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Major dietary patterns and their associations with cardiovascular risk factors among women in West Bengal, India

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Abstract

Few studies have examined dietary patterns in relation to cardiovascular risk factors in Asian populations, particularly in India. The present study was undertaken to explore dietary patterns in a general urban Bengalee population of women in West Bengal, India, and their association with cardiovascular risk factors. We performed a cross-sectional study of 701 women (aged 35 years and above) selected by cluster sampling from twelve different wards of the Kolkata Municipal Corporation (Kolkata, India). The following three major dietary patterns were identified: the ‘vegetable, fruits and pulses’ pattern (characterised by higher intakes of dark-yellow and green leafy vegetables, sweets, fruits, pulses, nuts, poultry and eggs, and lower intake of mustard oil); the ‘hydrogenated and saturated fat and vegetable oil’ pattern (characterised by higher intakes of butter, hydrogenated oil, ghee, vegetable oil, mustard oil, condiments, sweets, fish, high-fat dairy and refined grain); the ‘red meat and high-fat dairy’ pattern (characterised by higher intakes of red meat, high-fat dairy products, whole grain, high-energy drinks and condiments, and lower intakes of fish, refined grain and low-fat dairy products). The vegetable, fruits and pulses pattern was inversely associated with serum total cholesterol (TC), LDL-cholesterol and non-HDL-cholesterol (HDL-C) concentrations ($P<0·05$ for all). The hydrogenated and saturated fat and vegetable oil pattern was positively associated with BMI, waist circumference (WC) and HDL-C concentration ($P<0·05$ for all). In this Bengalee population, these three major dietary patterns were observed, and the dietary patterns were independently associated with BMI, WC and serum TC concentrations in women.

Key words: Dietary patterns: Cardiovascular risk factors: Women: West Bengal

Cardiovascular health in women demands priority in the present scenario due to an increasing incidence of cardiovascular events in women. The incidence of CVD rises sharply with age. Moreover, changes in serum total cholesterol (TC) level, BMI and diabetes prevalence explain only 50 % of the age-related increase in cardiovascular morbidity and mortality among women[1]. Thus, other factors are implicated in the high prevalence of CVD in women. Among these, diet is believed to play a major role in the aetiology of CVD[2]. Rapid economic growth, globalisation, urbanisation and rural–urban migration are all leading to a dramatic shift in the traditional dietary patterns of developing countries to Western patterns. Consequently, the nutritional transition is fuelling the epidemic of chronic diseases, particularly in urban areas. However, studies linking food intake pattern with cardiovascular risk factors in a population are not new. But most of these studies have been reported from the USA and European countries[3–5], whereas a very few reports are available from Asian populations[6–8]. Moreover, food consumption patterns show reasonable variations across different populations; therefore, the identified patterns in Western populations cannot be expected to explain the disease risk in Asian populations too. In addition, the traditional approach in nutritional epidemiology has focused largely on the effects of single nutrients or foods[9,10]. However, nutrients or foods are not consumed in isolation but in numerous different combinations. Therefore, analysing food consumption as dietary

Abbreviations: HDL-C, HDL-cholesterol; LDL-C, LDL-cholesterol; TC, total cholesterol.

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patterns offers a more comprehensive approach to disease prevention or treatment.

Data on dietary patterns in relation to CVD risk factors are sparse in India. In the present study, we explore for the first time the dietary patterns in a general urban Bengalee population of women in Kolkata, West Bengal, India, and their association with sociodemographic and lifestyle variables, nutrient intakes and biomarkers of CVD.

Materials and methods

Selection of study participants

The present study was undertaken on 701 women (aged 35 years and above) who were residents of the Kolkata urban wards staying for an average of 29·8 years in Kolkata. Sampling was carried out following the WHO-prescribed cluster sampling methodology[11] from twelve different wards out of 141 urban wards of the Kolkata Municipal Corporation according to the most recent census data. The wards or cluster were included in the study by simple random sampling without replacement. According to the cluster sampling strategy, in each of the chosen ward or cluster, a location near the centre of the ward was taken as the starting point, and a random direction was selected. The first house was decided randomly, and thereafter every next house was visited along the direction by checking the compliance with inclusion criteria such as age (regardless of a woman's marital status) and non-pregnancy. After reaching the end of an area at a particular direction, the investigator returned back to the starting point, and the aforementioned procedure was repeated until the remaining houses were enrolled. The total number of households selected from each of the wards was determined on the basis of the response from the residents of that locality. During the selection of subjects, women were considered postmenopausal if their menses had ceased naturally or surgically (e.g. hysterectomy) for at least continuous 12 months. Subjects suffering from acute illness and chronic debilitating diseases and unwilling to participate in the study were excluded during the survey. From each of the household, only one eligible member was included in the study to avoid within-household clustering.

Several initial visits were made to the selected wards, before the survey, to establish contact with the community and local volunteers such as municipal health workers of the locality. To establish rapport with the community, several medical camps were held in the area, offering free check-ups and medical advice. A medical team consisting of one physician, two technicians, one dietitian and three or four male and female volunteers was assigned for the field investigation. The team visited every selected house, and informed and motivated the eligible household members for the field exercise. Subjects agreeing to participate in the study were instructed to come to a defined place between 07.00 and 09.30 hours after 12 h of overnight fasting. In particular, the relevance of the overnight fast was explained to them. All subjects were fully informed about the purpose and the procedure of the study in detail. Subjects submitted their written consent to participate in the study before the survey. The study protocol was approved by the Human Ethical Committee of the Department of Human Physiology, University of Calcutta, Kolkata, West Bengal, India.

