

## DIETARY PATTERNS AND THEIR ASSOCIATION WITH OBESITY: A CROSS-SECTIONAL STUDY

G. Roman<sup>1</sup>, A. Rusu<sup>1,\*</sup>, M. Graur<sup>2,3</sup>, G. Creteanu<sup>4</sup>, M. Morosanu<sup>5</sup>, G. Radulian<sup>6,7</sup>, P. Amarin<sup>8</sup>, R. Timar<sup>9</sup>, L. Pircalaboiu<sup>10</sup>, C. Bala<sup>1</sup>

<sup>1</sup>“Iuliu Hatieganu” University of Medicine and Pharmacy - Diabetes, Nutrition, Metabolic diseases, Cluj-Napoca, <sup>2</sup>“Gr.T.Popa” University of Medicine and Pharmacy - Diabetes, Nutrition, Metabolic diseases, <sup>3</sup>“St.Spiridon” Clinical Hospital - Diabetes, Nutrition, Metabolic diseases, Iasi, <sup>4</sup>Emergency County Hospital, Suceava, <sup>5</sup>“Dunarea de Jos” University, Galati, <sup>6</sup>“Carol Davila” University of Medicine and Pharmacy, <sup>7</sup>“Prof. N. Paulescu” National Institute of Diabetes, Nutrition and Metabolic Diseases - Bucharest, <sup>8</sup>University of Oradea, Faculty of Medicine and Pharmacy, Oradea, <sup>9</sup>“Victor Babes” University of Medicine and Pharmacy, Timisoara, <sup>10</sup>Emergency County Hospital, Targu Jiu, Romania

### Abstract

**Context.** Scarce data on dietary habits in Eastern European countries is available and reports investigated individual food items and not dietary patterns in these populations

**Objective.** To identify dietary patterns and to explore their association with obesity in a sample from Romanian population.

**Design.** Cross-sectional.

**Subjects and Methods.** This was an analysis of data collected from 1398 adult participants in ORO study. Data on lifestyle, eating habits and food frequency consumption were collected.

**Results.** By principal component analysis we identified 3 dietary patterns explaining 31.4% of the diet variation: High meat/High fat pattern, Western pattern and Prudent pattern. High meat/High fat pattern was associated with male gender, lower educational level, living in a rural, smoking and a higher probability for the presence of obesity (OR 1.2 [95%CI: 1.1-1.4]). Western pattern was associated with younger age, a higher level of physical activity and smoking. Prudent pattern was associated with older age, female gender, a higher level of physical activity, not smoking status and a lower probability for the presence of obesity (OR 0.8 [95%CI: 0.7-0.9]).

**Conclusions.** This study provides for the first-time information on the association between dietary patterns in adults from an Eastern European country and the presence of obesity.

**Key words:** dietary pattern, general population, physical activity, principal component analysis.

### INTRODUCTION

An increasing number of evidences have linked diet with the risk of developing non-communicable chronic diseases, such as obesity, type 2 diabetes, cardiovascular diseases, and certain types of cancer (1). Identification of dietary components that may play a role in their prevention has become a major concern for researchers and public health authorities. While initial approach in the nutrition research was based on the investigation of individual nutrients or foods, recently the attention turned to the identification and analysis of dietary or food consumption patterns (1). The advantage of this approach is that it provides a comprehensive view of the overall diet, the combination of various nutrients and food groups, the frequency of their consumption and allows for the interaction between different nutrients consumed together (1). Two types of analyses have been used to assess dietary patterns – *a priori*, employing diet quality scores to evaluate the grade of individual adherence to certain dietary indexes, and *a posteriori*, used to identify dietary patterns in a population without making any prior assumptions on these patterns (2, 3).

