesterol

Indicator, (mean±SD)	Overall, (n=132)	Vegetarian, (n=66)	Non-vegetarian, (n=66)	Mean difference (95% CI)
TC (mmol/L)	4.44±1.00	4.24±0.80	4.64±1.14	-0.40 (-0.74, -0.06)
HDL (mmol/L)	1.10±0.87	1.04±0.22	1.17±1.21	-0.13 (-0.43, -0.17)
LDL (mmol/L)	2.74±0.86	2.50±0.65	2.98±0.98	-0.47 (-0.76, -0.19)
Triglyceride (mmol/L)	1.55±0.93	1.66±1.03	1.44±0.80	0.22 (-0.10, 0.54)
TC:HDL ratio	4.41±1.25	4.13±1.12	4.68±1.32	-0.55 (-0.98, -0.13)
LDL:HDL ratio	2.78±1.05	2.54±0.88	3.02±1.15	-0.48 (-0.84, -0.13)
FBS (mmol/L)	5.85±1.53	5.76±1.12	5.95±1.86	-0.19 (-0.72, 0.33)
ALT (U/L)	18.06±10.33	18.38±9.51	17.75±11.16	0.63 (-2.94, 4.19)
Serum creatinine (mmol/L)	61.77±16.31	62.20±18.47	61.35±13.96	0.85 (-4.79, 6.49)
BMI	20.47±3.18	20.23±3.25	20.68±3.17	-0.42 (-1.52, 0.68)
Waist-hip ratio	0.87±0.20	0.89±0.28	0.86±0.10	0.02 (-0.05, 0.09)
Values are mean ± SD, unless specified otherwise				

TC, total cholesterol; LDL, low density lipoprotein; HDL, high density lipoprotein; FBS, fasting blood sugar; ALT, alanine aminotransferase

Table 1: Serum lipid profile concentration and nutritional status of study participants by group.

were significantly lower among vegetarians than non-vegetarians (Table 1). The ratios of TC: HDL and LDL: HDL was significantly lower among the non-vegetarians. However, serum HDL levels, and FBS were similar between the vegetarians and the non-vegetarians. The BMI, waist-to-hip ratio, blood pressure, and pulse rate were also similar between the two groups.

Consumption of vegetable diet significantly correlated with serum TC, LDL-cholesterol and TG: HDL and LDL: HDL ratios (Table 2). FBS was found to be correlated with TC, LDL, TC: HDL and ALT. TC significantly correlated with LDL, TG, TC: HDL and LDL: HDL ratios and serum LDL significantly correlated with TG, TC: HDL and LDL: HDL ratios. Significant correlation was also observed between HDL with its ratios TC: LDL. TC: HDL-cholesterol ratio correlated with LDL: HDL ratio (Table 2).

In multiple regression analysis, age, dietary habit, BMI, FBS, and radial pulse significantly correlated with serum LDL, while age having the strongest relation as determined by Beta coefficients. The overall F ratio was 11.31 (d.f. =5), which was statistically significant ($p<0.001$). All variables were also found to be statistically significant when equated in univariate analysis (Table 3). On the other hand, same model was equated for TC: HDL (Table 4) and LDL: HDL (Table 5) ratio. Instead of radial pulse, for TC: HDL ratio, sex correlated along with other factors. Whereas, direct correlation was found with age, dietary habit and BMI with LDL: HDL ratio.

	FBS	TC	LDL	HDL	TG	TC/HDL ratio	LDL/ HDL ratio	ALT
Group	NS	0.20 p=0.02	0.27 p<0.01	NS	NS	0.22 p=0.01	0.23 p=0.01	NS
FBS		0.34 p<0.01	0.33 p<0.01	NS	NS	0.17 p=0.05	NS	0.18 p=0.04
TC			0.94 p<0.01	NS	0.39 p<0.00	0.60 p<0.01	0.60 p<0.01	NS
LDL				NS	0.18 0.04	0.65 p<0.01	0.72 p<0.00	NS
HDL					NS	-0.18 p=0.04	-0.18 p=0.04	NS
TG						0.46 p<0.01	0.29 p<0.01	NS
TC:HDL ratio							0.83 p<0.01	NS
LDL:HDL ratio								NS

NS = Not significant
FBS, fasting blood sugar; TC, total cholesterol; LDL, low density lipoprotein; HDL, high density lipoprotein; TG, triglyceride; BMI, body mass index

Table 2: Correlation between different lipoprotein and fasting blood sugar.

