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ORIGINAL ARTICLE

Association between Dietary Patterns and Cardiometabolic Risks in Malaysian Punjabi Adults

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ABSTRACT

Introduction: Globally, the prevalence of cardiovascular diseases (CVD) is high in Punjabi population. This could due to the increased cardiometabolic risks associated with diets high in dietary fats and refined grains. However, studies on the relationship between dietary pattern and cardiometabolic risks involving Malaysian Punjabis population are scarce. Hence, this study aims to determine the associations between dietary patterns and cardiometabolic risks in Malaysian Punjabi adults. **Methods:** Socio-demographic, lifestyle and dietary intake information was collected using self-administered questionnaire. Anthropometric measurements: weight and height for body mass index (BMI) calculation, waist circumference (WC); systolic (SBP) and diastolic blood pressure (DBP); and biomarkers: blood glucose, glycated haemoglobin A1c (HbA1c), triglycerides, total cholesterol (TC), low-density-lipoprotein cholesterol (LDL-C), high-density-lipoprotein cholesterol (HDL-C), apolipoprotein A1 and B100 were obtained. Major dietary patterns were derived using principal component analysis. Association between dietary patterns and cardiometabolic risk factors were performed using ANCOVA and Kruskal-Wallis tests. **Results:** A total of 164 (35.4% males and 64.6% females) Punjabis were included in this study. Four dietary patterns were extracted, namely 'fruits and vegetables diet' (FVD), 'whole grains, condiments and beverages diet' (WCBD), 'protein diet' (PD) and 'rice, noodles, cereals and meat diet' (RNCMD). Significant associations were obtained for FVD with BMI (p=0.012), WC (p=0.011), SBP (p=0.020) and DBP (p=0.009); WCBD with TC (p=0.010), LDL-C (p=0.015) and apolipoprotein B100 (p=0.038). **Conclusion:** Dietary pattern comprised of fruits, vegetables and beverages containing antioxidant-rich spices, ginger, and black tea may lower cardiometabolic risks in Malaysian Punjabis, particularly in obesity, high blood pressure and hyperlipidaemia.

Keywords: Dietary pattern, Cardiometabolic risks, Cardiovascular disease, Malaysian Punjabis, Principal component analysis.

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INTRODUCTION

Cardiovascular diseases (CVD) are the leading cause of death worldwide with more than 75.0% of CVD deaths were from low- and middle-income countries (1). In Malaysia, 35.0% of deaths occurred before the age of 70 were caused by CVDs (2). The increasing CVD incidences have exacerbated the economic burden in the country. The CVD risks are multifactorial, include metabolic, lifestyle, sociodemographic and genetic factors. Cardiometabolic risks refer to the chances of damaging the heart and vascular system when one or more risk factors are present (3). These cardiometabolic risk factors include obesity, high blood pressure, raised blood glucose, hyperlipidaemia (high low-density lipoprotein cholesterol (LDL-C), high triglycerides and low high-density lipoprotein cholesterol (HDL-C)) (4). Biomarkers apolipoprotein A1 and B100 were also reported to have significant associations with CVD risks (5). The National Health and Morbidity Survey in Malaysia 2015 (NHMS 2015) reported nearly half of the adult population were overweight/obese (48.0%) or hyperlipidemia (47.7%), whereas high blood pressure and raised blood glucose were 30.3% and 17.5% respectively (6).

Malaysian Punjabis, who originally migrated from Punjab, are the minority ethnic group with an estimated population of 100,000. Globally, Punjabis are reported to have a higher risk of CVDs (7,8). Punjabi ethnic group is the largest population in Pakistan (accounting for 50.0% population) and the third largest population in India. With India and Pakistan contribute to 86.0% of total South Asian population, Punjabis are often part of studies involving South Asians. South Asians are reported to have higher prevalence of cardiometabolic risks compared to other ethnic groups (7,8). Studies also indicated migrant South Asians have three to five times higher cardiometabolic risks than those residing in the country of origin (7), as a result of a more sedentary lifestyle and a shift to diets higher in carbohydrates, saturated and trans-fats and low in dietary fiber (9,10). Punjabis, who resided in Punjab, India, also reported having excessive consumption on cereals, pulses, sugars, fats and oils, which were associated with increased cardiometabolic risks (11).

The development of cardiometabolic risks is largely linked to unhealthy diets than other lifestyle factors. Since foods and nutrients are not consumed in isolation, diets are reflected in combination of various food ingredients that interact. Hence, dietary pattern analysis, which describes the overall diets and the combinations of foods people are eating, draws a broader picture of the cumulative and interactive effects of certain food combinations on the cardiometabolic risks (12,13). Therefore, it is the preferred approach to study how certain combinations of foods (dietary patterns) are associated with cardiometabolic risks. Dietary patterns with cardiovascular health promoting effects often include foods like vegetables, fruits, whole grains, legumes (14). Whereas diets high in added sugars, refined grains and other processed foods, were associated with increased cardiometabolic risks (15). Findings from Malaysian Adults Nutrition Survey (MANS) 2003 and 2014 reported high sugar/carbohydrate consumption among adults with rice, sugar and sweetened condensed milk were the top daily consume foods (16). Abundant studies on dietary status and cardiovascular health have been realised in major ethnic groups in Malaysia (27,30). However, based on literature search, there is no data on the dietary pattern of Malaysian Punjabis and the associations with cardiometabolic risk factors. Given this gap in the knowledge between dietary patterns and cardiometabolic risks in Malaysian Punjabis, this study is aimed to determine the associations between dietary patterns and cardiometabolic risks in Malaysian Punjabi adults.