Out of the 701 individuals who participated in the study, 645 provided complete data for analysis (fifty-six were excluded due to missing data for relevant variables).

Dietary and other questionnaires

The usual dietary intakes were ascertained by employing an FFQ[12], composed of ninety-nine different food items commonly consumed in the population. To simplify the analysis, the food items used in the FFQ were collapsed to twenty-four distinct food groups to closely resemble the food groups that have been used previously in the literature (see Table 1 for food groups). This is done to limit subjectivity in defining food groups and to allow us to replicate studies already reported in the literature. Individual food items were also preserved if they constituted a distinct item on their own (e.g. eggs, chicken, mustard oil, refined oil, vanaspati, ghee and butter). For each food item, participants reported their average frequency of consumption over the past 6 months in terms of frequency categories classified as follows: (1) never or occasionally; (2) once in a month; (3) once in 15 d; (4) 1–3 times/week; (5) 4–6 times/week; (6) daily. It is important to note that portion sizes were not defined; it is a non-quantified FFQ. The frequency of all consumption variables was standardised as 'times/month' by using the conversion factors 4·3 weeks/month and 30·4 d/month rounded to the nearest whole number.

In addition, food intake was ascertained by a detailed questionnaire based on a 24 h dietary recall proforma. Consumption of foods, listing the details of morning tea, breakfast, mid-morning, lunch, evening tea and dinner for two non-consecutive days (a weekday and a weekend) was recorded for each of the individuals. A weekend record of 24 h dietary recall was included in the present study to know about the food preferences (if any) especially related to holidays, which include items such as red meat, snacks, ice creams, sweet dishes or carbonated beverages, usually consumed on a weekly basis rather than daily by this population. The consumption of each food was recorded in terms of portion sizes during the interview. As an aid to quantification, standard sets of common utensils used in Indian households were shown to the participants to assess the accurate portion size. Standard-size spoons were used to assess the intake of sugar and edible oils. Individual intake in terms of each raw food item (e.g. rice, legumes, potato, etc.) was calculated by the formula: $F = (P/Q) \times R$, where F is the individual intake of raw food item by the study participant from a particular preparation, P is the amount in g of the total raw food ingredient used for cooking a standard portion size of this preparation, Q is the total amount in g of the standard portion size of this preparation, R is the amount in g of the cooked food preparation consumed by the study participant. The total intake (24 h) of each nutrient (carbohydrate, protein, fat, vitamins and minerals) and energy consumption were calculated using a spreadsheet. For this purpose, a detailed

Table 1. Food groupings used in the dietary pattern analysis

Foods or food groups	Food items
Refined grain	Boiled rice, puffed rice, flaked rice, white bread, sweet biscuits, salty biscuits, luchi, paratha and noodles
Whole grain	Whole wheat flour
Pulses and legumes	Lentil, green gram dhal, black gram dhal, dry peas, red gram dhal, soyabean, bengal gram dhal, rajmah and chole
Green leafy vegetables	Amaranth, spinach, fenugreek leaves, cabbage, pumpkin leaves, radish leaves and colocasia leaves
Dark-yellow vegetables	Carrots and pumpkins
Other vegetables	Cluster beans, bitter gourd, bottle gourd, brinjal, cauliflower, drumstick, ladies finger, onion stalk, papaya green, plantain green, plantain flower, plantain stem, parwar, ridge gourd and snake gourd
Roots and tubers	Potato, beetroot and colocasia
Fruits	Apple, banana, guava, grapes, orange, mosambi, mango, lichi, bael fruit, jackfruit, pineapple, pomegranate, sapota, watermelon, papaya ripe and raisins
Nuts	Almond, cashew nuts and groundnuts
Fish	Rohu, katla, air, boal, bata, bhetki, hilsa, koi, parsey, tengra, pomfrets and prawn
Poultry	Chicken
Eggs	Fried, omelettes and boiled eggs
Red meats	Beef and mutton
Low-fat dairy products	Low-fat (1·5 %) double-toned milk, reduced or medium-fat (3·2 %) toned milk and low-fat curd
High-fat dairy products	Whole milk including buffalo's milk, cow's milk; cheese, paneer and ice creams
Butter	Butter
Ghee	Desi ghee
Sweets	Cakes, sandesh, rosogulla, gulabjamun, chamcham, kheer, jalebi, custard, chocolates, honey and jaggery
Snacks	Salted snacks, such as potato chips and other chips, namkeen mixture; chop, samosa and kachori
High-energy drinks	Carbonated sweetened drinks
Condiments	Chutney and pickles (added to foods at the table)
Vegetable oil	Soyabean oil, sunflower oil and groundnut oil
Mustard oil	Mustard oil
Hydrogenated oil	Vanaspati or dalda

database was prepared for the nutrient consumption per 100 g of raw food items. The composition of raw foods was obtained from information published by the National Institute of Nutrition, Hyderabad, India[13]. Food composition (nutritive values) for ready-to-eat items (e.g. biscuits, salted snacks and carbonated beverages) was obtained from information on the food packages.