Variables	Un-adjusted		Adjusted	
	B	95 % CI	B	95 % CI
Age*	0.00	-0.14, 0.15	0.03	0.01, 0.04
Group (vegetarian = 0; non-vegetarian = 1)	0.47	0.19, 0.76	0.49	0.24, 0.75
BMI*	0.03	-0.01, 0.08	0.04	0.00, 0.09
Fasting blood sugar*	0.19	0.10, 0.28	0.18	0.10, 0.27
Pulse*	0.02	0.01, 0.04	0.03	0.01, 0.04

Multiple R=0.56; R^2=0.31; Adjusted R^2=0.28; F=11.31; d.f.=5; p<0.001.
CI, confidence interval; * CI of mean difference; LDL, low density lipoprotein; BMI, body mass index

Table 3: Multiple regression analysis for serum LDL.

Variables	Un-adjusted		Adjusted	
	B	95 % CI	B	95 % CI
Age*	0.01	-0.01, 0.03	0.03	0.01, 0.05
Group (vegetarian=0; non-vegetarian=1)	0.55	0.13, 0.98	0.51	0.11, 0.91
BMI*	0.08	0.01, 0.14	0.09	0.02, 0.15
Fasting blood sugar*	0.14	0.00, 0.28	0.16	0.03, 0.30
Sex (female=0, male=1)	0.58	0.15, 1.00	0.61	0.21, 1.02

Multiple R=0.45; R^2 = 0.20; Adjusted R^2 = 0.17; F=6.24; d.f.=5; p<0.001.
CI, confidence interval; * CI of mean difference; HDL, high density lipoprotein; BMI, body mass index.

Table 4: Multiple regression analysis for TC:HDL ratio.

Variables	Un-adjusted		Adjusted	
	B	95 % CI	B	95 % CI
Age*	0.02	0.00, 0.04	0.03	0.01, 0.05
Group (vegetarian=0; non-vegetarian=1)	0.48	0.13, 0.84	0.49	0.14, 0.83
BMI*	0.04	-0.02, 0.10	0.06	0.01, 0.12

Multiple R=0.37; R^2=0.13; Adjusted R^2 = 0.12; F=6.74; d.f.=3; $p<0.001$.
CI, confidence interval; * CI of mean difference; LDL, low density lipoprotein; HDL, high density lipoprotein; BMI, body mass index

Table 5: Multiple regression analysis for LDL: HDL ratio.

Discussion

We observed that serum TC and LDL-cholesterol were significantly higher among people on non-vegetarian diets including meat and fish. On the other hand, vegetarians had lower levels of these serum lipoproteins. The findings of our study indicate that consumption of vegetable-based diets for more than five years, as in this study, helps to maintain favorable concentrations of serum lipoproteins. The vegetarians in this study had significantly lower TC: HDL ratio as well as LDL: HDL ratio than the non-vegetarians. We also explored serum lipoproteins that increases risk for dyslipidaemia among non-vegetarian population, and compared them with those consuming vegetable-based diets. Our findings are similar to those of earlier studies, which reported that consumption of fruits and vegetable based diets, rich in fiber, folic acid, antioxidants, and phytochemicals are associated with lower serum cholesterol [4,22].

In our study, association was found between elevated level of LDL, and older age and consumption of non-vegetarian diet. Serum cholesterol increases till the age of 60-70 years, irrespective of sex, due to increase in LDL-cholesterol. Suppression of LDL receptor activity due to aging, along with sustained intakes of fat, increases the age-dependent risk of increasing atherogenic lipoprotein in the circulation [11]. This age-dependent changes in elderly population have been observed in several cross-sectional studies [23]. Our observation supports earlier observations such as age dependence of total cholesterol and non-HDL cholesterol, and the ratio of total cholesterol to HDL–cholesterol were less pronounced in case of vegetarians' nutrition and life-style (history of smoking) [11].