MATERIALS AND METHODS

Study Design

A total of 164 subjects were recruited from seven Gurdwaras in urban Klang Valley (Ampang Hulu Kelang, Chow Kit, Kajang, Klang, Petaling Jaya, Selayang Baru and Subang Jaya) between August 2018 and July 2019. Gurdwaras from different areas of Klang Valley were approached and subject recruitments were only conducted at Gurdwaras with permission obtained from the presidents. The convenience sampling approach was applied in this study. The most recent prevalence of cardiometabolic risk factor (raised blood glucose) of South Asians which involved Punjabi population, which is 12.0% (17), was used in the sample size calculation using formula, $N=(Z^2)(p(1-p)/(d^2)$ (18). The minimum sample size is equal to 162. This study had registered with Medical Research & Ethics Committee (MREC) and approved by Taylor's University Human Ethics Committee (HEC2018/005). Written informed consent was obtained from participants prior to study enrolment. All participants underwent pre-screening process to confirm eligibility criteria for enrolment: 1) age between 30-65, 2) descendants from two generations of Punjabi, 3) Malaysian citizen, 4) not on cholesterol, blood pressure and/or blood glucose lowering medication.

Data Collection

Anthropometric quantifications included height, weight and waist circumference. Height was measured using Seca 213 portable stadiometer and rounded to nearest 0.1cm. Tanita SC330 Body composition monitor was used to weigh participants and rounded to the nearest 0.1kg. Waist circumference was measured just above the navel using Seca 201 measuring tape in cm. Body mass index (BMI) below 18.5 kg/m^2 is defined as underweight, range 18.5-24.9 kg/m^2 is categorized as normal, range 25.0-29.9 kg/m^2 is overweight and 30.0 kg/m^2 and above is obese (19). Waist circumference above 90.0 cm (for male) and above 80.0 cm (for female) are served as cut-off points for central obesity (20). Blood pressures were measured using Omron blood pressure monitor SEM-1. High blood pressure is reflected with the presence of an average reading of systolic blood pressure (SBP) >140 mmHg and diastolic blood pressure (DBP) >90 mmHg (6). Ten-ml of 2-hour postprandial blood sample was drawn and collected into Becton Dickinson Vacutainer® tubes for analysis of blood lipids, apolipoprotein A1 and B100, glucose and glycated haemoglobin A1c (HbA1c). Blood glucose <5.5 mmol/L and HbA1c >5.7% indicate raised blood glucose (21). Triglycerides <1.7 mmol/L, total cholesterol <5.2 mmol/L, LDL-C <2.6 mmol/L, and HDL-C >1.04 mmol/L resolute hyperlipidemia (22).

Demographic, Lifestyle and Dietary Intake Information

Information on sociodemographic (age, gender) and lifestyle habits (alcohol consumption, smoking practice and physical activity) were obtained using self-administered questionnaire (23). Dietary intake information was obtained using self-administered validated food frequency questionnaire (FFQ), which incorporated Punjabi food items that were initially recorded using 3-day dietary record (DR) (24). The average weight of food items gathered from the 3-day DR against the reported portions stated on the Malaysian Food Composition table was used as standard serving size in the FFQ. This FFQ comprised of 10 food groups: 1) grains, cereals and starches; 2) meats and meat dishes; 3) legumes, pulses and nuts; 4) milk and dairy products; 5) vegetables and vegetable dishes; 6) fruits; 7) fried snacks/confectionaries; 8) spreads; 9) pickles; and 10) beverages, with a total of 123 dish-based food items and four categories of consumption frequency (per day, per week, per month, and never/less than one time per month). Subjects were asked to report the frequency of intake of each food item based on their habitual intake over the past month, and the number of servings consumed each time. Measuring cups and spoons were provided as dietary assessment tools. Scores were given to each food item by multiplying the consumption frequency (per day) with serving size. Serving size same as the standard portion size was given value of 1 (one), serving size smaller than standard portion size was given value of 0.5, and serving size larger than standard portion size was given value of 1.5 (25). The scores of food items were aggregated into 22 mutually exclusive groups based on the similarity of food types and nutrient composition (25). These food group scores were served as an indication on the average serving size of a particular food group being consumed by a subject in a day. The food group scores were then used to develop major dietary patterns.

Statistical Analysis

Data were analysed using statistical software, Statistical Package for Social Sciences (SPSS Statistics 25.0, IBM SPSS, Armonk, NY, USA). The normality of dependent variables: BMI, waist circumference, SBP, DBP and biomarkers (blood glucose, HbA1c, triglycerides, total cholesterol, LDL-C, HDL-C, apolipoprotein A1, apolipoprotein B100) were confirmed using Kolmogorov-Smirnov test. Normal distribution of data was obtained for BMI, waist circumference and HDL-C after log10 transformation (26). Hence, BMI, waist circumference, SBP, DBP, HDL-C and apolipoprotein B100 were dependent variables with normal distribution. Blood glucose, HbA1c, triglycerides, total cholesterol, LDL-C and apolipoprotein A1 were not normal distributed dependent variables. Age, gender, alcohol consumption, smoking habits and physical activity are potential independent risk factors. Pearson's and Spearman correlation coefficient tests were performed to determine the significant correlations between age and cardiometabolic risk factors with normal and non-normal distributed data respectively. The significant differences between the demographic (gender) and lifestyle (alcohol intake, smoking habits and physical activity) independent variables on cardiometabolic risk factors were determined using Student t-test and Mann-Whitney test. For BMI, waist circumference and HDL-C variables, log-transformed data were used in the Student t-test analysis.

