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Dietary Patterns and Prediction of Risk Factors of Diabetics Patients

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Analysis of dietary patterns has been used to examine the impact of diet on chronic diseases. The objectives of this study were to identify the dietary pattern among diabetic patients and to investigate the association between patterns and the metabolic risk factors i.e. anthropometric, glucose and lipid abnormalities. In a cross-sectional survey, 170 diabetic patients, both genders were randomly enrolled from Elnoor Hospital. Information about diet was obtained using a 74-item FFQ. Principal components analysis was applied to extract dietary patterns. Linear regression analysis evaluated the associations between the extracted dietary patterns and the metabolic risks. Six components were derived explaining 73.34% of the total variation. The components explained, 22.64, 16.63, 12.38, 10.41, 8.66 and 2.61% of the variation. Component 1 "Transitional pattern" was positively associated with risk factors (r-range 0.556-0.784, p-range 0.022-0.0001). An inverse association was found for Healthy and Traditional patterns (r-range -0.468 to -0.709, p-range 0.05-0.0001, r-range-0.466 to -0.673, p-range 0.05-0.0001), respectively. "Desirable fat pattern" was associated with modestly reduced risks of diabetes. No association was found between miscellanies and snacks patterns and metabolic risk factors. A dietary pattern that includes meat, refined cereals, was associated with increased levels of risk biomarkers, whereas fish, legumes, vegetables, fruits and nuts intake showed the inverse results.

Key words: Diabetes mellitus, dietary pattern, glycemic, lipidmic, anthropometric

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INTRODUCTION

Diabetes mellitus (DM) is one of the most prevalent chronic diseases and represents a clinical and health dilemma worldwide including kingdom of Saudi Arabia (Shaw *et al*., 2010; Alqurashi *et al*. 2011). Diet is considered an environmental factor in the initiation and treatment of DM (Alberti *et al*., 2007). Many studies have evaluated the correlation between intakes of individual food and risk of diseases (Naja *et al*., 2012). Although, investigation on the correlation between diet and disease, using single foods approach seem informative, the results were incompatible (Schulze and Hoffmann, 2006). Thus dietary pattern approach, which examines diet intake collectively rather than isolated food or nutrient (Kant *et al*., 2009) seems an alternative strategy in nutrition epidemiology (Mizoue *et al*., 2006; Khor *et al*., 2009).

Food consumption patterns worldwide have changed markedly and Saudi Arabia with no exception. There has been an increased consumption of food rich in total and saturated fats, refined products, high protein, energy dense diets, highly processed foods, fast food and sugary beverages (Kearney, 2010). According to Millen *et al*. (2005), such dietary patterns, which, coupled with a sedentary lifestyle, has resulted in steadily increase of chronic diseases rates. Studies on dietary patterns of the Saudi population and risk for diabetes are sparse. Thus, the purpose of the present study is to identify the dietary patterns and to investigate the associations between these patterns and anthropometric and biochemical abnormalities of diabetic patients.

MATERIAL AND METHODS

Data collection instrument: Structured questionnaire was used to collect the study information. The questionnaire consisted of two parts: Part one: a close-ended questionnaire was introduced with the aim to elicit demographic, biochemical and anthropometric information. Part two: a Food-frequency Questionnaire (FFQ) with 74-food items was administered to appraise the usual food intake. The FFQ was a modified version of the National Cancer Institute Food Frequency Questionnaires (Subar *et al*., 2001). The questionnaire was validated through pilot study. The reliability of the questionnaire was evaluated using Cronbach's coefficient alpha. Reliability statistics of Cronbach's alpha was 0.799. The participants were asked to indicate how often, on average, they had consumed a specified food. Each such item provided nine possible responses, ranging from "never or less than once a month" to 6-7 times per day. The questionnaire was completed by the researchers to minimize the distortion of the result.

Study subjects: Patients were selected for this study on the basis of the following inclusion criteria; diagnosis of type I DM or type II DM, both genders, individuals from (30-79 year) and informed consent to be obtained from the patients. The exclusion criteria include; pregnancy, end-stage renal or liver disease. After being screened for eligibility (170) diabetic subjects at Al Noor Hospital were enrolled in the study. A method of selecting respondents from the diabetic's population was based on a random starting point and a fixed, periodic interval (5th) under the supervision of the hospital dietitians.