A detailed questionnaire-based interview was used to collect information on demographic profiles such as age, personal health-related behaviours such as smoking habit (no/yes), alcohol consumption (no/yes) and exercise frequency (rarely/never or 1–2 h/week or <1 h/week or 30 min–1 h/d or >1 h/d) and on socio-economic profiles such as educational level (never attended school or primary or secondary or higher secondary or senior secondary), employment status (employed or housewife) and total household income/month (<Rs. 5000 or Rs. 5001–10 000 or more than Rs. 10 000) of each individual. In addition, the participants were interviewed about their menopausal status and history of any surgical intervention such as hysterectomy, personal and family history of hypertension (no/yes), diabetes (no/yes), dyslipidaemia (no/yes) and myocardial infarction (no/yes). The participants were also interviewed about the current use of anti-hypertensive, anti-diabetic, hypoglycaemic or lipid-lowering drugs and the use of postmenopausal hormone therapy. The validity of responses to questions on the use of drugs was confirmed by checking medical records.

Physical examinations

Height was measured to the nearest 0·5 cm without shoes using a standard anthropometer (Holtain Limited, Crymych, Pembs, UK)[14]. Weight was recorded in light clothing after removal of shoes to the nearest 0·1 kg. Waist circumference was measured using a non-stretching measuring tape at the midpoint between the lowest rib and the iliac crest in a horizontal plane. Maximum hip circumference was measured horizontally at the level of maximum extension of the buttocks posterior. For each of waist and hip circumferences, two measurements to the nearest 0·5 cm were recorded. The mean of the two closest measurements was calculated. The waist:hip ratio was calculated by the standard equation: waist:hip ratio = waist circumference (cm)/hip circumference (cm).

BMI was calculated as weight/height squared (kg/m^2). Blood pressure was measured on the right arm of the participants in a relaxed, sitting position and arm supported at heart level using a standard mercury sphygmomanometer[15]. Systolic and diastolic blood pressures were recorded as the onset of first and fifth Korotkoff phases, respectively. For each of the measurements, two readings 5 min apart were taken, and the mean of the two readings was calculated to obtain the final blood pressure. Participants were advised to avoid cigarette smoking, caffeinated beverages and exercise for at least 30 min before the blood pressure measurement.

Participants were requested to fast at least 10 h before the blood samples were collected on the next day morning. Venepuncture was performed by a trained physician with the participants in a sitting position. Fasting serum glucose was measured by the glucose oxidase–peroxidase method[16], serum TC was determined by the cholesterol oxidase–peroxidase–amidopyrine method[17] and serum TAG was measured by the glycerol phosphate oxidase–peroxidase–amidopyrine method[18] using assay kits from Randox Laboratories Limited (Crumlin, County Antrim, UK) on

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a spectrophotometer (Bio-rad, Hercules, CA, USA). HDL-cholesterol (HDL-C) was also determined by the same method after the precipitation of VLDL and LDL by polyethylene glycol 6000. LDL-cholesterol (LDL-C) was calculated using the formula: LDL-C = TC − HDL-C − (TAG/5)[19]. Apo A1 and B were measured by an automated turbidimetric immunoassay[20,21], with reagent kits from Randox Laboratories Limited on a Randox RX Daytona Autoanalyser system.

Definitions and diagnosis criteria

According to the Seventh Report of the Joint National Committee on prevention, detection, evaluation and treatment of high blood pressure[15], subjects were considered hypertensive if systolic blood pressure was ≥140 mmHg, diastolic blood pressure was ≥90 mmHg or both, or if they were taking anti-hypertensive medication. Diabetes was defined as a fasting serum glucose level of 7·0 mmol/l or more (≥1260 mg/l) or on medication for diabetes by the criteria laid down by National Cholesterol Education Program, Adult Treatment Panel III[22]. Dyslipidaemia was defined according to the diagnostic criteria of the National Cholesterol Education Program, Adult Treatment Panel III guidelines[22] as a TC level of 5·18 mmol/l or more (≥2000 mg/l) or a TAG level of 1·69 mmol/l or more (≥1500 mg/l) or a HDL-C level less than 1·03 mmol/l (<400 mg/l) or an LDL-C level of 3·36 mmol/l or more (≥1300 mg/l), or if the subject was taking any lipid-lowering medications.

Statistical analysis

Because the distributions of the dietary data were extremely non-normal, data values are truncated at 3 SD above the mean and then log-transformed. Factor analysis (principal component) was used[23] to derive food patterns based on the frequency of consumption of each of the twenty-four food groups obtained by collapsing the groups in the FFQ. The analyses were conducted using the FACTOR PROCEDURE in SPSS software package version 10.0 (SPSS Inc., Chicago, IL, USA). In determining the number of factors to retain, we considered the Scree test, which clearly identified the three major dietary patterns (with eigenvalues >1·5) that were used in further analyses with CVD risk factors. Factors were rotated by using varimax rotation to obtain orthogonal (uncorrelated) factors, which are easier to interpret. A factor score created for each individual was based on the monthly intake frequencies of the twenty-four food groups and the standardised scoring coefficient of each food group for each factor. Thus, each person had a factor score for each factor that emerged from the data.

