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Original Research Article

Macronutrient intake in dyslipidemia: a population-based study from Haryana, North India

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ABSTRACT

Background: Dyslipidemia is a highly prevalent physiological condition and it is one of the major risk factors for cardiovascular diseases (CVDs) worldwide. Diet as a modifiable factor gaining more scientific attention in managing the problem of dyslipidemia among vegetarian populations in order to reduce the burden of CVDs.
Methods: The present study was conducted on a total of 497 adult participants of either sex recruited randomly from Palwal Haryana, North India. Data related to socio-demographic variables was collected by using pretested and modified interview schedules. Dietary data was collected by using validated food frequency questionnaire (FFQ), and entered and analyzed by using Dietcal software. Lipid profile was done on 12 hours overnight fasting blood samples by using commercial kits Randox, USA. All the statistical tests were performed by using IMB's SPSS software version 22.
Results: Adjusted odds ratio revealed that total fat intake was positively associated with TG and VLDL while carbohydrate intake was found to be positively associated with TG, low-HDL, LDL, and VLDL. >3 times intake of RDAs for total fats and carbohydrates posed 2.4 and 2-folds increased risk for high TG and VLDL.
Conclusions: Present study suggested a positive association between the intake levels of macronutrients and elevated lipids. Nutritional education and promoting diet diversity among vegetarian populations may reduce the burden of dyslipidemia.

Keywords: Diet diversity, Dyslipidemia, Macronutrients, Recommended dietary allowance, Vegetarian population

INTRODUCTION

The prevalence of cardiovascular diseases is alarmingly high across the globe, wherein up to 80% of the burden and mortality of cardiovascular disease is found in low- and middle-income nations, making it a worldwide epidemic.[1,2] Cardiovascular diseases (CVDs) accounted for 17.6 million deaths out of a total of 40.5 million deaths in the year 2016 worldwide.[3] According to the WHO, ischemic heart disease and stroke are the leading causes of death.[3]

The epidemiological and dietary shifts that come along with economic growth and urbanization-related lifestyle changes are among the probable explanations for the rise in the incidence of CVD. Dyslipidemia is a major independent modifiable risk factor for cardiovascular disease, which has been strongly associated with the pathogenesis of CVD.[1] In order to estimate the risk of CVD, which is not always manifested but often begins at a younger age, epidemiologic data on the incidence and determinants of dyslipidemia needs to be updated in most countries.[4]

A deeper comprehension of these connections could aid in illness prevention by changing dietary suggestions.[5] One of the most significant environmental variables that modulates illness risk by interacting with the physiology and genome of an individual is their diet. Increased intake of macronutrients like total fats and carbohydrates has been extensively reported to be linked with important CVD markers like abnormal lipid concentrations or hyperlipidaemia, obesity, and hypertension.[6]

Eating a diet low in saturated fatty acids has been extensively advocated to lower LDL cholesterol levels and presumably lower the risk of cardiovascular disease. Additionally, the guideline to limit total fat does not include the different kinds of fats or the overall impact of substituting one type of fat with another or with carbohydrates on risk factors for cardiovascular disease.[7]

Hence, the relationship between the consumption of macronutrients and dyslipidemia should be an immediate concern for the scientific community. The present study aimed to explore the relationship between the intake of macronutrients like total fats and carbohydrates among the adults of Palwal district, Haryana, North India.

METHODS

Study design and recruitment of participants

The present study was a population-based and cross-sectional study conducted on a total of 497 apparently healthy individuals of both sexes aged 30 to 75 years (52.47±10.06 years) following a lacto-vegetarian dietary pattern. The fieldwork for the present study was conducted in 15 villages of Palwal district of Haryana, North India, from April-September 2018. All the participants were recruited randomly by using household survey method. Participants with any kind of physical or mental illness and pregnant women were excluded from the study.

Data collection

Demographic information

Data pertaining to socio-demographic variables like age, sex, marital status, education status, occupation status, and family income were collected by using pretested and modified interview schedules.