Study type: Cross-sectional quantitative survey.

The study approval: Study was approved by the Hospital Boards in which the study was conducted. Each subject provided either verbal or written informed consent.

Assessment of the variables

Anthropometric measurements: Weight was recorded to the nearest 100 g using digital scale. Subjects were minimally clothed. Height was recorded to the nearest 1 cm. Subjects were in a standing position, bare footed and shoulders were in a normal position. BMI (kg m^{-2}) was calculated.

Laboratory analysis: Fasting blood samples for the measurement of glucose and lipid concentrations were drawn after an overnight fast of 12 h. Lipid profile and glucose concentrations were measured in hospital laboratories.

Statistical analysis: Anthropometric and biochemical variable: continuous variables are presented as Means±SD. Categorical variables are presented as absolute frequencies.

Dietary patterns: Exploratory factor analysis of the eight food groups was used. Factor loadings were estimated after oblique rotation using the promax method. A number of criteria were used to determine the number of factors to retain including the scree test and Kaiser criterion (Eigen values over 1.0). For factor interpretability, a selected food was considered to load on a specific factor if the factor loading was ≥ 0.30 for that factor and <0.30 for all other factors. No food item was permitted to load more than one factor. Kaiser-Meyer-Olkin (KMO) to examine sample adequacy and the Bartlett Test of Sphericity (BTS), to examine the presence of correlations between variables, were used. KMO for this study was 0.846 and Bartlett Test of Sphericity (BTS) is highly significant <0.0001.

The correlation between pattern factors and risk factors of diabetes was tested with linear regression model. In multivariate models, the initial model was adjusted for age, BMI and gender.

P values are based on two-sided tests and compared with a significance level of 5%. All analyses were conducted using SPSS software.

RESULTS

Socio-demographic and clinical findings: Table 1 presents the distribution of the subjects surveyed according to demographic variables. Summary of the results of the biochemical and anthropometrics assessment are given in Table 2. Poor glycemic and lipidemic control were found among subjects surveyed. Figure 1 showed comparison between study findings and guidelines for diabetes according to American Diabetes Association (2010).

Dietary findings: Six components were identified through factor analysis, based on the Kaiser criterion and the scree plot (Fig. 2). These six components accounted for 73.337% of the variability within the sample. The factor loading matrices for the six dietary patterns after promax rotation are shown in Table 3.

The first factor reflects the change of Saudi's lifestyle and dietary habits. Therefore, it was labeled Transitional Dietary Pattern. This Component explained 22.64% and highly loaded with meat, chickens, egg, fats and oil, potatoes, refined grain and whole fat dairy products. The second factor explained 16.63% of the total variance. This factor was characterized by the intake of vegetables and fruits, it was labeled "Healthy pattern". The third factor accounted for 12.38% of the total variance. Since this factor was characterized by food items rich in mono and polyunsaturated fat, it was labeled "desirable fat pattern". The fourth factor accounted for 10.41%. Since this factor was characterized by the intake of pulses and whole grains, it was labeled "Traditional pattern". The fifth factor accounted for 8.66%. It was characterized by variation of food items, it was labeled "miscellanies dietary pattern". The sixth factor accounted for 2.61% and loadings were observed for fruits only. This factor was labeled "snacks pattern".

Associations of factor analysis-derived pattern with risk factors of diabetes mellitus: The associations of food pattern with metabolic risk factors of diabetes as well as

