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Dietary Patterns Associated with Risk for Metabolic Syndrome in Urban Community of Karachi Defined by Cluster Analysis

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Abstract: Dietary trends have been found to be related with metabolic syndrome in various studies. To identify dietary patterns and study associations between the dietary patterns of subjects with high and low risk of metabolic syndrome in a Karachi based community. A group of 871 men and women were selected randomly from 532 households. Data about consumption of specific foods was available for 867 adults. Participants completed a health and lifestyle questionnaire and 363 subjects provided fasting blood samples for glucose and lipids. Dietary intake was assessed by a questionnaire to identify consumption of 33 specific food items and the dietary patterns categorized into 6 food groups was assessed by cluster analysis. Five dietary patterns were identified through cluster analysis. Cluster 1 had the lowest proportion of persons with metabolic syndrome i.e. 42.7% while cluster 2 had the highest percentage of metabolic syndrome subjects (56.3%) ($p = 0.09$). Consumption of fat and caloric dense foods was significantly higher among highest risk group (cluster 2) compared to lowest risk group (cluster 1) ($p = 0.0001$). The consumption of food groups containing fruit, milk and meat was also more than twice in high risk compared to low risk group ($p = 0.0001$). Even within the same population there are marked differences in dietary patterns and these apparently contribute to the risk of developing metabolic syndrome. Dietary pattern studies will help elucidate links between diet and disease and contribute to developing healthy eating guidelines.

Key words: Dietary patterns, cluster analysis, metabolic syndrome, South Asians

INTRODUCTION

High prevalence of metabolic syndrome and Cardiovascular Disease (CVD) risk factors have been reported worldwide especially in South Asians (Ramachandran *et al.*, 2003; Wierzbicki *et al.*, 2005; Basit *et al.*, 2002; Jafar *et al.*, 2005). Metabolic Syndrome (MS) has been shown to be a good marker of future disease risk and it is estimated that subjects with metabolic syndrome are three times more likely to have and twice as likely to die from a heart attack or stroke compared to people without the syndrome (Sarkar *et al.*, 2006). Similarly, people with metabolic syndrome have a five-fold increased risk of developing type 2 diabetes. Although dietary intake has been linked to individual components of MS or the outcome diseases such as diabetes and cardiovascular diseases, the dietary patterns which may lead to the development of metabolic syndrome have not been specified. In recent years there has been increasing interest in the identification of dietary patterns as consumed by populations to better understand the association of diet with chronic diseases (Schwerin *et al.*, 1982; Randall *et al.*, 1990). During the last two decades, there has been significant changes in society's life style habits with increase in unhealthy eating, sedentary activities and smoking (Panagiotakos *et al.*, 2003). These habits have fueled the epidemic of obesity, which is an important risk factor for diabetes, cardiovascular diseases, hypertension and dyslipidemia all of which may be preceded by metabolic syndrome (Basit and Shera, 2008).

The 1990-1994 National Health Survey of Pakistan showed that overall 25% of the population was overweight or obese. The factors significantly associated with obesity were increasing age, being female, higher education, urban residence, high economic status and a high intake of meat (Jafar *et al.*, 2006). Knowledge of specific food patterns is important for relating diet to nutritional status and for the identification of groups at risk of under-or over consumption of specific food items (Tucker *et al.*, 1992).

Several studies have shown that adopting a dietary pattern characterized by high intake of red meat, refined grains, snacks, sweets and fried foods contribute to the

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increased prevalence of type 2 diabetes (Song *et al*., 2004; Schulze *et al*., 2003; Van *et al*., 2002). Whilst adopting a dietary pattern characterized by high consumption of non-refined cereals, fruits and vegetables, a moderate intake of dairy products, poultry and fish and a low intake of red meat contribute towards a reduced prevalence of type 2 diabetes, metabolic syndrome and cardiovascular disease (Kris-Etherton *et al*., 2001; Trichopoulou *et al*., 2003; Chrysohoou *et al*., 2004).