Major dietary patterns were developed using principal component analysis (PCA) with Varimax rotation (27). The adequacy and suitability of using PCA were evaluated using Kaiser-Meyer-Olkin (KMO) measurement of adequacy and Bartlett's test of Sphericity (28). Factor loadings were extracted using PCA. Food groups were reduced to 19 groups after removing food groups with factor loadings that did not fit into any factor. The factors were then derived from factor loadings using Varimax orthogonal rotation. Factors were extracted based on a minimum of 8.0% to the total variance and eigenvalue >1.0. A cut-off of 0.40 was used as the criterion to identify high factor loading, factor loadings of less than 0.4 were suppressed (29). The regression factor scores for each dietary pattern were categorised into tertiles as a measure of adherence: lowest tertile (T1) denoting the lowest adherence, medium tertile (T2) representing the medium adherence, and highest tertile (T3) indicating the highest adherence to a specific dietary pattern (26). Tertiles of factor scores for each of the dietary pattern were then used in the statistical analysis of association between tertiles of dietary patterns and cardiometabolic risk factors. Analysis of Covariance (ANCOVA) was used to analyse the significant differences between tertiles of dietary patterns and normal distributed cardiometabolic risk factors. Log-transformed data of BMI, waist circumference and HDL-C variables were used in the ANCOVA analysis. The independent risk factors associated with cardiometabolic risk factors were identified and controlled for its potential confounding effect in the ANCOVA analysis (30). For example, gender and alcohol intake were included as potential confounding variables after the result of the analysis indicated both gender and alcohol consumption were significantly associated with BMI and waist circumference. Age, smoking habits and physical activity were not included due to the insignificant associations with cardiometabolic risk factors of BMI and waist circumference. A variable is recognized as potential confounding variable, if 1) it is associated with the exposure (independent variable) either causally or not, 2) it is associated with the outcome (dependent variable), and 3) it must not involve in the causal pathway between the exposure and outcome (31). Kruskal-Wallis test was performed for non-normal data of cardiometabolic risk factors. Post-hoc test was performed to identify the significant difference between groups ($p<0.05$) (if at least one pair is different). Mean values were obtained using non-transformed data and a p-value of <0.05 was considered statistically significant.

RESULTS

Cardiometabolic Risk Factors of the Subjects

A total of 164 subjects (58 males (35.4%) and 106 females (64.6%)) with mean age 51±9 were included in this study. Table I shows the characteristics of cardiometabolic risk factors of the subjects by gender. In comparison between gender, males had significant higher BMI, SBP, DBP, blood glucose, triglycerides and apolipoprotein B100 levels and significant lower HDL-C and apolipoprotein A1 levels compared to females. Table II explains the significant positive correlations between age and cardiometabolic risk factors of SBP, DBP, blood glucose, HbA1c and total cholesterol levels. However, significant positive correlations were also observed between age with HDL-C and apolipoprotein

Table I: Characteristic of the subjects by gender

Variables	Males (n=58)	Females (n=106)	Total (n=164)	*p*-value
* BMI (kg/m[2])	27.6 ± 5.1	25.7 ± 4.7	26.4 ± 4.9	0.019
* Waist Circumference (cm)	102.7 ± 13.2	90.8 ± 12.1	95.0 ± 13.7	ND
* Systolic blood pressure (mmHg)	134 ± 16	126 ± 18	129 ± 17	0.008
* Diastolic blood pressure (mmHg)	82 ± 9	76 ± 9	78 ± 9	<0.001
* Blood glucose (mmol/L)	5.00 ± 1.40[a]	4.80 ± 0.50[a]	4.80 ± 0.70[a]	0.037
HbA1c (% of total Hb)	5.60 ± 0.50[a]	5.60 ± 0.50[a]	5.60 ± 0.50[a]	0.597
* Triglycerides (mmol/L)	1.55 ± 0.80[a]	1.10 ± 0.70[a]	1.20 ± 0.80[a]	0.003
Total cholesterol (mmol/L)	5.40 ± 1.20[a]	5.30 ± 1.40[a]	5.35 ± 1.30[a]	0.724
LDL-C (mmol/L)	3.40 ± 1.00[a]	3.30 ± 1.00[a]	3.30 ± 1.01[a]	0.386
* HDL-C (mmol/L)	1.24 ± 0.26	1.52 ± 0.38	1.42 ± 0.37	<0.001
* Apolipoprotein A1 (mmol/L)	1.49 ± 0.23[a]	1.60 ± 0.34[a]	1.54 ± 0.33[a]	0.004
* Apolipoprotein B100 (mmol/L)	1.15 ± 0.25	1.07 ± 0.22	1.10 ± 0.24	0.035

Data are presented in mean ± S.D. Analysis by gender performed using Student t-test, * p<0.05.
[a] Data are presented in median ± IQR. Analysis by gender performed using Mann-Whitney test, *p< 0.05.

A1 levels.