Table 1: Socio-demographic characteristics of subject surveyed

Variable	Type 1	Type 11	Total
Gender			
Male/female (%)	38 (45.80%)/36 (41.40%)	45 (54.20%)/51 (58.60%)	(48.80%)/(51.20%)
Age			
Mean	55.18±10.51 (52.74-57.6)	54.19±8.52 (52.46-55.91)	54.62±9.42 (53.19-56.04)
Income/riyal			
Mean	6702.70±3143.72 (5974.36-7431.04)	6406.25±3256.016 (5746.52-7065.98)	6535.29±245.55 (6050.55-7020.04)
Family size (%)			
1-3	10 (5.9%)	17 (10.0%)	27 (15.9%)
4-6	36 (21.2%)	52 (30.6%)	88 (51.8%)
≤7	28 (16.5%)	27 (15.9%)	55 (32.4%)
Duration(years) of diabetes			
Mean	11.04±3.57 (10.21-11.87)	7.22±4.51 (6.3057-8.1318)	8.88±4.53 (8.1965-9.5682)
Education level (%)			
Illiterate	9 (5.3%)	29 (17.1%)	38 (22.4%)
Primary	17 (10.0%)	15 (8.8%)	32 (18.8%)
Intermediate	9 (5.3%)	18 (10.6%)	27 (15.9%)
Secondary	12 (7.1%)	10 (5.9%)	22 (12.9%)
University or above	27 (15.9%)	24 (14.1%)	51 (30.0%)
Smoking (%)			
Yes/no	9 (5.3%)/65 (38.2%)	22 (12.9%)/74 (43.5%)	31 (18.2%)/139 (81.8%)
Exercise (%)			
Never	33 (19.4%)	26 (15.3%)	59 (34.7%)
Sometimes	24 (14.1%)	45 (26.5%)	69 (40.6%)
Always	17 (10.0%)	25 (14.7%)	42 (24.7%)
No. of meal/day			
Once	-	-	-
Twice	15 (8.82%)	18(10.59%)	33 (19.41%)
Three times	41(24.12%)	57(33.53%)	98(57.65%)
More than three	18(10.59%)	21 (12.35%)	39(22.94%)

Table 2: Anthropometric and biochemical means among subjects surveyed

Variable	Type 1	Type 11	Total	p-value
Height (cm)	162.32±8.83	160.70±9.85	161.41±9.43	0.882
	(160.28-164.37)	(158.71-162.70)	(159.98-162.84)	
Weight (kg)	79.10±16.87	81.11±18.57	80.10±17.80	0.236
	(74.00-84.20)	(77.54-85.07)	(75.9 8-84.39)	
BMI (kg $m^{-2)}$	30.2732±11.08	31.39±10.40	30.92±10.70	0.196
	(28.56-31.99)	(29.70-33.08)	(28.40-33.40)	
Glucose (mg dL^{-1})	154.80±27.81	156.73±28.14	155.89±27.93	0.619
	(148.36-161.24)	(156.73-151.03)	(151.66-160.12)	
HbA1c (%)	8.49±3.86	8.81±3.96	8.67±3.91	0.307
	(7.29-9.69)	(8.57-9.04)	(7.51-9.83)	
Postprandial (mg dL^{-1})	158.91±18.97	158.44±17.42	158.65±17.10	0.246
	(158.45-159.37)	(158.44-157.95)	(154.31-162.99)	
Total cholesterol (mg dL^{-1})	179.29±12.30	179.60±13.34	179.46±12.86	0.249
	(176.44-182.13)	(176.90-182.03)	(171.52-185.41)	
HDL (mg dL^{-1})	44.38±3.98	44.06±4.08	44.20±4.03	0.420
	(38.46-50.30)	(36.24-51.89)	(37.59-50.81)	
LDL (mg dL^{-1})	141.63±20.11	141.52±19.69	141.57±19.90	0.795
	(131.26-152.00)	(133.56-149.48)	(132.07-151.07)	
Triglyceride (mg dL^{-1})	165.17±28.21	170.04±28.21	167.921±30.75	0.212
	(158.63-171.70)	(163.44-176.64)	(163.26-172.58)	

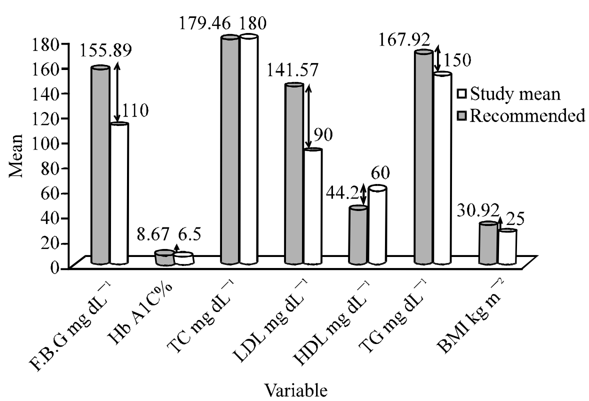

Fig. 1: Comparison between study finding means and guidelines (target) for diabetes