Thus understanding the food patterns around which diets are formed is important for meal planning and nutritional counseling. Cross-sectionally, dietary intake rich in whole-grain foods have been linked to a lower prevalence of metabolic syndrome (Sahyoun *et al*., 2006; McKeown *et al*., 2004; Esmaillzadeh *et al*., 2005). Dairy intake has been inversely associated with metabolic syndrome (Azadbakht *et al*., 2005; Mennen *et al*., 2000; Pereira *et al*., 2002). Greater intakes of fruit and vegetables have been associated with a lower prevalence of metabolic syndrome (Esmaillzadeh *et al*., 2006). No association has been found between metabolic syndrome and intakes of meat and fish (Mennen *et al*., 2000).

In cross-sectional dietary pattern analysis, a greater prevalence of MS was found among consumers of empty calorie dietary patterns, whereas a lower prevalence was found among those consuming a healthy dietary pattern (Esmaillzadeh *et al*., 2007; Sonnenberg *et al*., 2005).

There are no clear recommendations regarding dietary guidelines for the prevention of metabolic syndrome in persons at risk. The present study will help to evaluate the relationship between dietary intake and the risk of developing MS. Cluster analysis offers advantages over the alternative quantitative approaches as it aims to identify distinct, relatively homogeneous groups based upon selected attributes (the dietary variables) (Hu, 2002).

The aim of the present study is to identify dietary patterns within a general population sample of urban Pakistani subjects. We also aim to report the associations between dietary patterns and prevalence of metabolic syndrome which is a precursor for the development of Cardiovascular Disease (CVD) and glucose intolerance.

MATERIALS AND METHODS

The survey was conducted from July 2004 to December 2004 over a period of 6 months. The Lyari Town Geographical Information System (GIS) was used in this survey which ascribed unique identification numbers to 85,520 households in Lyari, where the study on prevalence of metabolic syndrome amongst selected households was undertaken (Hydrie *et al*., 2009). The ethical approval for the Lyari survey was given by the Institutional Review Board (IRB) of Baqai Institute of Diabetology and Endocrinology. The survey activities were divided into two phases, the household interview based on questionnaire and blood sample collection. The questionnaire included demographical details, diet and physical activity questions and anthropometric measurements.

Around 532 households were randomly selected through the GIS software and maps. All adults older than 25 years were invited to participate after providing signed consent. By following this procedure, a total of 871 persons were approached, out of which 867 persons participated in the survey (response rate: 99.5%). These people were interviewed by the field teams and their anthropometric measures taken. Of these, 363 persons gave blood samples, producing a response rate of 42% for blood collection.

Anthropometry: Weight, height, waist, and hip circumference were measured with the subjects in standing position wearing light clothes and no shoes. The weight was taken to the nearest 0.1 kg by a digital bathroom scale and height was taken to the 0.1 cm. Body Mass Index (BMI) was calculated as a ratio of weight (kg) to height in meters squared. Waist circumference was measured at the minimum circumference between the lower border of the ribs and iliac crest on the midaxillary line and hip circumference was measured at the greatest protrusion of the buttocks just below the iliac crest The measurements were taken in centimeters and the Waist-to-Hip Ratio (WHR) was calculated as waist/hip circumference. Blood pressure was measured twice by using a mercury sphygmomanometer, with individuals requested to sit for 10 min before measuring the blood pressure as a special precaution to minimize blood pressure variations and a mean value taken for the final measurements.

Laboratory assays: All subjects were asked to undertake an 8 h fast for blood tests (fasting blood glucose and lipid profile) that were collected at home on weekends (Hydrie *et al*., 2009). All selected parameters of blood lipids (total cholesterol, triglycerides, High Density Lipoprotein Cholesterol [HDL-C] and Low-Density Cholesterol [LDL-C]) and blood glucose estimation were performed using a Vitalab Selectra autoanalyzer. Fasting blood glucose and lipid profiles were done by the glucose oxidase GOD PAP method and cholesterol CHOD PAP method, respectively.