Many studies, the majority performed in the USA, Canada and Western Europe, have investigated dietary patterns and their association with non-communicable chronic diseases (4-8). Dietary patterns characterized by a frequent intake of refined cereals, red meat, and processed foods, usually called as “Western” diet, were associated with higher prevalence and incidence of overweight and obesity, cardiovascular

\*Correspondence to: Adriana Rusu MD, “Iuliu Hatieganu” University of Medicine and Pharmacy, Diabetes, Nutrition, Metabolic diseases 2 Clinicilor street, Cluj-Napoca, 400006, Romania, E-mail: adriana.rusu@umfcluj.ro

diseases, type 2 diabetes, and cancer (4-9). Scarce data on dietary habits in Eastern European countries is available and reports investigated individual food items and their relationship with chronic diseases and not dietary patterns in these populations (10-13). For Romania, information on dietary habits is available only until 2011, and is limited to empirical findings or results of consultation with focus groups and provides information on daily consumption of certain individual food items or food groups (14-16).

Obesity in Romania Study - Study of the prevalence of obesity and related risk factors in Romanian general population (ORO study) was an observational, cross-sectional study conducted in 8 centres across Romania between January and August 2014 (17). It enrolled a sample representative for adult Romanian population, from all age groups and country regions, with the main objective to assess the prevalence of overweight and obesity and the lifestyle habits in the Romanian population (17). By analysing eating habits, we previously reported a high frequency of unhealthy lifestyle habits (breakfast skipping, eating during night or in front of TV, low frequency of eating 3 meals/day on a regular basis) in the younger age groups (18 to 39 years and 40 to 59 years) as compared to the older ones (18).

This is a post-hoc analysis of the ORO study aiming to identify major dietary patterns and their predictors in the population included in the ORO study. We also aimed to assess whether the patterns identified were associated with obesity.

## **MATERIALS AND METHODS**

### ***Study participants***

The study population and study procedures were previously described elsewhere (17,18). Briefly, 8 participating investigators from 6 main historical regions of Romania were involved. Each of them, with the support of trained resident physicians and medical students were asked to enrol participants from their geographical areas. Details on the enrolment procedures are provided in Roman G *et al.* (17).

Adults >18 years of age were enrolled in the participating centres. Persons were excluded if they refused to participate or if they were incapable to understand the information given during the informed consent process. For all enrolled participants investigators were asked to measure participant's height, weight, and to collect demographic data, data on employment status, education, family and personal

medical history by participant interviews. Body mass index (BMI) was calculated as weight (kg)/[height (m<sup>2</sup>)]. Obesity was defined as a BMI  $\geq 30$  kg/m<sup>2</sup>.

### ***Physical activity***

Physical activity was assessed using 9 questions on intensity and frequency of occupational and leisure time physical activity (17). All questions were derived from the Global Physical Activity questionnaire (19), which was conceptually translated into Romanian language and adapted. Before study start, we tested its linguistic interchangeability between translation and original question (correlation coefficients varied from 0.915 to 1.000,  $p < 0.0001$ ) and its test-retest reliability (Spearman correlation coefficients for the 9 questionnaire items varied between 0.679 and 1.000,  $p < 0.01$ ). For the analysis presented here we used 4 questions assessing only the intensity of the physical exercise. Potential answers to each question were "Yes", which was assigned a score of 1 for questions referring to moderate physical activity and a score of 2 for questions referring to intense physical activity, and "No", which was assigned a score of 0. For the overall assessment of the occupational and leisure-time physical activity, we calculated a total score by summing all individual scores. Values of this total score ranged between 0 for persons with no moderate or intense physical activities and 6 for persons who declared both moderate and intense physical exercise related to occupation and leisure time.

### ***Dietary intake assessment***

Dietary intake was assessed using a semi-quantitative food frequency questionnaire comprising questions on food frequency from the Nurses Health Questionnaire (20) and validated in Romanian population against 24-h dietary recall and by test-retest reliability. The questionnaire showed good internal validity (Cronbach's Alpha 0.949) and test-retest reliability (Spearman correlation coefficients between 0.548 and 1.000 for individual items). Total number of kcal/day and number of kcal/day consumed from main macronutrients derived from food frequency questionnaire were statistically significant correlated with those derived from 24-h dietary recall (unpublished results).