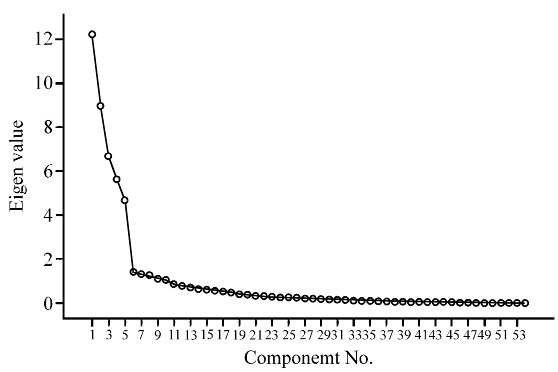

Fig. 2: Scree plot of Eigen value for each component in factor extraction of food frequency intake

adjusted correlation of dietary patterns with glycemic indexes, lipid profile and BMI among subjects surveyed are shown in Table 4-6.

- Transitional pattern strongly and positively correlated with the metabolic risk factors of diabetes (r range 0.556-0 .784, all p = 0.0001). Adjustment for BMI, gender and age did not substantially change the associations (r = 0.554-0.673 and p-range 0.024-0.0001). Hence, "Transitional pattern" remains independent predictor of diabetes risk factors
- "Healthy pattern" was inversely correlated with BMI, glucose, HbA1c, T C, LDL-c. (r = -0.468 to-0.709, p-range 0.05-0.0001). Slightly significantly correlated with postprandial. Non-significantly correlated, however, inversely with HDL-c and no longer associated with triglyceride. Inversely correlated with glucose after adjustment but marginally significant for HbA1c and was no longer associated with postprandial, TC, LDL-c and HDL-c after adjusting with BMI
- Desirable pattern was inversely correlated with HbA1c and glucose (r = -0.514 to-0.589, p-range 0.03-0.008). Slightly significantly correlated with postprandial and HDL. Non-significant, however, inversely correlated with LDL-c, TC and TG and no longer associated with BMI. This association remains significant for fasting blood glucose, postprandial and HbA1c after adjusting, however, insignificant after adjusting for LDL-c, HDL-c and triglyceride
- Traditional pattern had inverse association with BMI, FBG, HbA1c, TC, LDL-c, (r =-0.466-- 0.673, p-range 0.05-0.0001). Insignificant but inverse association for postprandial, HDL-c and triglyceride. The inverse association remains significant for FBG, HbA1c after adjustment. The association with postprandial, T C, LDL, HDL and triglyceride became insignificant after adjustment for BMI

Table 3: Food groups with high factor loadings for the six dietary patterns

First component: Transitional dietary pattern		Second component: Healthy pattern		Third component: Desirable fat pattern		Fourth component: Traditional pattern		Fifth component: Miscellaneous pattern		Sixth component: Snacks pattern	
Lamb	0.912	Green leafy veg	0.909	Pistachios	0.809	Brown bread	0.848	Low fat cheese	0.772	Dates	0.608
Potatoes	0.907	Cucumber	0.877	Fish (sea products)	0.768	Breakfast cereal	0.742	Apple	0.67	Fruit, canned	0.492
Pasta (macaroni)	0.903	Molokhia	0.856	Yogurt low fat	0.766	Chickpeas	0.735	Kiwi	0.663	Apricots	0.452
whole fat cheese	0.951	Tomatoes	0.814	Low fat milk	0.73	Beans	0.73	Cinnamon	0.561	Melon	0.441
Chicken with skin	0.945	Okra	0.797	Skim milk	0.702	peas	0.71	Olive	0.545		
Beef	0.926	Carrots	0.778	Almonds	0.663	Rice (brown)	0.674		0.439		
Cake and cookies	0.896	Orange	0.756	Olive oil	0.618	Lentils	0.582				
White bread	0.761	Grapefruit	0.699	Walnuts	0.599						
Egg	0.757	Parsley	0.682	Cashew	0.443						
oil (corn Palm oil.. etc	0.756	Zucchini	0.531								
Labnah	0.656	Pear	0.525								
Rice(white)	0.65	Cabbage	0.46								
yogurt whole fat	0.594										
Chicken without skin	0.506										
Meat organ	0.302										
Whole fat milk	0.301										
Initial eigenvalues	12.23		8.98		6.68		5.62		4.68		1.41
% of variance	22.64		16.63		12.38		10.41		8.66		2.61
Cumulative %	22.64		39.28		51.65		62.07		70.72		73.34
Frequency of factor (%)	30.87		22.68		16.88		14.2		11.81		3.56