Criteria for metabolic syndrome: Diagnostic criteria for the metabolic syndrome were taken from the American Heart Association (AHA)/National Heart, Lung and Blood Institute (NHLBI) (Table 1) (Grundy *et al*., 2005).

Table 1: AHA/NHLBI diagnostic criteria for metabolic syndrome

Measure (any three of the five criteria below constitute a diagnosis of metabolic syndrome)	Categorical cut points
Elevated waist circumference	U.S. population: $\geq$102 cm in men, $\geq$88 cm in women; lower cut points for insulin-resistant individuals or ethnic groups. For South Asians: $\geq$90 cm in men, $\geq$80 cm in women
Elevated triglycerides	$\geq$150 mg/dl (1.7 mmol/l) or on drug treatment for elevated triglycerides
Reduced HDL cholesterol	<40 mg/dl (1.03 mmol/l) in men, <50 mg/dl (1.29 mmol/l) in women
Elevated blood pressure	$\geq$130 mmHg systolic blood pressure or $\geq$85 mmHg diastolic blood pressure or on drug treatment for hypertension
Raised fasting glucose	Fasting plasma glucose $\geq$100 mg/dl (5.6 mmol/l) or previously diagnosed type 2 diabetes

Dietary data: Dietary consumption was assessed by a 33 food items interviewer-administered semi quantitative food-frequency questionnaire. The food items were categorized into 6 major food groups: Dairy, meat, fat and sweet, cereals, vegetables and fruits groups. Out of the 363 subjects assessed for metabolic syndrome 362 completed the food-frequency questionnaire.

Statistical analysis: We used cluster analysis to identify dietary patterns and to segregate subjects based on the similarity of diet. We chose food variables because we wanted to identify food patterns clusters. K-means cluster analysis was used to define clusters of subjects using the cluster analysis option in SPSS. This procedure attempts to identify relatively homogeneous groups of cases based on selected characteristics.

In K-means cluster analysis, the homogeneity of cases within a cluster is measured by the total within-cluster sum of squares. Cluster memberships are determined by sequentially moving cases from one cluster to another so that the total within-cluster sum of squares is minimized.

The algorithm requires the number of clusters to be specified prior to analysis. It is possible to identify seeds using information derived from previous research.

Five clusters were defined. We investigated metabolic syndrome prevalence for each cluster and compared the dietary patterns of the clusters with the lowest and highest prevalence of metabolic syndrome.

RESULTS

We identified five distinct groups in this population on the basis of cluster analyses. A total of 75 participants (20.7%) were in cluster 1, 71 (19.6%) in cluster 2, 64 (17.8%) in cluster 3, 85 (23.5%) in cluster 4 and 67 (18.5%) in cluster 5. Frequency of consumption of each food group in all the clusters is shown in Table 2.

Analyzing for proportion of subjects with metabolic syndrome in each cluster it was observed that cluster 1 had the lowest proportion of persons with metabolic syndrome while cluster 2 had the highest percentage of metabolic syndrome subjects (42.7% vs. 56.3%) with a p value of 0.09 compared to the other clusters as shown in Fig. 1.

Table 2: Frequency of consumption of food groups in clusters (%)

	Clusters				
	1	2	3	4	5
Milk group	24	69	32	57	29
Meat group	35	79	61	61	56
Fat group	13	70	20	42	44
Cereal group	76	91	90	92	81
Vegetables group	72	94	83	93	82
Fruit group	34	74	45	59	46