Blood sample collection and lipid assay

Twelve hours overnight fasting blood sample (3 ml) was collected in plain vials. Serum total cholesterol (TC), triglycerides (TG), high-density lipoprotein (HDL), and low-density lipoprotein (LDL) were analyzed by spectrophotometer (automated biochemical analyzer XL-640) using commercial kits Randox, USA). Very low-density lipoprotein (VLDL) was calculated using Friedwald's equation.[8] Normal levels of blood lipids were defined as TC<200 mg/dl, TG<150 mg/dl, HDL-C≥40 mg/dl (for males) and ≥50 mg/dl (for females), LDL-C <130 mg/dl, and VLDL-C<30 mg/dl.[9]

Estimation of dietary intake of macronutrients (total fats and carbohydrates)

The assessment of dietary intake of total fat and carbohydrate was done by administering a validated (for rural Haryana) food frequency questionnaire (FFQ), which is a widely used nutritional assessment tool in epidemiological research for the collection of data regarding the consumed food items, its quantity, and frequency on a daily, weekly, monthly and occasional basis.[10] Data collected from FFQ was entered into Dietcal software for estimation of the nutrients on a daily basis by every participant. Participants were categorized into four groups depending on the portions of the macronutrients (total fat and carbohydrate) intake were made, i.e., <RDA, RDA-2RDA, 2RDA-3RDA, and >3RDA by comparing it with the recommended dietary allowance RDA guidelines given by Indian council of medical research.[11]

Statistical analyses

Statistical analyses were performed using IBM's SPSS software version 22. For categorical variables, the frequencies and percentages have been presented. Chi-square test was performed for the estimation of the differences in the frequencies. Binary logistic regression analysis was performed to understand the relationship between the dependent (lipid) variables and independent variables (different proportions of RDA for total fats and carbohydrates). The binary logistic regression model was adjusted for age and sex. All the statistical tests in the present study were considered significant at $p<0.05$.

Ethical approval

The present study was approved by the ethics committee of the Department of Anthropology, University of Delhi. Written informed consent (typed in Hindi) was obtained from each participant prior to data and blood sample collection.

RESULTS

General overview of the studied sample

More than half of the participants in the present sample were females (59%). Over half of the studied participants were illiterate, and only 1/10th of them were employed. The annual family income of almost 90% of the study participants was less than or equal to Rupees 50,000. The median intake of total fats and carbohydrates for all the categories of socio-demographic variables are presented in Table 1.

Table 1: General characteristics and the median (IQR) intake of studied macronutrients among the studied sample.

Socio-demographic variables		N (%)	Median intake (IQR) of total fat	Median intake (IQR) of carbohydrate
Sex	Males	204 (41.0)	61.93 (37.32-90.80)	211.11 (152.46-362.68)
	Females	293 (59.0)	60.10 (34.36-91.380)	205.05 (143.36-91.380)
Age groups in years	30-39	57 (11.5)	57.36 (25.71-83.89)	227.88 (158.50-308.65)
	40-49	156 (31.4)	61.90 (37.23-88.39)	204.94 (145.90-340.73)
	50-59	129 (26.0)	58.13 (37.10-90.91)	204.88 (146.06-377.76)
	60 and above	155 (31.2)	68.50 (36.92-93.06)	208.08 (143.28-359.37)
Marital status	Married	456 (90.1)	61.41 (36.11-89.70)	207.20 (145.40-361.85)
	Unmarried	14 (2.8)	67.30 (50.76-98.90)	141.61 (105.01-324.32)
	Widowed	36 (7.1)	62.66 (30.92-112.32)	249.30 (175.11-336.66)
Education status	Literate	224 (45.1)	61.56 (36.11-92.61)	215.40 (142.84-378.23)
	Non-literate	273 (54.9)	60.98 (35.68-90.86)	205.05 (148.38-313.62)
Employment status	Employed	47 (9.5)	60.42 (36.42-89.36)	227.48 (156.38-380.65)
	Unemployed	450 (90.5)	61.65 (35.73-91.86)	207.20 (143.89-344.53)
Per capita annual family income (INR)	≥50,000	53 (10.7)	60.65 (35.73-91.86)	227.48 (156.38-380.65)
	<50,000	444 (89.3)	61.65 (35.73-91.86)	207.20 (143.344-344.53)

Table 2: Overall and sex-wise chi-square distribution of the studied sample with respect to different proportions of RDA for total fats and carbohydrates intake.

		Overall (497)	Males (204)	Females (293)	P value
Total fat intake	<RDA	102 (20.5)	42 (20.6)	60 (20.5)	0.117
	RDA-2RDA	153 (30.8)	65 (31.9)	88 (30)	
	2RDA-3DRA	117 (23.5)	56 (27.5)	61 (20.8)	
	≥3RDA	125 (25.2)	41 (20.1)	84 (28.7)	
Carbohydrate intake	<RDA	114 (22.9)	43 (21.1)	71 (24.2)	0.709
	RDA-2RDA	214 (43.1)	90 (44.1)	124 (42.3)	
	2RDA-3DRA	73 (14.7)	28 (13.7)	45 (15.4)	
	≥3RDA	96 (19.3)	43 (21.1)	53 (18.1)	

Table 3: Distribution and interactive chi-square between lipid variables and different proportions of RDA.