Extraction method: Principal component analysis, Rotation method: Promax with kaiser normalization

Table 4: Association between dietary patterns and anthropometric and biochemical indexes among subjects surveyed

	BMI and glycemic indexes							
	BMI		Glucose		Postprandial		HbA1c	
Variables	r	p-value	r	p-value	r	p-value	r	p-value
Transitional pattern	0.784**	0.0001	0.703**	0.0001	0.662**	0.001	0.689**	0.0001
Healthy pattern	-0.709**	0.0001	-0.661**	0.0001	-0.391	0.062	-0.574**	0.014
Desirable fat pattern	0.110	0.152	-0.514*	0.03	-0.348	0.07	-0.589**	0.008
Traditional pattern	-0.596**	0.005	-0.673**	0.0001	- 0.347	0.07	-0.558*	0.020
Miscellanies pattern	-0.060	0.435	-0.389	0.063	-0.008-	0.914	0.013	0.862
Snacks pattern	0.100	0.196	.013	0.145	-0.105-	0.173	0.055	0.477
Lipid profile								
Transitional pattern	0.687**	0.0001	0.709**	0.0001	0.113	0.141	0.556	0.022
Healthy pattern	-0.468*	0.05	-0.484	0.048	-0.099-	0.198	0.113	0.141
Desirable fat pattern	-0.108	0.161	-0.006	0.938	-0.395	0.060	-0.148	0.160
Traditional pattern	-0.503*	0.041	-0.466	0.05	-0.111	0.150	-0.390	0.062
Miscellanies pattern	-0.018-	0.817	0.028	0.717	-0.145	0.162	-0.006	0.937
Snacks pattern	0.100	0.193	-0.043-	0.375	-0.006	0.937	0.056	0.469

*Correlation is significant at the 0.05 level (2-tailed), **Correlation is significant at the 0.01 level (2-tailed)

- Miscellanies pattern was no longer associated with metabolic risk factors and inversely correlated with BMI, FBG, PPG, TC, HDL, TGs however, not significantly
- Snack pattern was no longer associated with the metabolic risk factors of diabetes, however inversely correlated with postprandial, LDL, HDL

DISCUSSION

The associations between the various biomarkers of diabetes and dietary patterns in this study have provided evidence in support of the pattern based approach in relation to health. Transitional dietary pattern identified by the present study was characterized by increasing consumption of calorie-dense foods containing refined carbohydrates, fats, red meats, high fat dairy products and low fiber (Table 3). Meat one of component of this pattern was found to be positively correlated with diabetic's risk factors (Table 4) which is consistent with similar patterns in several other studies (Schulze *et al*., 2003; Song *et al*., 2004; Fung *et al*., 2004; McNaughton *et al*., 2008; Erber *et al*., 2010) and agrees with a meta-analysis that associated red and processed meat with diabetes (Aune *et al*., 2009). Findings of the present study were inconsistent with findings from (Mizoue *et al*., 2006) data which imply an inverse relation between the animal food pattern and diabetes risk. The "Healthy dietary pattern" and "Traditional dietary pattern" reported in the present study (Table 3) have

Table 5: Multivariate adjusted correlation of dietary patterns with glycemic indexes among subjects surveyed