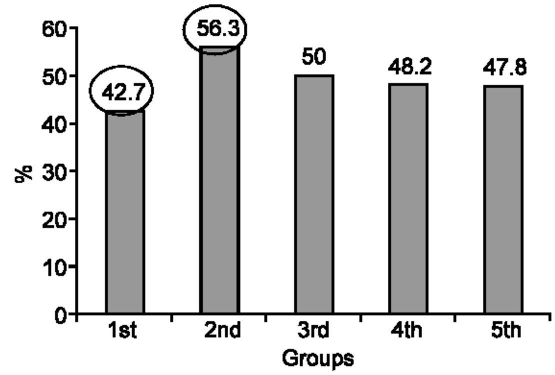

Fig. 1: Metabolic syndrome in five clusters according to modified ATP III definition

Comparing the food items in milk group it was observed that the consumption in cluster 2 (high risk group) was twice compared to cluster 1 (low risk group), the greatest consumption was in cream\custard (7.6 times) and ice cream\sweet lassi (5 times) as shown in Fig. 2.

In meat group the consumption of red meat, organ meat, prawns and eggs in cluster 2 was 3-5 times compared to cluster 1 as shown in Fig. 3.

There was five times increased consumption of the sweet and fat group in cluster 2 compared to cluster 1 as shown in Fig. 4.

In the cereal group there was not much difference in the consumption of legumes and fried rice in both the clusters but around 1.6 times more consumption of naans (refined grain) was seen in cluster 2 compared to cluster 1 (Fig. 5).

In the vegetable group there was also not much difference in the consumption of cooked vegetables and

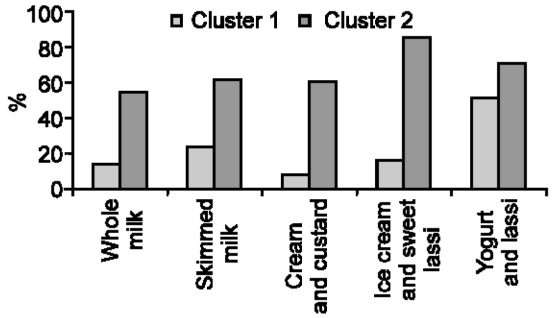

Fig. 2: Comparison of groups with regards to milk group

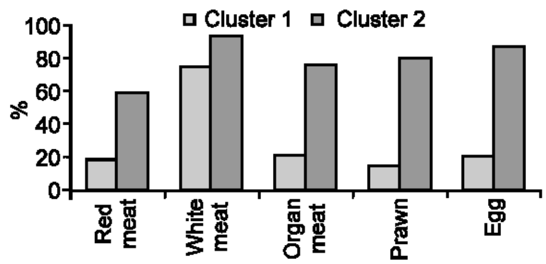

Fig. 3: Comparison of groups with regards to meat group

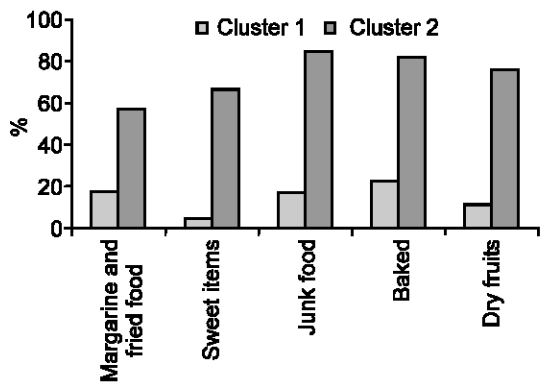

Fig. 4: Comparison of groups with regards to fat and sweet group

cooked potatoes in both clusters but the consumption of raw vegetables was almost double in cluster 2 compared to cluster 1 (Fig. 6).

In the fruit group both clusters showed high consumption of fruits but 8 times more consumption of fruit juices was seen in cluster 2 compared to cluster 1 as shown in Fig. 7.

DISCUSSION

Metabolic Syndrome (MS) has been identified as a precursor of predicting future disease and understanding how MS can be influenced by overall dietary pattern as an entity is valuable.