Lifestyle Habits and Cardiometabolic Risk Factors of the Subjects

In this study, there were 40 alcohol-drinkers (24.4%), four smokers (2.4%) and 52 physically non-active subjects (31.7%). Alcohol drinkers had significant higher BMI (27.8±5.16 kg/m^2 vs 26.0±4.81 kg/m^2, p=0.042) and waist circumference (100.6±15.2 cm vs 93.2±12.8 cm, p=0.003) compared to non-drinkers. Smokers had significant higher SBP (135±2 mmHg vs 129±17 mmHg, p=0.007) and triglycerides (3.00±2.30 mmol/L vs 1.20±0.80 mmol/L, p=0.009) level and lower HDL-C (1.01±0.10 mmol/L vs 1.44±0.37 mmol/L, p=0.009) and apolipoprotein A1 (1.38±0.14 mmol/L vs 1.55±0.33 mmol/L, p=0.027) levels compared to non-smokers.

Table II: Correlation and p-values between age and cardiometabolic risk factors

Variables	Age (years)
BMI (kg/m[2])	r=-0.102; p=0.196
Waist circumference (cm)	r=-0.046; p=0.555
* Systolic blood pressure (mmHg)	r=0.460; p<0.001
* Diastolic blood pressure (mmHg)	r=0.194; p=0.013
* Blood glucose (mmol/L)	r=0.282; p<0.001[a]
* HbA1c (% of total Hb)	r=0.292; p<0.001[a]
Triglycerides (mmol/L)	r=0.035; p=0.654[a]
* Total cholesterol (mmol/L)	r=0.211; p=0.007[a]
LDL-C (mmol/L)	r=0.130; p=0.099[a]
* HDL-C (mmol/L)	r=0.220; p=0.005
* Apolipoprotein A1 (mmol/L)	r=0.297; p<0.001[a]
Apolipoprotein B100 (mmol/L)	r=0.144; p=0.065

Analysis performed using Pearson's correlation coefficient test, * p < 0.05.
[a] Analysis performed using Spearman correlation coefficient test, * p < 0.05.

However, there were only four subjects reported to have smoking habits. There were no significant differences in all cardiometabolic risk factors between physically active and non-active subjects (p=0.204-0.871).

Dietary Patterns of the Subjects

Kaiser-Meyer-Olkin (KMO) correlations=0.639; determinant value=0.10; and p-value of Bartlett's test <0.001 confirmed the adequacy of the sample and the suitability of data for factor analysis. Factors with minimum of 8.0% to the total variance were extracted. A total of four factors (major dietary patterns) were extracted based on Kaiser criterion (eigenvalue >1) and Scree plot (26,32). Table III explains the four dietary patterns identified in this study: "fruits and vegetables diet" (FVD), "whole grains, condiments and beverages diet" (WCBD), "protein diet" (PD) and "rice noodles cereals and meats diet" (RNCMD). These four dietary patterns explained a total of 46.4% of the variance in the

Table III: Factor loading matrix of major dietary patterns

Food items	*Fruits and vegetables diet*	*Wholegrains, condiments and beverages diet*	*Protein diet*	*Rice noodles cereals and meats diet*
Apple, citrus, melons, pear and grapes	0.808	-	-	-
Tropical fruits (papaya, banana, guava, mango and pineapple)	0.772	-	-	-
Vegetables (leafy, cruciferous, fruit, root and other vegetables)	0.479	-	-	-
Cha, coffee with and without milk	-	0.813		
Condiments (*ghee*, butter, margarine, peanut butter, jam, condensed & evaporated milk and pickles)	-	0.800		
Beverages (cordial, malt, carbonated, herbal drinks and fruit juices)	-	0.528		
Whole grains (brown rice, whole meal bread)	-	0.404		
Bean curd, bean curd *sambal*	-	-	0.776	-
Dhal, *sholay*, peas and beans	-	-	0.705	-
Dairy products (milks, *lassi* and yogurt)	-	-	0.556	-
Red meat (lamb/mutton, pork, *bak kut teh*)	-	-	-	0.682
Processed foods (chicken sausage, chicken nugget, chicken burger, *paneer*, cheese)	-	-	-	0.666
Refined carbohydrates (white rice, *nasi* lemak, fried rice, fried/soup noodles, fried/soup rice noodles, cereals and breads)	-	-	-	0.559
Chicken and chicken egg	-	-	-	0.467

Factor loadings of <0.40 were excluded.

usual dietary intakes of the subjects.

FVD, which accounted for 19.5% of the total variance, was derived from higher loadings on fruits (such as papaya, banana, guava, mango, pineapple, apple, lime, pear, honeydew, watermelon, grapes and orange); vegetables and vegetable dishes (such as green leafy vegetables, saag (spinach dish), lettuce, cabbage, broccoli, cauliflower, tomato, pumpkin, brinjal sambal, okra, carrot and radish).

WCBD, which had higher loadings on *Cha*, coffee, and condiments represented a diet high in sugars and fats. This dietary pattern explained 10.8% of the total variance. WCBD comprised of high intakes of *Cha* (Punjabi spiced milk tea), coffee with and without milk; condiments (*ghee* (Indian clarified butter), butter, margarine, peanut butter, jam, *kaya* (coconut egg jam), condensed milk and evaporated milk); beverages (cordial drinks, malt drinks, carbonated drinks, herbal drinks and fruit juices); and whole grains (such as brown rice and whole meal bread).

PD and RNCMD were accounted for 8.1% of total variance respectively. PD shows high factor loadings for protein-based foods, which comprised of bean curd and bean curd *sambal* (chili paste); *dhal* dishes (black *dhal*, green *dhal*, yellow *dhal*, *parpu dhal* (mung bean *dhal*, a.k.a *payatham paruppu* in Tamil), *sholay* (chickpeas curry) and black chickpeas curry); and dairy products (buffalo milk, low fat milk, full cream milk, fresh cow's milk, milk powder, lassi (yogurt drink) and yogurt). Dishes like bean curd *sambal* and *sholay* contain moderate amounts of fats. Sambal is a chili paste which is typically made by sauté a mixture of chili peppers with oils, sugars and salts. Whereas *dhal* is a pulses thick soup, which is made by sauté a mixture of soaked lentils with ghee/oils, sugars and salts.