A recent study reported individuals with higher BMI to have 14% likelihood of hypercholesterolemia [24]. Serum lipoprotein concentration of an individual with increased BMI is associated with increased levels of Very Low Density Lipoprotein (VLDL) triglycerides, LDL-cholesterol and TG [25,26]. BMI alone has been reported to have striking relationship with co-morbidities [27] including cardiovascular diseases [28]. Though we did not find any significant difference in BMI between the two groups, mean BMI was apparently high among non-vegetarians than vegetarians. Thus, risk of increased level of LDL-cholesterol is likely to be associated with high BMI and consumed diet

that contain fish and meat. We observed significant positive association between FBS and LDL-lipoprotein. Earlier studies also reported increased FBS as a significant predictor of hypercholesterolemia [26], and its association with increased serum lipoproteins [29]. We did not observe any correlation between LDL and sex; however, a recent study suggested that males should take precautions to reduce serum cholesterol early in their lives, whereas women are required to take measures to reduce serum LDL particularly after menopause [12].

As lipids are transported in the blood as lipoproteins, among them, serum HDL is responsible for reverse transportation, specifically for carrying cholesterol from tissues back to the liver [30,31] and thus, acts as an anti-atherosclerotic factor. On the other hand, LDL, the chief pathogenic factor for atherosclerosis, drives cholesterol to the peripheral tissues. Since vegetable diets contain less saturated fat and cholesterol, and greater amounts of dietary fiber, their consumptions help to lower the level of serum cholesterol [22]. Results of our study suggest that vegetable-based diets lower both atherogenic lipoproteins as LDL-cholesterol and non-atherogenic lipoproteins as HDL lipoprotein, with potentials to reduce the risk of developing microvascular diseases. Vegetarians consume whole grains, soybeans, and nuts [32], all of which have significant cardio-protective effects, and reduce overall incidence of stroke, as well as risk of deaths from stroke and ischemic heart disease [33]. Elevated serum atherogenic lipoproteins and their higher ratios due to various vasoprotective lipoproteins are primary risk factors for atherosclerotic changes with increased risk of micro vascular diseases [34]. Higher TC, LDL-cholesterol and TG, and higher ratio of LDL: HDL and lower serum HDL-cholesterol increase the risk of coronary heart disease, and are considered major risk factors beside smoking and hypertension [35]. We did not observe significant difference in HDL-cholesterol and TG level in two groups of our study population; however, recent meta-analysis, based on prospective studies, identified high TG as an important risk factor for coronary heart diseases [36]. Overall, one milligram per deciliter (1mg/dL) reduction in HDL resulted in 3-4% increase in the prevalence of coronary arterial diseases. High levels of TG have also been associated with atherosclerosis and higher prevalence of coronary diseases [37]. Literatures suggest that vegetable-based diet is associated with longer lives [10], and a longitudinal study observed the life expectancy of healthy adults on vegetarian diets to be 3.6 years longer than the general adult population [38].

We had been careful in identifying two groups of study population by eliminating selection bias to the possible extent. In Bangladesh, true vegetarians are fewer and our sample size was thus smaller, which may have resulted in any statistically non-significant association. This could be one of the limitations of the study due to lack of adequate power. However, with this sample size we could first demonstrate important statistically significant associations which may have meaningful public health implications. The study followed cross-sectional design in the rural area and self-reported information of vegetarians were analyzed without any close observation of dietary intakes, calorie consumption, physical activity at work and leisure. Thus, findings might have been influenced and might not generalize the rural population of Bangladesh. However, the present study observations were mostly similar to those observed by earlier larger studies in other countries. Therefore, it is reasonable to consider that our findings as real and not by chance.

Conclusion

In conclusion, rural Bangladeshi vegetarians had a favorable lipid profile status than the non-vegetarians. Although our findings are limited to rural population and most of the people in Bangladesh are non-vegetarians, consumption of vegetable-based diets should be encouraged vigorously to reduce serum lipoproteins and thereby reduce its detrimental effects on human health. Further studies among urban populations are required to update policy makers on the importance of consumption of vegetable diets more often and discourage intake of animal proteins. National dietary guideline needs to be developed or updated considering the increasing elderly population of Bangladesh.

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