	Glucose		Postprandial		HbA1c	
Variables	r	p-value	r	p-value	r	p-value
Transitional pattern						
Model 1 (unadjusted)	0.703	0.0001	0.662	0.0001	0.689	0.0001
Model 2†	0.703	0.0001	0.660	0.0001	0.689	0.0001
Model 3‡	0.696	0.0001	0.661	0.0001	0.688	0.0001
Model4ǂ	0.673	0.0001	0.601	0.004	0.588	0.010
Healthy pattern						
Model 1 (unadjusted)	-0.661	0.0001	-0.391	-0.062	-0.574	0.014
Model 2†	-0.659	0.0001	-0.391	-0.062	-0.574	0.014
Model 3‡	-0.640	0.0011	-0.388	-0.063	-0.574	0.014
Model4ǂ	-0.514	0.030	-0.113	-0.141	-0.333	0.074
Desirable fat pattern						
Model 1 (unadjusted)	-0.514	0.030	-0.348	0.061	-0.589	0.008
Model 2†	-0.514	0.030	-0.347	0.061	-0.589	0.008
Model 3‡	-.503	0.041	-0.345	0.061	-0.583	0.010
Model4ǂ	-0.469	0.05	-0.218	0.133	-0.507	0.039
Traditional pattern						
Model 1 (unadjusted)	-0.673	0.0001	-0.347	0.07	-0.558	0.020
Model 2†	-0.673	0.0001	-0.346	0.07	-0.558	0.020
Model 3‡	-0.670	0.0001	-0.344	0.08	-0.557	0.020
Model4ǂ	-0.665	0.0001	-0.247	0.106	-0.550	0.028
Miscellanies pattern						
Model 1 (unadjusted)	-0.389	0.063	-0.008	0.914	0.013	0.862
Model 2 †	-0.289	0.108	- 019	0.807	0.017	0.823
Model 3 ‡	-0.289	0.108	-0.010	0.894	0.017	0.823
Model4ǂ	0.101	0.398	- 0.034	0.663	0.058	0.453
Snacks pattern						
Model 1 (unadjusted)	0.100	0.196	0.013	0.145	-0.105	0.173
Model 2 †	0.098	0.196	0.012	0.145	-0.105	0.173
Model 3 ‡	0.098	0.196	0.012	0.145	-0.103	0.171
Model4ǂ	0.096	0.189	0.011	0.142	-0.101	0.170

†: Adjusted by age (years), ‡: Adjusted further by gender, ǂ: Adjusted further by BMI

Table 6: Multivariate adjusted correlation of dietary patterns with lipid profile among subjects surveyed

	TC		LDL		HDL		Tgs	
Variables	r	p-value	r	p-value	r	p-value	r	p-value
Transitional pattern								
Model 1 (unadjusted)	0.689	0.0001	0.662	0.0001	0.113	0.141	0.556	0.022
Model 2†	0.688	0.0001	0.660	0001.	0.112	0.144	0.555	0.022
Model 3‡	0.688	0.0001	0.661	0001.	0.109	0.151	0.554	0.024
Model 4ǂ	0.588	0.008	0.591	007.	0.009	0.213	0.504	0.04
Healthy pattern								
Model 1 (unadjusted)	-0.468*	0.05	-0.484	0.048	-0.099	0.198	0.113	0.141
Model 2†	-0.468*	0.05	-0.484	0.048	-0.099	0.198	0.113	0.141
Model 3‡	-0.466	0.05	-0.480	0.049	-0.096	0.214	0.119	0.124
Model4ǂ	-0.201	0.156	-0.214	0.168	-0.101	0.192	0.069	0.374
Desirable fat pattern								
Model 1 (unadjusted)	0.195	0.161	-0.006	0.938	-0.395	0.060	-0.148	0.144
Model 2†	0.196	0.161	-0.006	0.938	-0.394	0.06	-0.146	0.143
Model 3‡	0.196	0.161	-0.008	0.941	-0.390	0.063	-0.145	0.143
Model4ǂ	0.160	0.325	0.011	886	-0.236	112	-0.007	0.939
Traditional pattern								
Model 1 (unadjusted)	-0.503*	0.041	-0.466	0.05	-0.111	0.150	-0.390	0.062
Model 2†	-0.499	0.045	-0.465	0.05	-0.110	0.155	-0.388	0.064
Model 3‡	-0.496	0.046	-0.465	0.05	-0.110	0.155	-0.387	0.064
Model4ǂ	-0.217	0.133	-0.201	0.156	-0.006	0.937	-0.211	0.137
Miscellanies pattern								
Model 1 (unadjusted)	-0.018	0.817	0.028	0.717	-0.145	0.162	-0.006	0.937
Model 2†	-0.18	0.817	0.041	0.599	-0.143	0.163	-0.004	0.961
Model 3‡	-0.16	0.819	0.032	0.864	-0.143	0.163	-0.001	0.996
Model4ǂ	0.011	0.886	0.019	0.899	-0.136	0.215	.026	0.734
Snacks pattern								
Model 1 (unadjusted)	0.100	0.193	-0.043	0.375	-0.006	0.937	0.056	0.469
Model 2†	0.099	0.193	-0.043	0.375	-0.007	0.938	0.054	0.466
Model 3‡	0.099	0.193	-0.041	0.371	-0.007	0.938	0.051	0.465
Model4ǂ	0.094	0.188	-0.040	0.371	-0.005	0.935	0.050	0.462