RNCMD with higher factor loadings for meat products and refined carbohydrates was constituted of red meats and dishes (pork and *bak-kut-teh* (pork rib dish), lamb/mutton); processed foods (chicken sausage, chicken nugget, chicken burger, *paneer* and cheese); refined carbohydrates (white rice, glutinous rice, white bread, bread bun, *nasi lemak* (steamed coconut milk rice), fried rice, *wantan mee* (wonton noodles), *pan mee* (flat noodles), fried or soup-based *meehoon/kueyteow/mee* (fried or soup-based noodles), breakfast cereals, oats and *idli* (savory rice cake)); and chickens and chicken egg. This dietary pattern was similar to the diet practiced by migrant South Asians living in UK, which comprised of foods high in animal proteins, sugars and fast foods (33).

Associations between Dietary Patterns and Cardiometabolic Risk Factors

Table IV shows subjects in the lowest tertile of FVD had significantly higher mean values in BMI (p=0.012); and waist circumference (p=0.011) compared to the highest tertile of FVD, after adjusting for gender and alcohol intake. The significant higher mean value of systolic blood pressure was observed in the medium tertile of FVD compared to the highest tertile of FVD, after adjusting for gender, age and smoking (p=0.020). The medium tertile of FVD also had significantly higher mean value in diastolic blood pressure level compared to the highest tertile of FVD, after adjusted for gender and age (p=0.009). No significant differences were obtained for blood glucose, HbA1c and blood lipids.

Significant differences were shown between tertiles of WCBD dietary pattern with blood lipids (total cholesterol, LDL-C and apolipoprotein B100) as indicated in Table V. Subjects in the medium tertile of WCBD showed

Table IV: Values of cardiometabolic risk factors according to tertiles of "fruits and vegetables diet" (FVD)

Variables	Tertiles of FVD			*p*-value
	T1 (n=55)	T2 (n=55)	T3 (n=54)	
* BMI (kg/m²) [b,e]	27.4 ± 0.7*	26.9 ± 0.7	24.8 ± 0.6*	0.012
* Waist Circumference (cm) [b,e]	97.8 ± 1.7*	97.1 ± 2.0	90.2 ± 1.7*	0.011
* Systolic blood pressure (mmHg) [b,c,d]	128 ± 2	132 ± 2*	127 ± 3*	0.020
* Diastolic blood pressure (mmHg) [b,c]	78 ± 1	81 ± 1*	75 ± 1*	0.009
Blood glucose (mmol/L)	4.80 ± 0.40[a]	5.00 ± 1.10[a]	4.90 ± 0.70[a]	0.308
HbA1c (% of total Hb)	5.60 ± 0.60[a]	5.70 ± 0.50[a]	5.60 ± 0.40[a]	0.060
Triglycerides (mmol/L)	1.20 ± 0.70[a]	1.30 ± 0.90[a]	1.20 ± 0.80[a]	0.789
Total cholesterol (mmol/L)	5.40 ± 1.30[a]	5.30 ± 1.60[a]	5.40 ± 1.10[a]	0.989
LDL-C (mmol/L)	3.20 ± 1.10[a]	3.35 ± 1.00[a]	3.40 ± 1.00[a]	0.982
HDL-C (mmol/L) [b,c,d]	1.45 ± 0.06	1.37 ± 0.04	1.45 ± 0.05	0.749
Apolipoprotein A1 (mmol/L)	1.55 ± 0.38[a]	1.53 ± 0.32[a]	1.54 ± 0.31[a]	0.667
Apolipoprotein B100 (mmol/L) [b]	1.12 ± 0.03	1.12 ± 0.04	1.06 ± 0.03	0.387

Data are presented in mean ± S.E. Analysis performed using ANCOVA with post-hoc test adjusted for gender (b), age (c), smoking (d) and alcohol intake (e).
[a] Data are presented in median ± IQR. Analysis performed using Kruskal-Wallis test.
* indicates significant difference between two groups (p<0.05).

Table V: Values of cardiometabolic risk factors according to tertiles of "whole grains, condiments and beverages diet" (WCBD)

Variables	Tertiles of WCBD			*p*-value
	T1 (n=55)	T2 (n=55)	T3 (n=54)	
BMI (kg/m²) [b,e]	26.6 ± 0.7	25.9 ± 0.6	26.7 ± 0.7	0.742
Waist Circumference (cm) [b,e]	96.0 ± 1.7	93.6 ± 1.7	95.5 ± 2.1	0.620
Systolic blood pressure (mmHg) [b,c,d]	131 ± 2	127 ± 2	129 ± 3	0.740
Diastolic blood pressure (mmHg) [b,c]	79 ± 1	78 ± 1	77 ± 1	0.354
Blood glucose (mmol/L)	4.90 ± 0.60[a]	4.80 ± 0.60[a]	4.85 ± 0.50[a]	0.519
HbA1c (% of total Hb)	5.60 ± 0.40[a]	5.70 ± 0.50[a]	5.60 ± 0.50[a]	0.959
Triglycerides (mmol/L)	1.20 ± 0.90[a]	1.20 ± 0.70[a]	1.20 ± 0.80[a]	0.853
* Total cholesterol (mmol/L)	5.40 ± 1.30[a]	5.50 ± 1.30[a]*	5.20 ± 1.00[a]*	0.010
* LDL-C (mmol/L)	3.40 ± 1.00[a]	3.50 ± 1.30[a]*	3.10 ± 0.80[a]*	0.015
HDL-C (mmol/L) [b,c,d]	1.41 ± 0.05	1.45 ± 0.05	1.41 ± 0.05	0.833
Apolipoprotein A1 (mmol/L)	1.56 ± 0.28[a]	1.54 ± 0.35[a]	1.52 ± 0.33[a]	0.803
* Apolipoprotein B100 (mmol/L) [b]	1.09 ± 0.03	1.15 ± 0.04*	1.05 ± 0.03*	0.038