		RDA proportion of total fat intake							RDA proportion of total fat intake						
		<RDA	RDA-2RDA	2RDA-3RDA	≥3RDA	P value[a]	P value[b]	P value[c]	<RDA	RDA-2RDA	2RDA-3RDA	≥3RDA	P value[α]	P value[β]	P value[γ]
		N (%)	N (%)	N (%)	N (%)				N (%)	N (%)	N (%)	N (%)			
TC	Normal	73 (72.3)	113 (74.3)	85 (73.9)	86 (69.9)	0.715	0.938	0.49	83 (72.8)	148 (70.1)	58 (81.7)	68 (71.6)	0.61	0.05	0.13
	High	28 (27.7)	39 (25.7)	30 (26.1)	37 (30.1)				31 (27.2)	63 (29.9)	13 (18.3)	27 (28.4)			
TG	Normal	92 (90.2)	120 (78.4)	97 (82.9)	77 (61.6)	0.013*	0.35	<0.001*	93 (81.6)	170 (79.4)	60 (82.2)	63 (65.6)	0.64	0.61	0.01*
	High	10 (9.8)	33 (21.6)	20 (17.1)	48 (38.4)				21 (18.4)	44 (20.6)	13 (17.8)	33 (34.4)			
HDL	Normal	56 (54.9)	78 (51.0)	58 (49.6)	50 (40.0)	0.53	0.817	0.134	67 (58.8)	117 (54.7)	29 (39.7)	29 (30.2)	0.47	0.196	0.027*
	Low	46 (45.1)	75 (49.0)	59 (50.4)	75 (60.0)				47 (41.2)	97 (45.3)	44 (60.3)	67 (69.8)			
LDL	Normal	83 (81.4)	118 (77.1)	93 (79.5)	88 (70.4)	0.415	0.64	0.10	83 (72.8)	180 (84.1)	55 (705.3)	64 (66.7)	0.01*	0.092	0.220
	High	19 (18.6)	35 (22.9)	24 (20.5)	37 (29.6)				31 (27.2)	34 (15.9)	18 (24.7)	32 (33.3)			
VLDL	Normal	93 (91.2)	120 (78.4)	97 (82.9)	77 (61.6)	0.007*	0.35	<0.001*	93 (81.6)	171 (79.9)	60 (82.2)	63 (65.6)	0.71	0.67	0.016*
	High	9 (8.8)	33 (21.6)	20 (17.1)	48 (38.4)				21 (18.4)	43 (20.1)	13 (17.8)	33 (34.4)			

*Significant at p<0.05; RDA: recommended dietary allowance; TC: total cholesterol; TG: triglycerides; HDL: high density lipoprotein; LDL: low density lipoprotein, VLDL: very low-density lipoprotein; p value: Interactive Chi-square value; [a] p-value <RDA versus RDA-2RDA; [b] p-value RDA-2RDA versus 2RDA-3RDA; [b]p-value 2RDA-3RDA versus >3RDA (RDA proportion of total fat intake); [α]p-value <RDA versus RDA-2RDA; [β]p-value RDA-2RDA versus 2RDA-3RDA; [γ] p-value 2RDA-3RDA versus ≥3RDA (RDA proportion carbohydrate intake).

Table 4: Odds ratio (adjusted for age and sex) analysis between abnormal lipids and RDA proportions.

Dependent variables	Odds ratio at 95% CI					
	RDA proportions of total fat intake			RDA proportions of total Carbohydrate intake		
	<RDA	2RDA-3RDA	≥3RDA	<RDA	2RDA-3RDA	≥3RDA
High TC	1.170 (0.659-2.077)	1.056 (0.603-1.848)	1.299 (0.759-2.224)	0.852 (0.510-1.423)	0.550 (0.279-1.082)	0.892 (0.520-1.530)
High TG	0.391 (0.182-0.839)*	0.726 (0.389-1.354)	2.439 (1.424-4.179)*	0.897 (0.501-1.607)	0.840 (0.421-1.677)	2.040 (1.188-3.502)*
Low-HDL	0.844 (0.508-1.402)	1.048 (0.644-1.705)	1.551 (0.956-2.515)	0.348 (0.208-0.584)*	0.302 (0.169-0.538)*	0.632 (0.330-1.210)
High LDL	0.789 (0.421-1.480)	0.868 (0.481-1.567)	1.483 (0.861-2.555)	0.384 (0.218-0.674)*	0.761 (0.420-1.379)	0.686 (0.344-1.365)
High VLDL	0.348 (0.158-0.767)*	0.725 (0.388-1.352)	2.421 (1.414-4.146)*	0.925 (0.516-1.658)	0.860 (0.431-1.719)	2.101 (1.222-3.611)*

*Significant at p value <0.01, RDA-2RDA was considered as normal range (reference category).