Mean and percentage values were calculated across the tertiles of dietary pattern scores. One-way ANOVA was used to compare group means across the tertiles, and the χ^2 test was used to compare proportions. We used Pearson's correlation coefficients for correlations with nutrient intakes. Before statistical testing, data were checked for normality. Because the distribution of factor 1 score was skewed, the variable was natural log-transformed before all analysis. Multiple logistic regression analyses were used to compute OR and 95 % CI for hypertension, diabetes and dyslipidaemia. Multiple linear regression models were performed to evaluate the independent relationship between factor scores (modelled as continuous variables) and other risk variables after adjusting for covariates such as age, menopausal status, exercise frequency, total household income/month, educational status and total energy intake. All analyses were performed using the SPSS software package version 10.0. P values <0·05 were considered as significant.

Results

Dietary patterns

Factor loadings of foods for the three identified dietary patterns are shown in Table 2. The larger the loading of a given food item or group to the factor, the greater the contribution of that food or group to a specific factor. The factors are labelled on the basis of food items with higher loadings for a specific factor. The factor that we labelled the 'vegetables, fruits and pulses' pattern was characterised by higher intakes of vegetables including dark-yellow and green leafy vegetables, sweets, fruits, pulses, nuts, poultry and eggs, and a lower intake of mustard oil. The 'hydrogenated and saturated fat and vegetable oil' pattern was characterised by higher intakes of butter, hydrogenated oil, ghee, vegetable oil, mustard oil, condiments, sweets, fish, high-fat dairy and refined grain. The 'red meat and high-fat dairy' pattern was characterised by higher intakes of red meat, high-fat dairy products, whole grain, high-energy drinks and condiments, and lower intakes of fish, refined grain and low-fat dairy products. The three patterns overall explained 27·0 % (11·1, 8·4 and 7·5 %, respectively) of the variations in food intake. Median intakes of different food groups are also shown in Table 2. Refined grain showed the highest frequency of intake (3·91 times/d) in the study participants, followed by food groups such as other vegetables (2·81 times/d), mustard oil (2·39 times/d) and roots and tubers (2·29 times/d). On the other hand, food groups such as high-energy drinks, butter, hydrogenated oil and red meat showed the lowest frequency of intake in the subjects.

Study population characteristics

Study participant characteristics at baseline are presented in Table 3. The mean age of the study subjects was 49·3 (SD 10·6) years. Most of the study participants (61·9 %) were postmenopausal, but none of them were found to take any hormone replacement therapy during the survey. In the study, 17·9 % of women were reported to do daily exercise activities such as yoga, free-hand exercises or other light exercises. Of the study subjects, 1·3 % smoked beedies (cigarettes made of tobacco leaves). No individual in the study subjects was reported to consume alcohol. Most of the participants (37·8 %) in the study population completed secondary education and had a monthly income of below Rs. 5000 (approximately US$ 109). Prevalences of hypertension and

Table 2. Factor loading* matrix for the three dietary patterns identified from an FFQ
(Medians, inter-quartile ranges and correlation coefficients)

	Intake of food groups (frequency/d)				
Foods or food groups	Median	Inter-quartile range	Factor 1†	Factor 2†	Factor 3†
Other vegetables	2·81	2·32–3·63	0·59	–	–
Dark-yellow vegetables	0·29	0·19–0·45	0·56	–	–
Green leafy vegetables	0·72	0·55–0·98	0·52	–	–
Sweets	0·62	0·29–1·14	0·49	–	–
Fruits	1·24	0·72–1·83	0·48	–	–
Pulses and legumes	0·98	0·62–1·25	0·48	–	–
Nuts	0·13	0·00–0·32	0·44	–	–
Poultry	0·06	0·00–0·13	0·38	–	–
Condiments	0·32	0·13–0·63	0·36	–	–
Eggs	0·13	0·03–0·29	0·35	–	–
High-energy drinks	0·00	0·00–0·03	0·33	–	–
Snacks	0·62	0·26–0·98	0·33	–	–
Roots and tubers	2·29	2·06–3·14	–	–	–
Butter	0·00	0·00–0·09	–	0·69	–
Hydrogenated oil	0·00	0·00–0·00	–	0·57	–
Ghee	0·06	0·00–0·19	–	0·56	–
Cooking oil (refined)	0·65	0·29–1·18	–	0·43	–
Cooking oil (mustard)	2·39	1·63–3·27	–	0·38	–
Red meat	0·00	0·00–0·03	–	–	0·68
High-fat dairy products	0·03	0·00–0·29	–	–	0·56
Fish	0·62	0·29–1·01	–	–	−0·47
Refined grain	3·91	3·08–4·68	–	–	−0·44
Whole grain	1·01	0·72–2·00	–	–	0·37
Low-fat dairy products	0·65	0·06–2·00	–	–	−0·33

Factor 1, vegetables, fruits and pulses pattern; Factor 2, hydrogenated and saturated fat and vegetable oil pattern; Factor 3, red meat and high-fat dairy pattern.
* Factor loadings represent the magnitude and direction of the association of foods or food groups with factors (dietary patterns).
† Absolute values <0·30 were excluded from the table for simplicity.

diabetes were 47·8 and 16·9 %, respectively. Hypercholesterolaemia was observed in 30·7 % of the study subjects. Overall, 7·2 % women were found to have a positive history of myocardial infarction. The mean of total energy intake in the population was 6978·9 kJ/d (1668 kcal/d). On average, 64·2 % of daily energy consumption was from carbohydrate.