No individual dietary component is wholly responsible for the association of diet with metabolic syndrome and its components. Rather it is the interaction between different components of diet as well as the consumption of different food items which contribute to the risk for metabolic syndrome. Thus overall dietary trends needs to be observed as individuals consume a mixture of different food items in a single meal, rather than isolated groups.

To our knowledge, this is the first investigation to look into major dietary patterns and its association with the metabolic syndrome by cluster analysis.

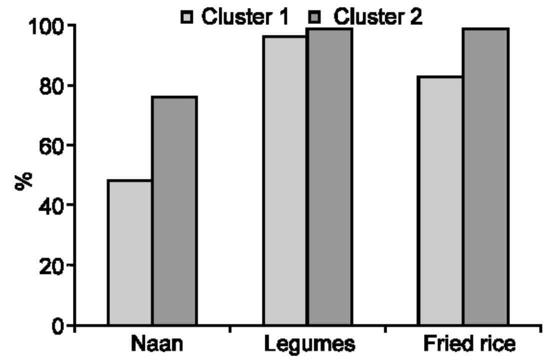

Fig. 5: Comparison of groups with regards to cereal group

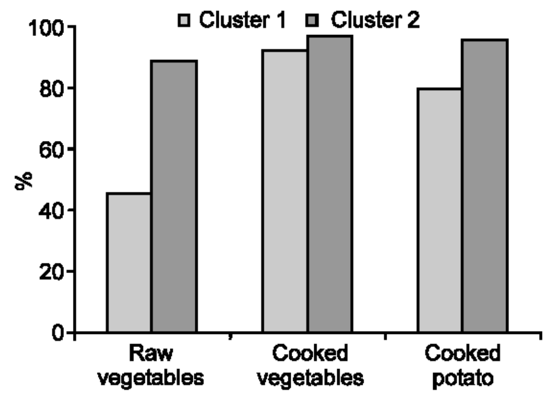

Fig. 6: Comparison of groups with regards to vegetable group

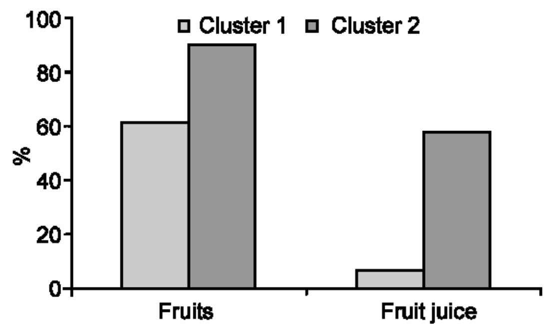

Fig. 7: Comparison of groups with regards to fruit group

In this study low MS risk group (cluster 1) had lowest consumption of all the food groups while the high MS risk group (cluster 2) had highest consumption in most of the food groups. This high food consumption may also contribute to the high prevalence of MS as seen in cluster 2.

Looking at the food groups individually it appears that the food items which were the most energy-dense had the highest consumption in cluster 2 and this probably had the most influence in creating an unhealthy dietary pattern which may lead to increased prevalence of MS.

It has been observed in other studies that the consumption of traditional food (low in saturated fat, low in simple sugars and high in fibre) has declined recently and energy-dense food (high in calories, carbohydrates and saturated fats and low in fibre) and non-traditional energy-dense fast food are being increasingly consumed in South Asia (Misra *et al*., 2009; Misra and Khurana, 2008).

Studies have shown that South Asians have a high consumption of dairy products and sugar compared to other populations (Misra *et al*., 2009; Popkin, 2001). Although dairy consumption has been inversely related to MS in some studies (Azadbakht *et al*., 2005; Mennen *et al*., 2000; Pereira *et al*., 2002) more than twice dairy consumption was seen in the high risk group. Looking further at the individual food items in the milk group it was observed that the highest consumption was in cream\custard and ice cream\sweet lassi; items which have a high fat and sugar content. Coincidently a high intake of fat, milk products and sugars in various regions in India has also shown to be associated with increased cardiovascular mortality (Gupta *et al*., 2006). Thus a combination of dairy products, with high fat and sugars may influence the individual properties of the food and produce a positive association with metabolic syndrome. In our study these factors probably made dairy consumption lose its protective effect in our subjects as documented elsewhere.