Overall and sex-wise distribution of the studied sample with respect to fats and carbohydrates intake

Almost 1/4th of the overall sample was found to be consuming more than thrice of recommended dietary allowance (RDA) for total fat and carbohydrates in their diet. Sex-stratified analysis revealed that there was a higher proportion of females who were consuming more than 3 times RDA for total fats when compared with their male counterparts, although the observed difference did not reach up to the level of statistical significance (Table 2).

Distribution of lipid variables in different proportions of RDA of total fats and carbohydrates

For total fat intake, the proportion of individuals with high TG where significantly higher in ≥3RDA categories than in <RDA category. The trend remained the same for VLDL-cholesterol (Table 3). Regarding intake of carbohydrates, a significantly higher proportion of individuals with high TG were consuming ≥3RDA for carbohydrates than those with normal TG. Similar trends were observed for HDL and VLDL also (Table 3).

Further, odds ratio (adjusted for age and sex) analysis revealed that total fat intake was positively associated with high TG and VLDL. High consumption of total fats posed 2.4 folds increased risk for high TG and high VLDL cholesterol. Further, carbohydrate intake was found to be positively associated with high TG, low HDL, high LDL, and high VLDL cholesterol. High carbohydrate intake, i.e., equal more than 3RDA, posed a 2-fold increased risk for high TG and high VLDL cholesterol (Table 4).

DISCUSSION

The present study explored the relationship between macronutrient intake (total fats and carbohydrates) and lipid variables among the adults of Palwal district, Haryana, North India. Our study found that higher intake levels of macronutrients (total fats and carbohydrates), especially equal to more than thrice of their respective recommended dietary allowance (RDA), were found to be positively associated with abnormal lipid concentrations.

Several other studies have also reported that high carbohydrate intake has the most adverse impact on cardiovascular disease risk factors, and reducing its intake may improve blood lipid concentrations.[7-15] Moreover, total fat intake was found to be positively associated with TG and VLDL cholesterol. Contrary to this result, a number of research studies have shown that high consumption of total fats may have positive effects on some lipid parameters, i.e., higher HDL cholesterol and lower triglycerides (TG), with the exception of total cholesterol and LDL cholesterol.[7] Some of the other reports suggest that a high intake of total fats may result in elevated levels of total cholesterol and LDL cholesterol, which in turn is believed to be a risk for cardiovascular diseases.[16-18]

Coming to the etiological pathways involved behind the high intake of macronutrients like carbohydrates and its adverse effect on lipid profile, high glycaemic index foods may promote Nuclear factor kappa B (NF-kB) activation and cause oxidative stress and persistent low-grade inflammation.[19] High carbohydrate intake is harmful not only to adipose tissue; it also encourages an increase in Tumor necrosis factor (TNF) production and liver TNF- concentration, suggesting that high carbohydrate meals may contribute to obesity and the comorbidities like dyslipidemia.[19]

Moreover, the majority of populations residing in low- and middle-income countries rely primarily on a cereal-based (wheat and rice) diet, where carbohydrate is the primary source of energy (>60% of the energy).[7]

There are some limitations of the study that should be stated. First, the use of a cross-sectional study design

prohibits the establishment of cause-and-effect relationships. While existing literature suggests a potential causality between high fats and carbohydrate intake and dyslipidemia, to confirm a definitive causal link, the implementation of a longitudinal study design is necessary. Additionally, it's important to acknowledge the potential for recall bias and inaccuracies associated with self-reported dietary information. Furthermore, given the singular site of the study, it is prudent to validate the findings in diverse vegetarian groups before broad generalizations can be made.

CONCLUSION

The present study suggests that a high intake of total fats and carbohydrates, especially more than thrice the respective RDAs, has an adverse impact on lipid levels, which is an important risk factor for cardiovascular disease. Therefore, promoting nutritional education and dietary diversification may help reduce the prevalence of dyslipidemia and, in turn, the CVD-related mortalities in developing nations like India.

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