†: Adjusted by age (years), ‡: Adjusted further by gender, ǂ: Adjusted further by BMI

been mentioned in previous studies (Becquey *et al*., 2010; Pala *et al*., 2006; Heidemann *et al*., 2008; Nettleton *et al*., 2008). These healthful patterns i.e. vegetables, fruits, legumes and whole grains were characterized by reducing risk of markers associated with DM through mechanism of lowering glycemic and insulinemic response (Fung *et al*., 2001; Mizoue *et al*., 2006). The favorable impact of these dietary patterns on the promotion of health would be due to the low fat concentration (Schulze *et al*., 2007), complex carbohydrates and fiber (Villegas *et al*., 2008), beta carotene, vitamins C, E, polyphenols (Brighenti *et al*., 2005) and various minerals, in particular magnesium (Bo *et al*., 2006).

The "Desirable fat dietary pattern" identified in this study showed an inverse association between nuts, fish and low dairy products consumption and risks of DM. Findings of this study were in favor with other studies which suggest that consumption of foods high in unsaturated fat associated with a beneficial effect on the characteristics of the metabolic syndrome (Tong *et al*., 2011). Dietary patterns characterized by higher low-fat dairy intake, would lower the risk of type 2 diabetes in men (Mozaffarian *et al*., 2010) and in women (Margolis *et al*., 2011). Nutrients in dairy products, including calcium, magnesium, potassium and vitamin D have shown inverse associations with T2DM and metabolic syndrome (Pittas *et al*., 2007) each of these dairy components have a neutral or beneficial effect on the serum lipid profile, blood pressure, fasting glucose and body composition (Rice *et al*., 2011). Moreover, It has been suggested that low-fat dairy may lower the risk of diabetes by increasing the body's production of hormone adiponectin. Adiponectin is a hormone involved in fat and blood sugar metabolism and has been shown to improve the body's response to insulin and thus reduce the risk of diabetes (Yannakoulia *et al*., 2008). Findings of this study support previous research that a diet rich in nuts, improves glycemic control, blood cholesterol levels in individuals with type 1 and 2 diabetes (Aune *et al*., 2009; Sabate *et al*., 2010; Jenkins *et al*., 2011). The effect on HDL cholesterol levels f replacing saturated fat with monounsaturated or polyunsaturated fat is established (Siri-Tarino *et al*., 2010). The triglyceride-lowering effect of omega-3 fat consumption is well established and the effect of this formulation on LDL cholesterol levels were variable (Meksawan *et al*., 2004). Nuts are a nutrient-dense food rich in plant protein, fat, mostly unsaturated fatty acids (MUFA and PUFA), dietary fiber, minerals (copper, magnesium and potassium), vitamins (folic acid, niacin, vitamin E and vitamin B_6) and other bioactive constituents such as phenolic antioxidants and phytosterol (Sabate *et al*., 2010). Thus, nuts may offer anti-hyperglycemic, anti-hyperlipidemic benefits.

The inverse association with fish intake in the present study is consistent with the findings of other studies in diabetic patients. Patel *et al*. (2009) and Nanri *et al*. (2011) found that high fish and seafood consumption was associated with a lower risk of type 2 diabetes. The omega-3 PUFAs, eicosapentaenoic acid and docosahexaenoic acid are suggested to be the beneficial components within fish that may affect health (Xun and He, 2012). High concentrations of omega-3 PUFAs in human skeletal muscle cells have been associated with improved insulin sensitivity (Hartweg *et al*., 2008). Another potential mechanism relates to the amino acid composition of fish protein, which may increase glucose uptake by skeletal muscle via improved insulin sensitivity (Ouellet *et al*., 2007). Findings of this study were inconsistent with findings from Schulze *et al*. (2003) study which found no significant association between total fish intake and diabetes. From findings of the present study, it appears that the risk of developing diabetes and its complications can be reduced by changing dietary patterns recognizing decreased consumption of meat, whole milk products and refined grain.

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