Sociodemographic characteristics, lifestyle and selected cardiovascular risk factors in association with dietary patterns

The means and percentages of sociodemographic and lifestyle characteristics in addition to multivariate-adjusted odds of some selected metabolic components by tertiles of dietary pattern scores are shown in Table 4. Higher vegetables, fruits and pulses pattern scores were associated with younger age, higher educational level, higher income and more daily exercise activities. In examining the adjusted OR of selected cardiovascular risk factors across the tertiles of dietary pattern scores, the vegetables, fruits and pulses pattern was associated with a decreased risk of diabetes across increasing tertiles of the dietary pattern scores. The hydrogenated and saturated fat and vegetable oil pattern score was associated with younger age, a higher educational level, higher income and higher daily exercise activities. The red meat and high-fat dairy pattern was associated with lower educational level and lower income in the subjects. The percentage of smoking in this population was very low (1·3 %), so it was not analysed in relation to lifestyle characteristics. No individual in the study subjects reported consuming alcohol.

Association with nutrient intakes

Information regarding nutrient intakes was collected using a 24 h dietary recall proforma for two non-consecutive days (described in details in Methods section).

Higher vegetables, fruits and pulses pattern scores were significantly associated with a higher intake of Ca (Table 5). The hydrogenated and saturated fat and vegetable oil pattern score was associated with higher intakes of total fat including saturated fat, monounsaturated fat, polyunsaturated fat, cholesterol, Ca, carotene, vitamin A, vitamin C and vitamin E, and lower intakes of carbohydrate, dietary fibre and Fe. The red meat and high-fat dairy pattern score was associated with higher intakes of carbohydrate, dietary fibre and Fe, and lower intakes of monounsaturated fat and Ca.

Biomarkers of CVD

Regression coefficients for the association between dietary pattern scores (modelled as continuous variables) and biomarkers for CVD are shown in Table 6. A significant inverse association was observed between the vegetables, fruits and pulses pattern and serum TC (P=0·01), LDL-C (P=0·02) and non-HDL-C (P=0·03) levels after multivariate adjustments for potential confounders (age, menopausal status, exercise

Table 3. Baseline characteristics of the study population
(Mean values, standard deviations and percentages)

	Mean	SD	%
Age (years)	49·3	10·6	
Postmenopausal			61·9
Current hormone therapy			–
BMI (kg/m^2)	25·0	4·7	
Waist:hip ratio	0·92	0·05	
Daily exercise activity			17·9
Current smoking			1·3
Alcohol consumption			–
Educational status			
Primary			12·5
Secondary			37·8
Higher secondary			11·0
Senior secondary			16·8
Income (rupees (US$))			
≤ Rs. 5000 (approximately US$ 109)			44·0
Rs. 5001–10 000 (approximately US$ 109–218)			35·4
More than Rs. 10 000 (approximately US$ 218)			20·5
Diabetes*			16·9
Hypertension†			47·8
Hypercholesterolaemia‡			30·7
History of MI			7·2
Use of anti-hypertensive medication			23·7
Use of anti-diabetic medication			6·7
Use of serum lipid-lowering medication			0·6
Total energy intake (kJ/d)	6978·91	1707·07	
Total fat (% of energy intake)	25·5	6·7	
Carbohydrate (% of energy intake)	64·2	7·0	
Protein (% of energy intake)	11·6	2·7	

MI, myocardial infarction.
* Fasting plasma glucose ≥126 mg % or if subjects were on medication.
† Systolic blood pressure ≥140 mmHg or diastolic blood pressure ≥90 mmHg or both, or if subjects were on medication.
‡ Total cholesterol ≥200 mg % or if the subjects were on medication.

frequency, monthly income, educational status and energy intake). The hydrogenated and saturated fat and vegetable oil pattern scores were positively associated with obesity measures such as BMI ($P=0·04$) and waist circumference ($P=0·007$). A significant positive association was also found between this pattern and serum HDL-C level ($P=0·03$). However, the present analysis did not suggest any significant association between the red meat and high-fat dairy pattern and any of the biomarker values.

Discussion

In the present study population of urban Bengalee women of Kolkata, we identified three major dietary patterns, which we labelled as the vegetables, fruits and pulses pattern, the hydrogenated and saturated fat and vegetable oil pattern and the red meat and high-fat dairy pattern. The vegetables, fruits and pulses pattern score was associated with younger age, higher educational level, higher income and more daily exercise activities, which indicates that younger people with a higher socio-economic background are more health conscious and had knowledge about healthy food choices and lifestyles. In addition, the present results also indicated positive associations between the hydrogenated and saturated fat and vegetable oil pattern scores and younger age, higher educational level, higher income and higher daily exercise activities in the study participants. The association of the dietary pattern scores with a higher socio-economic profile supports the fact that foods such as butter, ghee, vegetable oil, high-fat dairy products, fish and refined grain were affordable by individuals with a higher socio-economic background. On the other hand, the red meat and high-fat dairy pattern was associated with lower educational level and lower income profile in the subjects. The higher loadings of these food items were related to this pattern because in the other two patterns, these food items showed a much lower frequency of consumption in comparison with the other staple foods in the diet. Moreover, people with a lower educational background might not be conscious enough in making healthy food habits.

