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RESEARCH ARTICLE

Assessment of Dietary Intake among Patients with Metabolic Syndrome and Comparison with Healthy Patients in Accordance with the Questionnaire

Ayaulym Nurgozhina[1,2*], Roza Bakenova[2], Nazar Seydallin[2], Samat Kozhakhmetov[1,2], Shynggys Sergazy[1], Madiyar Nurgaziyev[1], Arailym Ziyat[1], Laura Chulenbayeva[1], Altynay Tuyakova[1], Alexandr Gulyayev[1], Almagul Kushugulova[1,2]

1. *National Laboratory Astana, Nazarbayev University, Nur-Sultan, Republic of Kazakhstan.*
2. *Medical Centre Hospital of President's Affairs Administration of the Republic of Kazakhstan, Nur-Sultan, Republic of Kazakhstan.*

***Corresponding Author: Ayaulym Nurgozhina**

Introduction

Metabolic syndrome is a cluster of conditions that occur together, increasing the risk of heart disease, stroke, hypertension, and glucose intolerance. Metabolic syndrome has a major impact on the development of diabetes and cardiovascular diseases. Insulin resistance and ß-cell function are also related to metabolic syndrome function. It is crucial to manage correct balance of energy requirement of cells and bodily inflammation for insulin sensitivity and control of metabolic syndrome [1].

About 30.2 million adults aged 18 years or older had type 2diabetes in 2017 according to CDC data. Almost 24% of them did not know they are having type 2 diabetes (WHO). Epidemiological studies conducted in Kazakhstani population in 2016 shows the overall prevalence of type 2 diabetes for 12.5% which is increasing every year [2]. According to the IDF statistics, now every seven second patient with diabetes dies. 4 million patients under the age of 60 die every year [3].

In 2015 there was global survey obesity in 195 countries which concluded 604 million adults and 108 million children had obesity. In 35 years prevalence of obesity doubled in 73 countries [4]. In Kazakhstan, epidemiological monitoring of childhood obesity showed that 77.5% of all children in grades 3-4 are normal in weight and 19.1% of children are overweight, including obesity [5]. Worldwide obesity data was tripled since 1975 according to WHO data [6].

Sudden cardiac death is a leading cause of death in the United States, accounting for up to 350 000 deaths annually [7]. An estimated 17.9 million people died of CVD in 2016, accounting for 31% of all deaths in the world. 85% of these deaths occurred as a result of a heart attack and stroke [8]. About 2 million people suffering from chronic vascular heart diseases were registered in Kazakhstan in 2013-12% of the country's employable citizens [9].

Although a link between the metabolic syndrome and cardiovascular mortality is well established, a potential association between metabolic syndrome and sudden cardiac death has not been fully explored [10]. In the study role of nutrients in metabolic syndrome, Hua J Kern came to a conclusion that both nutrition and health are complex and dynamic systems with a hierarchical nature. It is necessary to receive all nutrients as they are important for the health however they do not work in isolation [11].

In Norway there was a study where the link between metabolic syndrome and risk of mortality was studied. 6,748 men and women participated in the Nord-Trøndelag Health

Study, Norway, from 1995 to 1997 and defined the metabolic syndrome by the International Diabetes Federation criteria. The conclusion of the study was that the metabolic syndrome is a risk factor for mortality, over and above the Framingham risk score, in middle-aged, but not in elderly individuals [12].

In 2017 Polish researchers conducted the study on 7997 participants, coming to the conclusion that the link between metabolic syndrome and associated diseases. However, suggested diet of the doctors and consuming products differ a lot in the country resulting in 30.7% of men and 26.8% of women with metabolic syndrome [13]. Metabolic syndrome prevalence in Chinese adults is 18.2%, according to the International Diabetes Federation.

This study was the first one where relationship of metabolic syndrome and diet was studied in China. Some foods and nutritional factors correlate with an increased number of altered metabolic syndrome components in Chinese adults [14]. Diet is one of the main factors affecting metabolism and factor which can be controlled by human leading to prevent the risk of the disease.

Western diet is the most studied one comparing to the Central Asian or Southeast Asian diets. There is less information about Central Asian diet but it is known significant difference between other diets such as boiled meat, a lot of gluten products, and small amount of fruits. Therefore, this is the pilot study estimating the quantitative consumption of macro and micronutrient influences and their association with indicators of metabolic syndrome. The aim was to investigate the effect of consumption of micro-and macronutrients on health indicators in metabolic syndrome in Central Asian population.