Data are presented in mean ± S.E. Analysis performed using ANCOVA with post-hoc test adjusted for gender (b), age (c), smoking (d) and alcohol intake (e).
[a] Data are presented in median ± IQR. Analysis performed using Kruskal-Wallis test.
* indicates significant difference between two groups (p<0.05).

significant higher median values in total cholesterol (*p*=0.010) and LDL-C (*p*=0.015) levels compared to the highest tertile of WCBD. The mean value of apolipoprotein B100 level also significantly higher in the medium tertile of WCBD compared to the highest tertile of WCBD, after adjusted for gender (*p*=0.038). However, no significant differences were obtained for triglycerides, HDL-C and apolipoprotein A1 levels. Results also indicated no significant differences between tertiles of WCBD with BMI, waist circumference, BP, DBP, blood glucose, HbA1c, triglycerides, HDL-C and apolipoprotein A1 levels. There were also no significant differences obtained between tertiles of PD (*p*=0.072-0.930) and RNCMD (*p*=0.176-0.996) with all cardiometabolic risk factors, as tabulated in Table VI and Table VII respectively.

Table VI: Values of cardiometabolic risk factors according to tertiles of "protein diet" (PD)

Variables	Tertiles of PD			*p*-value
	T1 (n=55)	T2 (n=55)	T3 (n=54)	
BMI (kg/m²) [b,e]	27.5 ± 0.7	25.5 ± 0.6	26.2 ± 0.7	0.151
Waist Circumference (cm) [b,e]	98.3 ± 1.9	92.3 ± 1.5	94.4 ± 2.0	0.104
Systolic blood pressure (mmHg) [b,c,d]	130 ± 3	129 ± 2	128 ± 2	0.930
Diastolic blood pressure (mmHg) [b,c]	79 ± 1	77 ± 1	78 ± 1	0.787
Blood glucose (mmol/L)	4.90 ± 1.30[a]	4.80 ± 0.60[a]	4.85 ± 0.40[a]	0.231
HbA1c (% of total Hb)	5.60 ± 0.50[a]	5.60 ± 0.60[a]	5.60 ± 0.50[a]	0.521
Triglycerides (mmol/L)	1.40 ± 0.80[a]	1.30 ± 0.90[a]	1.10 ± 0.70[a]	0.450
Total cholesterol (mmol/L)	5.50 ± 1.10[a]	5.30 ± 1.70[a]	5.30 ± 1.30[a]	0.202
LDL-C (mmol/L)	3.50 ± 1.30[a]	3.20 ± 1.20[a]	3.20 ± 0.90[a]	0.259
HDL-C (mmol/L) [b,c,d]	1.32 ± 0.04	1.47 ± 0.05	1.48 ± 0.05	0.072
Apolipoprotein A1 (mmol/L)	1.50 ± 0.25[a]	1.53 ± 0.33[a]	1.62 ± 0.34[a]	0.099
Apolipoprotein B100 (mmol/L) [b]	1.14 ± 0.03	1.11 ± 0.03	1.06 ± 0.03	0.266

Data are presented in mean ± S.E. Analysis performed using ANCOVA with post-hoc test adjusted for gender (b), age (c), smoking (d) and alcohol intake (e).
[a] Data are presented in median ± IQR. Analysis performed using Kruskal-Wallis test.

Table VII: Values of cardiometabolic risk factors according to tertiles of "rice noodles cereals and meat diet" (RNCMD)

Variables	Tertiles of RNCMD			*p*-value
	T1 (n=55)	T2 (n=55)	T3 (n=54)	
BMI (kg/m²) [b,e]	26.6 ± 0.8	26.4 ± 0.7	26.2 ± 0.5	0.673
Waist Circumference (cm) [b,e]	93.9 ± 2.0	95.0 ± 2.0	96.2 ± 1.5	0.776
Systolic blood pressure (mmHg) [b,c,d]	131 ± 3	128 ± 2	128 ± 2	0.324
Diastolic blood pressure (mmHg) [b,c]	79 ± 1	77 ± 1	79 ± 1	0.300
Blood glucose (mmol/L)	4.90 ± 0.50[a]	4.80 ± 0.70[a]	4.90 ± 0.70[a]	0.887
HbA1c (% of total Hb)	5.60 ± 0.40[a]	5.60 ± 0.60[a]	5.60 ± 0.60[a]	0.314
Triglycerides (mmol/L)	1.20 ± 0.90[a]	1.00 ± 0.80[a]	1.50 ± 0.80[a]	0.235
Total cholesterol (mmol/L)	5.40 ± 1.50[a]	5.30 ± 1.40[a]	5.40 ± 1.20[a]	0.296
LDL-C (mmol/L)	3.30 ± 1.20[a]	3.30 ± 1.20[a]	3.30 ± 0.90[a]	0.291
HDL-C (mmol/L) [b,c,d]	1.45 ± 0.06	1.50 ± 0.05	1.33 ± 0.04	0.673
Apolipoprotein A1 (mmol/L)	1.56 ± 0.36[a]	1.57 ± 0.33[a]	1.47 ± 0.27[a]	0.996
Apolipoprotein B100 (mmol/L) [b]	1.14 ± 0.03	1.05 ± 0.04	1.12 ± 0.03	0.176

Data are presented in mean ± S.E. Analysis performed using ANCOVA with post-hoc test adjusted for gender (b), age (c), smoking (d) and alcohol intake (e).
[a] Data are presented in median ± IQR. Analysis performed using Kruskal-Wallis test.