The associations between the various biomarkers and dietary pattern scores in the present study were in the expected direction. After adjusting lifestyle variables and other potential confounders, the vegetables, fruits and pulses pattern score was inversely associated with serum TC, LDL-C and non-HDL-C levels in the subjects. In addition, we further investigated the association between the dietary pattern scores and nutrient intakes of the individuals using a 24 h dietary recall proforma of two non-consecutive days (a weekday and a weekend). The present analyses indicate that individuals who had higher scores for this pattern had higher intakes of protein, Ca and Fe in their diet without increasing the amount of total or saturated fat intake, and thus may explain the association of this pattern with a more favourable lipid profile in the subjects. These observations suggest that the pattern shows a protective association with cardiovascular risk factors in the present study population of women. Thus, the present results are consistent with the findings of van't Veer *et al.*[24], as well as of Law & Morris[25], and support the role of a diet rich in vegetables and fruits as a possible approach for preventing CVD. On the other hand, the hydrogenated and saturated fat and vegetable oil pattern scores were significantly and positively associated with HDL-C. We also observed significant associations between the biomarkers of obesity such as BMI and waist circumference and the pattern scores. The higher concentrations of HDL-C associated with a high hydrogenated and saturated fat and vegetable oil pattern score could be related to the higher total fat content and lower carbohydrate content identified with this pattern[26]. At the same time, the higher intake of saturated fat and dietary cholesterol and lower intake of dietary fibre associated with this particular pattern may lead to a gain in both overall and abdominal adiposity in women as reported by Newby *et al.*[27] in the Baltimore Longitudinal Study of Aging. The present analyses suggest no significant association between the red meat and high-fat dairy pattern scores with any of the risk variables. The pattern was characterised by higher intakes of food items such as red meat, high-fat dairy products, whole grain and high-energy drinks. However, most of these items usually show either a weekly or monthly frequency of consumption in the population but had higher loadings in this pattern because others consume

Table 4. Descriptive characteristics and multivariate adjusted† odds ratios (95 % CI) for selected cardiovascular risk factors of the study participants across tertiles of dietary pattern scores

(Mean values, standard deviations, odds ratios and 95% confidence intervals)

	Vegetables, fruits and pulses pattern score			Hydrogenated and saturated fat and vegetable oil pattern score			Red meat and high-fat dairy pattern score		
	1	2	3	1	2	3	1	2	3
Age (years)‡									
Mean	51·0	49·4	47·4**	50·6	49·1	48·0*	48·3	49·4	50·1
SD	11·7	10·4	9·2	11·6	10·9	8·9	10·0	10·6	11·0
Hypertension§									
OR	1	0·90	0·82	1	1·43	1·07	1	1·23	0·71
95 % CI	Ref	0·55–1·47	0·49–1·36	Ref	0·87–2·35	0·64–1·80	Ref	0·75–2·00	0·43–1·17
Diabetes§									
OR	1	0·65	0·50	1	1·31	1·25	1	1·06	1·18
95 % CI	1	0·36–1·17	0·26–0·95*	1	0·70–2·44	0·65–2·41	1	0·59–1·91	0·65–2·13
Dyslipidaemia§									
OR	1	0·86	0·90	1	0·66	0·65	1	1·07	1·30
95 % CI	1	0·53–1·40	0·54–1·49	1	0·39–1·08	0·38–1·11	1	0·66–1·74	0·79–2·14
Educational level (%)									
Primary	15·2	10·2	11·4	22·0	9·1	6·4****	9·5	10·5	16·8*
Secondary	38·9	40·0	33·8	31·5	43·6	38·4	41·4	36·5	35·6
Higher secondary	8·8	10·2	14·0	4·5	12·6	15·7***	11·6	13·0	8·4
Senior secondary	9·8	16·0	25·0**	5·0	16·2	29·0****	23·7	17·0	9·9***
Total monthly income (%)‡									
≤ Rs. 5000	47·8	40·6	43·6	68·5	36·6	27·3****	40·0	45·3	46·6
Rs. 5001–10 000	33·8	42·5	29·8	24·4	39·4	41·9****	33·4	32·7	40·0
> Rs. 10 000	18·3	16·8	26·5*	7·0	23·9	30·6****	26·4	21·9	13·2***
Frequency of exercise (%)‡									
Rarely or never	48·2	46·7	45·3	53·2	44·1	42·2*	48·4	46·5	45·5
Weekly	38·0	37·8	27·9	35·1	38·8	31·1	27·2	39·5	38·4
Daily	13·6	15·3	27·3**	11·5	17·0	26·6***	24·2	13·9	15·9

Ref, reference; WC, waist circumference.
† Adjusted for age (years), energy intake (kcal/d), BMI, WC, menopausal status (yes/no), monthly income (categorical), educational level (categorical) and exercise frequency (categorical).
‡ *P* values were computed with one-way ANOVA for age and for categorical variables with the χ^2 test (*$P<0.05$, **$P<0.01$, ***$P<0.001$, ****$P<0.0001$).
§ *P* values comparing OR between reference and the highest tertiles of pattern scores.

these foods rarely. Moreover, in the present study, this pattern was more likely to be associated with a lower socio-economic status of the population, which implies that the use of these food items in this lower income group is related to more traditional ways and may not be actually consumed in very high amounts. However, we found a significant positive association between this pattern and dietary intakes of carbohydrate, dietary fibre and Fe. On the other hand, nutrients

Table 5. Pearson's partial correlation coefficients (*r*) between dietary pattern scores and nutrient intakes among the study participants after adjustment of total energy intake