Materials and Methods

Recruitment of Patients

Clinical and laboratory studies were conducted in accordance with the study protocols and consent documents approved by the Ethics Committee of the Center for Life Sciences National Laboratory Astana, Kazakhstan, Nazarbayev University with ethical approval number 311/2537 (IORG0006963). All files are available from the http://www.isrctn.com database ISRCTN37346212 DOI 10.1186/ ISRCTN37346212.

Personal and familial disease anamnesis, characteristics, socioeconomic status was collected by trained physicians. Statistical processing of personal data was carried out in accordance with the recommended for each questionnaire.

Participants received all the required information during the recruitment and the further validation process, not only in oral format, but also in writing. The participants were informed about the possibility of withdrawal at any time with no consequences (also without specifying the reasons for their decision). Finally, the validation of assessed FFQ was conducted on a group of 84 individuals of both sexes, aged 29-75 years.

There were 2 groups: healthy individuals and people with metabolic syndrome. Eighty-four individuals meeting the inclusion criteria volunteered to participate in the study and gave their informed consent to participate. FFQ has been adapted to the studied population's language. All questions were translated into Russian language.

Clinical Laboratory Investigations

All anthropometric measurements were made by the same trained person and under the supervision of the same doctors. Physical examination was carried out according to standard protocols using calibrated instruments at the beginning and at the end of the test. The nurse recorded measurements of height, weight, waist, hip and chest, and took blood pressure and lung volume readings. Participants also gave blood samples. The questionnaire required participants to write down in detail what they ate and drank for one day. Nurses received specific training in dietary screening techniques to ensure that participants recorded their diet correctly.

As a result, all participants completed the food diary, and they were performed at a very high level. This helped us to accurately determine the nutritional composition of their diet. All the results of the health check, including blood pressure and cholesterol levels, were also recorded.

Dietary Assessment

Dietary data were obtained by a Food Frequency Questionnaire (FFQ) using the information on previous week. FFQ is a limited checklist of foods and beverages with a frequency response section for subjects to report how often each item was consumed over a specified period of time [15]. In the current analysis were used two parts of the questionnaire. The first one has a food list of 134 lines. There were 9 groups of food: starchy food, fruits, cooked and raw vegetables, meat-poultry-fish-eggs, prepared dishes, dairy products, fats, drinks, and miscellaneous. Study participants were requested to select an appropriate frequency of consumption for each line, from the nine frequency categories.

Frequency answers are the following: never or less than once/month; 1-3 per month; once a week; 2-4 per week; 5-6 per week; once a day; 2-3 per day; 4-5 per day; 6+ per day. The second part contains further questions, a number of which ask for more detailed information that links back to food lines in part 1. For example, questions about vitamins or drug supplements which are taken during the past year or type of meat (grilled/roast) which is consumed daily. All collected data was converted to micro and macronutrients using EPIC software.

Statistical Analysis

Statistical analysis was performed with SPSS statistic software package. Data were expressed as means ± standard deviation (SD). Comparisons between groups were performed with analysis of non-parametric test. A value of $P < 0.05$ was considered statistically significant.

Results

Baseline Characteristic

Two hundred people were recruited for the survey. Survey was completed by 134 patients. Out of 134 patients, 84 individuals had all clinical-laboratory tests' results. Of these, 58 participants were patients with metabolic syndrome and 26 healthy controls. Therefore, 84 participants were included in the regression analysis, aged between 29-75 years (mean = 54.5 years in men; mean = 40.5 years in women).

After dividing on metabolic syndrome and healthy patients, WHO index of age was used to divide 84 patients by groups. The demographic characteristics of the participants with metabolic syndrome and healthy groups were similar at baseline. Regarding the marital status, questionnaire showed the following results: 75% married, 14% unmarried, 10% widowed/divorced.

Table 1: Characteristics of participants (mean values)

	Systolic pressure	Diastolic pressure	Waist circumference (cm)	Triglyceride level (mg/dl)	High-density lipoprotein (HDL) cholesterol level (mg/dl)	Glucose	Total cholesterol	Low density lipoproteins
Female Metabolic Syndrome	126	79	91+-9	144	128	52	5,12	2,97
Female healthy	108	69	77+-9	96	139	49	4,5	2,69
Male Metabolic Syndrome	123	81	99	172	97	54	4,9	3,15
Male healthy	118	78	89	127	124	58	5,18	3,1

There were 24 male participants and 34 female participants with metabolic syndrome and 6 male and 20 female healthy participants. Mean BMI for patients with metabolic syndrome was 29 and 23 for healthy patients.