DISCUSSION

Cardiometabolic Risk Factors of the Subjects

This study was the first study on the dietary pattern and cardiometabolic risks in Malaysian Punjabis. Male subjects reported having higher mean values for most of the cardiometabolic risk factors compared to female subjects. However, data from NHMS 2015 on Malaysian adults indicated the prevalence of abdominal obesity, raised blood glucose and hypercholesterolemia were higher among females compared to males (6). The cardiometabolic risks of high blood pressure and raised blood glucose were also mostly increased with age. Similar findings were found in a study involving South Asians and Punjabis (34).

Lifestyle Habits and Cardiometabolic Risk Factors of the Subjects

The results indicated alcohol drinkers possess higher cardiometabolic risks of obesity and high blood pressure, whereas smokers were more likely to develop cardiometabolic risks associated with high blood pressure and hyperlipidemia. Although Student-t test or Man Whitney test do not require minimum sample size per group with n≠0 (n=sample size), the smaller sample size in a group also indicated lesser power of the test (35). Nevertheless, the smoking habit was included as a potential confounding variable in the ANCOVA analysis between dietary patterns and cardiometabolic risk factors of SBP and HDL-C.

Dietary Patterns of the Subjects

The overall dietary intakes of subjects reflected the common foods and drinks consumed by Punjabi community. White rice, *capati* (Indian flatbread), bread, *paratha* (Indian flatbread), various types of dhal, fruits (such as bananas and red apples) and vegetables (such as carrots, cabbage, cauliflower and lettuces) are the most consumed food items. *Ghee* (Indian clarified butter) and butter were the top condiments used in their diets. Nearly 96.0% of the subjects consumed at least one type of beverages and 88.0% of the subjects consumed *Cha* (Punjabi spiced milk tea), which is popular among Punjabi community.

The results suggested fruits and vegetables were the most consumed food groups among the Malaysian Punjabi subjects as FVD contributed the highest percentage of total dietary variation. This may associate with Sikhs religion which promotes vegetarianism. Fruits and vegetables are micronutrient-dense foods, rich in vitamins, minerals and phytochemicals. Hence, FVD may provide supportive effect on reducing cardiometabolic risks. FVD is similar to cardioprotective dietary patterns such as DASH and Mediterranean diets. Both diets emphasise on the intakes of vegetables, fruits and low-fat foods, which play beneficial roles in the prevention of CVD (36). According to the Malaysian Adults Nutrition Survey (MANS) 2014, FVD appeared to be similar with the major dietary patterns in Malaysia (western diet, mixed diet and traditional diet), particularly mixed diet, in which fruits and vegetables are the major food components in these dietary patterns (27). The MANS 2014 survey also revealed that green leafy vegetables were the third most consumed food items among Malaysians (16). However, subjects in FVD showed higher consumption on both fruits and vegetables than vegetables, compared to general Malaysians, as MANS 2014 reported the fruit consumption was remained low among Malaysian adults (16).

WCBD had the second highest percentage of total dietary variation with higher factor loadings on *Cha* and condiments. WCBD exhibited an eating pattern of higher intake of beverages and high fats high carbohydrates foods, such as condiments that are high in dietary fats and refined sugars, white rice and/or white breads. This dietary pattern shows the consumption of *Cha* and condiments were common among Malaysian Punjabi subjects. Dietary intakes of foods high in fats and sugars are often served as major contributing factors for the increased cardiometabolic risks. Hence, higher consumption of *Cha* (which often sweetened with condensed/evaporated milk) and condiments (high in fats and sugars) might increase the risk of obesity, impaired blood glucose and hyperlipidemia (37). In addition, this dietary pattern displayed similarity with what was commonly consumed by Malaysians whereby sweetened condensed milk and condiments were listed in the top ten most consumed daily food items among Malaysians (16).

PD exhibited a diet rich in bean curd, *dhal*-dishes and dairy products. This PD was not similar to any of the dietary patterns identified from the MANS 2014 but it was comparable with the "mixed" dietary pattern, which included legumes (include pulses and soybeans), milk and milk products as well as cereals, bread, spread vegetables, fruits and confectionaries (27). This PD represented the traditional Punjabi dietary pattern which was high in pulses, sugars, fats and oils, excessive consumption of these foods was associated with increased risk of obesity (11).

RNCMD was similar to the "noodles and meat diet" reported in MANS 2014, which had higher factor loadings for meats and processed foods. In addition, rice, noodles and bread are included in this dietary pattern. Rice, which was the top most consumed food item among the majority of Malaysians, are also part of this dietary pattern. This result may represent a dietary pattern in which Malaysian Punjabis may have adapted their diets from Punjabi staple foods (flatbreads such as *Capati, paratha, puri, naan, roti canai, thosai*) to local Malaysian staple foods (such as rice and noodles). This dietary pattern also displayed the practice of eating out as most of the food items presented in this dietary pattern are available in most eateries.