	Vegetables, fruits and pulses pattern score	Hydrogenated and saturated fat and vegetable oil pattern score	Red meat and high-fat dairy pattern score
Total fat (% of energy intake)	−0·15	0·33***	−0·06
Protein (% of energy intake)	−0·02	−0·03	−0·001
Carbohydrate (% of energy intake)	−0·11	−0·32***	0·08
Total fat (g/d)	−0·20	0·31***	−0·07
Saturated fat (g/d)	−0·60	0·24***	−0·008
Monounsaturated fat (g/d)	−0·04	0·24***	−0·16***
Polyunsaturated fat (g/d)	−0·03	0·26***	−0·01
Trans-fat (g/d)	0·18	−0·12	−0·007
Cholesterol (mg/d)	−0·02	0·12**	0·07
Protein (g/d)	−0·01	−0·01	−0·01
Carbohydrate (g/d)	−0·10	−0·30***	0·07*
Dietary fibre (g/d)	0·06	−0·18***	0·22***
Dietary free folate (g/d)	−0·02	−0·01	−0·02
Ca (mg/d)	0·15**	0·12**	−0·12**
Fe (mg/d)	0·06	−0·08*	0·10*
Carotene (μg/d)	−0·01	0·10**	−0·03
Vitamin A (μg/d)	0·04	0·15***	−0·02
Vitamin C (mg/d)	0·08	0·12**	−0·12
Vitamin E (mg/d)	0·03	0·23***	0·04

Correlation coefficients were significant: * $P<0.05$; ** $P<0.01$; *** $P<0.0001$.

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Table 6. Regression coefficients associating dietary patterns with biomarker values among the study participants
(Regression coefficients with their standard errors)†

	Vegetables, fruits and pulses pattern		Hydrogenated and saturated fat and vegetable oil pattern		Red meat and high-fat dairy pattern	
Dependent variables	Regression coefficient	SE	Regression coefficient	SE	Regression coefficient	SE
BMI (kg/m²)‡	0·08	0·27	0·10*	0·25	0·05	0·25
Waist circumference (cm)‡	0·07	0·73	0·14*	0·69	0·01	0·67
Waist:hip ratio‡	0·05	0·003	0·05	0·003	−0·03	0·003
Systolic blood pressure (mmHg)§	−0·03	0·008	−0·004	0·008	−0·07	0·008
Diastolic blood pressure (mmHg)§	−0·03	0·006	0·05	0·006	−0·08	0·005
Fasting glucose (mg/l)§	−0·05	0·1	0·6	0·1	−0·3	0·1
Total cholesterol (mg/l)§	−1·7*	22·2	0·3	21·5	−0·4	20·6
TAG (mg/l)§	−0·07	0·2	0·5	0·2	−0·4	0·2
HDL-C (mg/l)§	−0·1	8·7	1·1*	7·3	−0·4	6·9
LDL-C (mg/l)§	−1·7*	22·3	−0·2	21·8	−0·08	20·8
Non-HDL-C (mg/l)§	−1·6*	23·2	0·01	22·5	−0·3	21·4
TC:HDL-C ratio§	−0·05	0·02	−0·07	0·02	0·01	0·02
Lipoprotein (a) (mg/l)§	−0·6	2·4	1·1	1·4	0·3	1·3
Apo A1 (mg/l)§	1·8	30·4	−1·6	39·8	0·1	26·8
Apo B (mg/l)§	−0·07	23·5	−2·3	27·6	−0·2	20·4

HDL-C, HDL-cholesterol; LDL-C, LDL-cholesterol; TC, total cholesterol.
* Regression coefficient was significantly different: * $P<0·05$.
† Persons using anti-hypertensive medications were excluded from blood pressure analysis, persons with anti-diabetic medications were excluded from fasting plasma glucose analysis and persons on lipid-lowering medications were excluded from analysis with lipid and lipoprotein variables as dependent variables.
‡ Adjusted for age, menopausal status (yes/no), exercise frequency (rarely or never, 1–2 h/week, >2 h/week, <1 h/week, 30 min–1 h/d or >1 h/d), total household income/month (≤Rs. 5000, Rs. 5001–10 000 or >Rs. 10 000), educational status (primary, secondary, higher secondary or senior secondary) and total energy intake.
§ Additionally adjusted for BMI and waist circumference.

such as monounsaturated fat and Ca showed a significant negative association with this pattern. Unlike the ‘Western’ dietary pattern, identified in other populations[3,4,28], whole grain shows a higher loading than refined grain in this pattern, which may contribute to the higher intakes of nutrients such as carbohydrate and dietary fibre associated with this pattern. Surprisingly, intake of Ca was inversely associated with this pattern, which indicates that consumption of high-fat dairy products may not be in sufficient amount to serve as a source of Ca in this dietary pattern. Moreover, other major sources of Ca such as green leafy vegetables, fish and low-fat dairy products are inversely associated with this pattern, which also partly explains the negative association of Ca with this pattern.

Limited epidemiological studies have reported the association of dietary patterns with cardiovascular risk factors in Asian populations[6,8]. To the best of our knowledge, this is the first study in India reporting such associations in a Bengalee population of women.