A significant difference between patients with metabolic syndrome and healthy participants did not exist for age, gender, income and employment. At the time of the examination, in the group with metabolic

syndrome, high blood pressure was (high blood pressure, systolic pressure (SBP) from 120 to 129 mmHg and diastolic pressure (DBP) less than 80 mmHg), 48/130 patients were registered. Overweight in this group is 100%. 14.2% patients smoke cigarettes and 19% patients do not drink alcohol, 32% patients do not drink coffee and 10.7% participants do not eat chocolate. Personal and familial disease anamnesis, including 22 features such as personal history of pathologies of the digestive and circulatory systems, as well as cancer, and also familial history of cardiovascular and metabolic diseases showed that the metabolic syndrome group had more background diseases in relatives such as cancer, respiratory diseases, and ulcer and stomach cancer.

Patients did not have disease such as Barrett's Esophagus, Celiac Disease, Inflammatory Bowel Disease, Crohn's Disease, Ulcerative colitis, Dyspepsia, Irritable Bowel Syndrome, Liver Disease, colorectal cancer, Stomach cancer, pancreatic cancer, cancer of the liver and biliary tract. One patient had Diverticular Disease, four had Duodenal Ulcer, one patient had Gastric Ulcer, 15 participants had Gastroesophageal Reflux Disease, three patients had hepatitis, five of them had H. Pylori infection, nine participants had Pancreatitis, and only one had Esophageal Cancer. No one patient had lactose intolerance. Educational status was satisfactory since almost 97% of participants had high education. 44.8% of patients' relatives with metabolic syndrome have hypertension. 3 patients have hypertension. 34.4% of patients' relatives with metabolic syndrome had been diagnosed with stroke. 22.4% of patients' relatives have type 2diabetes.

Clinical and laboratory data include anthropometric measurements, cardiovascular status (systolic and diastolic blood pressure, heart rate), lipid profile, levels of inflammatory markers, immunologic status, general analysis of feces (e.g. coprogram), and reports on stool consistency and frequency. The table 2 shows the mean BMI and mean waist circumference.

Obtained results were compared with normal values [16] and conclusion was derived accordingly. In general, men had higher values of BMI than women except for the people at advanced adulthood. After 60+ years both female and male had almost the same BMI and were overweight. Moreover, mean waist circumference also followed the same trend. Normal weight was observed only in female at early adulthood, other groups showed characteristic values for being overweight.

Table 2: Relationship of mean BMI and mean waist circumference to being overweight

Age group	Sex	n	Mean BMI, (kg/m^2)	Mean waist circumference (cm)
25-44 years	m	8	29,10±5.62	96.50±19.40
	f	19	25,70±3.95	74.31±10.50
45-60 years	m	16	27.92±3.28	95.72±10.53
	f	30	27.07±4.04	87.34±11.36
61-75 years	m	8	28.08±3.92	100.50±9.05
	f	8	29.08±3.31	95.22±11.28

4.18 mg/L and 2.16 mg/L were respectively for metabolic syndrome group Female and Male. The normal range of CRP level is 3.0 mg/L

Stool frequency for female with metabolic syndrome was 1.9, for male with metabolic syndrome was 1.8. Stool frequency for healthy female was 2.1, for healthy male was 2.

Stool consistency for female with metabolic syndrome was 3, for male with metabolic syndrome were 3.4. Stool consistency for healthy female was 4, for healthy male was 4.4.

Clinical data for glucose, hemoglobin, triglyceride level, erythrocytes, diastolic pressure, leukocytes, heart rate and lymphocytes were similar between patients with metabolic syndrome and healthy individuals.

Macronutrients

The difference in dietary patterns showed a slightly higher intake of a group with metabolic syndrome compared to healthy individuals group. The metabolism of the carbohydrates galactose, fructose, and glucose is closely related to interactions between different enzymatic pathways. Disorders that associated with these interactions may have symptoms and signs having range from not serious to very intense. These symptoms such as hypoglycemia (low blood sugar), liver enlargement, and muscle pain are all related to the disorders of metabolism of carbohydrates. Nevertheless, disorders can be treated or controlled with special diet.