Red meat, organ meat and prawns from the meat group were consumed 3-5 times more in cluster 2 compared to cluster 1. All of these food items are known to be high in saturated fat, which has been adversely associated with cholesterol (Schaefer, 2002), blood pressure (Appel *et al*., 2006), obesity and diabetes risk (Parillo and Riccardi, 2004).

Similarly all the food items in fat and sweet group were consumed five times more in cluster 2 compared to cluster 1. Sweet products were consumed at an alarming 13 times more in cluster 2 and they probably influenced the increased prevalence of MS in cluster 2 with their load of empty calories in the diet.

South Asians consume more carbohydrates compared to Europeans and this may lead to hyperinsulinemia, postprandial hyperglycemia, hypertriglyceridemia and low HDL cholesterol levels, all of which is probably due to insulin resistance (Burden *et al*., 1994). Processed cereals, such as refined grains have been shown to be associated with an increased risk of the components of the metabolic syndrome in The Malmö Diet and Cancer Study (Wirfalt *et al*., 2001). Similarly in our study refined grains were consumed nearly twice in the high MS risk group (cluster 2).

Almost double consumption of raw vegetables was seen in cluster 2 compared to cluster 1. Similarly the overall double consumption of the fruit group was seen in cluster 2. An inverse association between prevalent MS and intakes of fruit and vegetables has been reported previously (Esmaillzadeh *et al*., 2006). Also consumption of diets high in fruit and vegetables has been associated with lower blood pressure (Appel *et al*., 2006) and a better lipid profile (Lichtenstein *et al*., 2006). Looking at the individual food items in the fruit group it was observed that the consumption of fruit juices which accounts to empty calories was 8 times more in cluster 2 compared to cluster 1. As mentioned earlier empty calories in diet may lead to increased prevalence of MS; the increased consumption of fruit juices probably undermined the protective effect which vegetables and fruits may have in cluster 2.

In summary the dietary pattern in cluster 2 was loaded with both healthy (milk, legumes, vegetables and fruits) and unhealthy (refined grains, potatoes, meat and meat products, high fat dairy products, snacks, sweet items and fruit juices) foods. Although the healthy foods have been reported to be protective against the metabolic syndrome, the cluster's unhealthy diet constituents have adverse effects on metabolic markers which may lead to increased prevalence of MS.

A limitation to consider in the interpretation of our results is the use of an FFQ containing only 33 items, thus restricting the number of food items needed to characterize usual dietary intake. Furthermore, for some food groups such as dry fruits, low consumption and a narrow range of values among consumers may have prevented us from detecting a relationship if one was present. Moreover, reporting biases may have occurred. Although we acknowledge these limitations, other studies have indicated that there is reasonable validity and reliability of food groups and major dietary patterns obtained from FFQs.

Another limitation of our study is its cross-sectional nature. Thus, the association observed between these dietary patterns and the metabolic syndrome needs to be confirmed in prospective analyses. Furthermore we cannot generalize our findings to Pakistani populations, since only one area within an urban city was used for the sample population.

However, participants in the current study reflected almost all major ethnic groups of Pakistan so that a broad range of dietary habits were represented. Most previous studies relating MS to diet have focused on a single food group. Thus, a major strength of our study is that all six major food groups have been covered in the FFQ.

Thus we need to further explore the development of a method which accurately measures an individual's overall diet quality and quantity and this is a prerequisite for further research regarding the relationship between diet and metabolic syndrome. Further research is required in larger prospective populations to be able to validate the findings of this study and improve our understanding of the association of diet with MS.

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