Findings from the present study are in agreement with previous investigations on serum lipids and their relation to a healthy vegetable pattern. In a cross-sectional study[29] among Iranian women, individuals in the top quintile of the healthy dietary pattern (characterised by higher intakes of fruits, vegetables, tomatoes, poultry, legumes, cruciferous and green vegetables and whole grain) had lower TC and LDL-C levels than those in the lowest quintile. In a longitudinal analysis[30] among Finnish adolescents, a dietary pattern reflecting more health-conscious food choices (such as a high consumption of vegetables, legumes, nuts, tea, cheese and other dairy products) was inversely associated with TC and LDL-C in women. In other studies also, dietary patterns reflecting healthy food choices have often been found to have stronger associations with more favourable levels of CVD risk factors[31,32].

In the Health Professionals Follow-up Study[3], the ‘Western pattern’ characterised by a higher intake of red and processed meats, high-fat dairy products, refined grains, desserts, sweets, condiments and butter was in some aspects similar to the hydrogenated and saturated fat pattern as well as to the red meat and high-fat dairy pattern, identified in the present study. However, it is worth noting that unlike the ‘Western pattern’, a higher intake of red or processed meat is replaced by a higher intake of fish in the ‘hydrogenated and saturated fat and vegetable oil’ pattern identified in the present study population. Moreover, the ‘red meat and high-fat dairy’ pattern identified in the present study is also not exactly comparable with the ‘Western’ dietary pattern identified in US populations[3,4,28]. Whole grain, in contrast to refined-grain, shows a higher frequency of consumption in association with red meat and high-fat dairy products in this pattern. Although, in a common Bengalee diet, boiled rice (a refined grain product) is predominantly considered as a staple cereal, conventionally, non-vegetarian food items such as red meat are more often consumed along with whole-grain preparations such as ‘chapatti’ (a preparation made from whole wheat flour), rather than with refined-grain products. Moreover, since the red meat and high-fat dairy pattern was more likely to be adopted by people with a lower socio-economic status, they usually consume more whole grain instead of refined grain as a comparatively cheaper source of nutrients. It is somewhat surprising, although not inconsistent with prior reports, that the hydrogenated and saturated fat and vegetable oil pattern and the red meat and

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high-fat dairy pattern in the present study were not associated with serum lipid concentrations. An analysis of dietary intake in free-living persons with the use of National Health and Nutrition Examination Survey III data[33] showed a positive relationship between dietary fat intake and serum TC in men but not in women. Results similar to those reported in the present study were found in the Health Professionals Follow-up Study, in which a Western dietary pattern was not associated with serum lipid concentrations[3,4]. In addition, a similar association was found by Kerver *et al.*[28] in the National Health and Nutrition Examination Survey III study, in which a Western pattern characterised by a higher intakes of processed meats, eggs, red meat and high-fat dairy products was not associated with serum TC concentrations. The higher concentrations of HDL-C associated with a high Western pattern score were observed in the Health Professionals Follow-up Study by Fung *et al.*[3]. In addition, the Monitoring Project on Risk Factors and Chronic Diseases in The Netherlands (MORGEN study)[34] revealed a positive association between the traditional pattern scores (with a higher intake of fat and cholesterol and a lower intake of carbohydrate) and higher HDL concentrations in women without increasing the TC level.

Identifying the association between major dietary patterns and obesity is not new. A cross-sectional study[35] on Iranian women revealed that a Western dietary pattern, characterised by higher intakes of refined grain, red meat, butter, sweets and hydrogenated fat, was associated with an increased risk of general and central obesity in women. A similar observation has also been reported in other cross-sectional[36–38] as well as in prospective studies[39]. A positive association between the Western dietary pattern (loaded heavily with energy-dense foods, dietary cholesterol, animal protein, refined grain, high-fat dairy and sugar) and obesity has also been observed by Slattery *et al.*[37].

The strength of the present study includes the extensive information about socio-economic and lifestyle factors along with the dietary habit of the study participants, which makes the investigation much more comprehensive and conclusive. Another strength of the study is sampling from the general population that may contribute in the implementation of necessary dietary changes in the population to prevent cardiovascular risk, particularly in women. In addition, there are some limitations in the present study. First, the cross-sectional design of the study that precludes the determination of a cause - and - effect relationship between the dietary patterns and the biological risk markers. Therefore, possible assumptions are needed to be verified in future prospective investigations. Second, measurement errors are inherent in the use of FFQ; during the dietary assessment, they may include possible under-reporting or over-reporting of intakes of certain foods or both. Moreover, a 24 h recall of dietary intake may not always be useful. Individual dietary intake may vary from day to day, so the last 24 h record may not necessarily be representative for each individual. Moreover, the use of principal component analysis requires several subjective decisions in the selection of included variables as well as in the detainment of number of factors to retain. In spite of these limitations, the use of multivariate data reduction techniques (e.g. factor analysis) to define dietary patterns is emerging in nutritional epidemiology as an important method of presenting a snapshot of the entire diet in a population.

In conclusion, the present study suggests that consuming a diet rich in green leafy and dark-yellow vegetables, fruits, pulses, nuts, eggs and poultry was associated with lowering of serum TC, LDL and non-HDL-C concentrations in women. In addition, a diet with higher intakes of butter, hydrogenated oil, ghee, vegetable oil, mustard oil, fish, high-fat dairy products and refined grain was associated with an increase in the serum HDL-C level and an increased risk of general as well as of central obesity in women.

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