Carbohydrate-galactose

Table 2: An overview of energy and nutrient consumption in study participants (median)

FFQ-estimated daily dietary intakes	Men Met S	Men Healthy	P-value (metabolic syndrome /healthy)
Carbohydrate-galactose, g	0,23±0,72	1,08±3,70	0,009
Carbohydrate-lactose, g	34,44±14,38	50,39±19,56	0,003
Saturated fatty acids(SFA), g	67,32±47,58	106,80±45,94	0,058
	Women Met S	Women Healthy	
Carbohydrate total, g	646,29±423,17	785,37±489,72	0,048
Carbohydrate-galactose, g	0,65±2,13	1,23±3,65	0,032
Energy, kcal	5640,84±3386,99	6485,47±4048,15	0,037
Energy, kJ	23750,67±14226,32	27288,71±16981,07	0,038
Carbohydrate-lactose, g	39,26±20,57	48,13±28,67	0,021
Carbohydrate-maltose, g	4,91±7,02	12,47±11,85	0,0005
Carbohydrate-sucrose, g	111,15±100,62	174,59±172,13	0,0037
Fat-total, g	229,55±151,17	301,60±196,20	0,0131
Monounsaturated fatty acids (MUFA) - total ,g	70,08±55,61	103,65±72,31	0,0119
Saturated fatty acids (SFA) - total ,g	77,75±59,00	121,33±79,32	0,0039

Shown are mean values as well as P-values of t-tests for the difference between metabolic syndrome and healthy groups

Micronutrients

Table 3: An overview of micronutrients consumption in study participants according to the questionnaire

FFQ-estimated daily dietary intakes	Women Met S	Women Healthy	P-value (metabolic syndrome /healthy)
Iodine, mcg	306,11±222,98	402,25±255,04	0,0500
Vitamin A-retinol, mcg	1572,36±1356,56	1982,08±1888,72	0,0538

Discussion

The aim of the study was to compare daily intakes of metabolic syndrome group and healthy patients according to the FFQ. Moreover, nutritional biomarkers were assessed and compared with the results of the questionnaire as well. The difference between micro and macronutrients are shown in table 2 and 3. According to that, we can conclude there is selective difference between people with and without metabolic syndrome by gender. However, participants who had metabolic syndrome obviously have slower metabolism brings to the support of

their syndrome even further [17]. High-density lipoprotein cholesterol emerged as a protective factor, and waist circumference was a risk factor. This is evidenced by the lower energy value of the food consumed the low level of total cholesterol in the blood, low-density lipoproteins high level of total cholesterol in the blood in participants with metabolic syndrome. Female participants had big difference only in Iodine and Vitamin A.

A cross-sectional study was conducted of 1928 participants in China examining the association of vitamin A with metabolic syndrome. Groups with metabolic syndrome had significant vitamin A deficiency comparing with healthy individuals. Vitamin A deficiency is a severe health problem associated with obesity and metabolic syndrome [18].

Individuals with metabolic syndrome are at a greater risk for developing subclinical hypothyroidism and iodine intake is associated with an increased level of serum *thyroid-stimulating hormone* and more cases of hypothyroidism in the population. Thyroid dysfunction, particularly subclinical hypothyroidism is common among metabolic syndrome patients and is associated with some components of metabolic syndrome (waist circumference and HDL cholesterol).

In 2017 an unselected cohort of 66,822 participants with and without metabolic syndrome were studied for the research about hypothyroidism [19]. Male participants had a difference in carbohydrates, which can lead to disorders of metabolic syndrome. In the group with metabolic syndrome, it was found that 8 people do not eat or rarely eat meat comparing with others. The main difference was in the lipid profiles.

They have lower total cholesterol due to the significant value of triglyceride (p=0.04). It also follows on markers of inflammation and with reactive protein lower in CD4-CD8. There were some limitations of the study. One of the limitations was that we did not consider supplement intake. Information about supplement use was not collected. Next one was not using common food in Kazakhstan. Kazakh people eat horse meat, drink horse, camel milk not listed in the questionnaire.

The amount of participated men was less than women. It could lead to not significant difference in the results. Also the survey was taken only one time and it could effect on the results if it was taken two or three times. All participants answered the whole questionnaire by themselves. It means it was biased and each person answered by his or her understanding of the portion or frequency. It leads to another limitation about the size of the portion, vegetable or fruit. These limitations were not significant to change the results a lot. In the next research, all these limitations are ought to be considered and we will add Kazakh national products to the questionnaire.

Conclusions

In the present study, results showed that metabolic syndrome and healthy patients' dietary intakes were different because of the consumed food. The questionnaire allowed us to calculate and assess micro- and macronutrients, most of which depend on the lipid profile and metabolic syndrome. The results allowed concluding that the accuracy of the FFQ was achieved. This tool for converting food frequency questionnaire data into nutrient and food group values can be used widely for different study populations.

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