Associations between Dietary Patterns and Cardiometabolic Risk Factors

The significant differences obtained between the tertiles of FVD and cardiometabolic risk factors of BMI, waist circumference, SBP and DBP indicated subjects in the highest tertile of FVD were at lower risk of obesity and high blood pressure compared to those in the lowest tertile of FVD. These results suggested higher intakes of fruits and vegetables may associated with lower cardiometabolic risks.

Fruits and vegetables rich in vitamins, minerals, fiber and bioactive compound are parts of the evidence-informed beneficial dietary patterns for cardiovascular health (38). Hence, FVD may possess positive cardiometabolic effects on obesity and high blood pressure in Malaysian Punjabis. The potential positive cardiometabolic effects from FVD was in route with other studies done on Mediterranean diet which emphasises on fruits and vegetables. Numerous studies had shown Mediterranean diet improves a range of cardiometabolic risks, including improvement on blood pressure, glucose, insulin, blood lipids and lipoproteins levels, and reduce long-term weight gain (39). An increase in fruits, non-starchy vegetables, nuts, yogurt, fish and whole grains consumption appeared to have protective effects against chronic weight gain and were consistently linked to better cardiometabolic outcomes, particularly foods richest in phytochemicals and bioactive polyphenols like grapes, citrus fruits and apple (39). In addition, diet high in fruits and vegetables was reported to have blood pressure lowering effect (40) and improvement on blood lipids such as lessen the triglycerides (41) and rise HDL-C (42) levels. Other Study also indicated flavonoids-rich fruits improved blood pressure, endothelial function, insulin resistance and blood lipids (43). However, the results obtained in this study showed no significant differences between tertiles of WCBD and blood glucose, HbA1c and all blood lipid variables. These results possibly linked to the confounding effects as potential confounders were not included in the Kruskal-Wallis test.

Interestingly, subjects in the highest tertile of WCBD had lower mean values of total cholesterol, LDL-C and apolipoprotein B100 levels compared to subjects in the medium tertile of WCBD. These results were contradicted with the findings from study by Loh *et al.* (44), which reported sugar-sweetened beverages intake was deleteriously associated with increased triglycerides and LDL-C levels and lower HDL-C level. Another study by Mohammadi *et al.* (45) also informed that higher consumption of dietary fats and refined sugars were associated with higher risks of obesity, impaired blood glucose and increased detrimental effect on those with atherogenic dyslipidemia. Despite WCBD represented dietary pattern comprised of foods and/or beverages high in sugars and fats/oils. There were no significant differences between tertile of WCBD and cardiometabolic risks of obesity, high blood pressure and raised blood glucose. The lower blood lipid levels in highest tertile of WCBD may possibly link to the ingredients used in *Cha* and/or coffee, since *Cha* is the key component in the WCBD. There was no study on the direct association between *Cha* and cardiometabolic risk factors. However, the unique blend of spices, ginger and black tea in *Cha* preparation may explain the potential beneficial effect on blood lipids. Study by Khan *et al*. (46) revealed that consuming cinnamon for 40-day had significantly reduced the mean values in triglycerides, LDL-C and total cholesterol by 7-30%. Black tea was reported to have significant effect in reducing the LDL-C (47) and apolipoprotein B100 (48) levels. A systematic review and meta-analysis of randomised controlled trial stated consumption of black tea significantly reduced LDL-C level (49).

Although no significant associations were found between PD and RNCMD dietary patterns with cardiometabolic risk factors in this study. RNCMD was similar to dietary pattern practiced by migrant South Asians living in UK. Such dietary pattern which was higher in meats, sugars and fast foods was associated with increased cardiometabolic risks (33). Hence, moderation should be emphasised.

The strength of this study is that this study is the first study on the dietary pattern and cardiometabolic risks in Malaysian Punjabis. Several limitations were identified in this study. The use of FFQ in assessing dietary intake information may incur potential misreporting as the recall of quantities of foods and drinks consumed were based on memory, therefore the frequency of consumption and portion size reported by subjects may deviate from the usual intake (50). Other limitations included the use of convenient sampling method and non-normal distribution data of the cardiometabolic risk factors.

CONCLUSION

This study reveals the food patterns practised by Malaysian Punjabis living in urban Klang Valley area and the effects of these combinations of foods on cardiometabolic risks. These four dietary patterns determined in this study may reflect the common dietary patterns of urban Malaysian Punjabis, suggesting Malaysian Punjabis are towards dietary patterns comprised of fruits, vegetables, *Cha*, coffee, condiments, whole grains, legumes, meats, processed foods, and refined carbohydrates such as rice, noodles and cereals. As dietary patterns represent the overall combination of all food groups which together produce a synergistic effect on health, the present study provided insights on the associations between tertiles of different dietary patterns and cardiometabolic risks. The results highlighted Malaysian Punjabis with risk factors of obesity and high blood pressure could be benefited from a diet rich in fruits and vegetables. Whereas the key component of WCBD, *Cha*, may provide beneficial effects on blood lipids, particularly total cholesterol, LDL-C and apolipoprotein B100. However, whether the WCBD or a diet contains tea with a combination of spices, ginger and black tea, which all exhibit antioxidant properties, could help in improving the obesity, blood pressure and blood lipids of Malaysian Punjabis is yet to confirm. Further research involving a larger sample from different regions of Malaysia is recommended to further confirm the finding.

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