The questionnaire evaluated the frequency of consumption of 90 food items and beverage categories, such as bread, cereals, pasta, eggs, meat, fish, milk and dairy products, sweets, snacks, cooked food, legumes, vegetables, fruits, fried and fast-food and type of fat

used for cooking in the past 12 months. For each item, the participants were provided the typical portion size and were asked to choose between 9 frequency response options of consumption of the specified portion size, ranging from “never” to “6 or more times per day”. Individual food item scores possible values ranged between 1 and 9 for 83 of the 90 items (with 1 for never or less than once/month and 9 for over 6 times/day). For items “frequency of fried food consumption” and “fast-food consumption frequency” potential scores ranged between 1 and 4; for type of fat used (butter/margarine/olive oil/ lard/vegetable oil/) potential scores were 0 (not used) and 1 (used).

The 90 individual food items from the food frequency questionnaire were aggregated in 37 mutually exclusive food groups with similar nutrient profile, based on previous literature reports (21). Those individual items that did not fit in any of the groups or which indicated certain lifestyle habits were kept as individual food items – e.g. fried potatoes, spirits, eggs, soy milk. Total score for each food group was calculated as described by Atkins *et al.* (21). The actual scores for each food group were obtained by summing the individual scores as provided by participants for each food item included in the group. The range of potential scores was obtained by summing the range of potential scores of individual food items. Total score for each food group was calculated only if the information was available for all individual food items. As type of fat used was assessed as “not used” or “used” and we did not assess the frequency of consumption of these items we chose to calculate these scores and not to assess frequency of consumption of food groups per week or day. The list of the 37 food groups obtained from the food frequency questionnaire and the range of their potential scores are provided in Table 1. Range of scores displays frequency of consumption, with minimum values corresponding to never or less than 1/month and maximum values corresponding to more than 6 times per day.

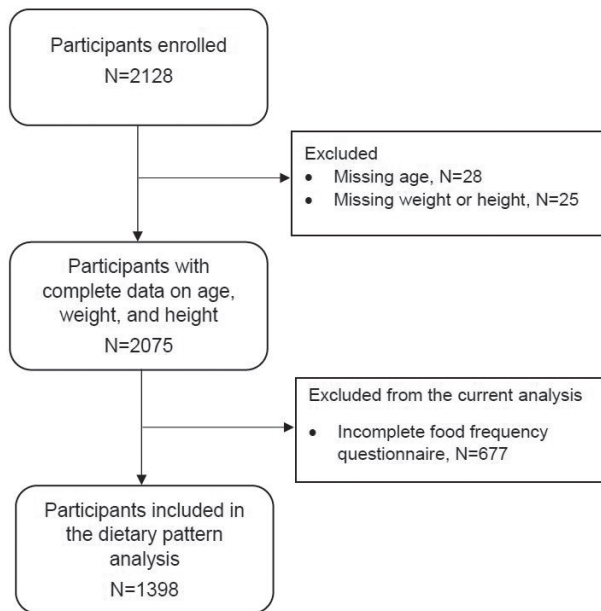
### *Statistical analysis*

For the analysis provided here were included only participants with complete demographic and food frequency data. The assessment of dietary patterns was performed using the principal component analysis calculated in the whole sample and not by age groups or sex. Previously described 37 food groups were entered in the principal component analysis, performed using the orthogonal varimax rotation. Sample adequacy for factor analysis was evaluated by Kaiser-Meyer-Olkin

index and Bartlett’s sphericity test. A Kaiser-Meyer-Olkin index with values  $>0.60$  was considered as an indicator of adequate sampling. Based on the Scree plot analysis, the eigenvalue over 1 and the interpretability (22), we retained principal components (factors) – dietary patterns. For each dietary pattern, the food groups with a factor loading  $\geq 0.4$  were considered to contribute significantly to it and therefore were retained and used to calculate factor scores (23). Each dietary pattern was labelled based on the major food groups with high factor loadings. Principal component factors scores were calculated for each participant by regression method. Calculated factor scores could display negative values, representing a low consumption of the food characteristic for a certain dietary pattern and positive values representing a high consumption of the food characteristic for a certain dietary pattern. Statistical analysis was performed using IBM SPSS Statistics for Windows®, Version 22.0 (Armonk, NY: IBM Corp). Mean  $\pm$  standard deviation and frequencies were used for the description of the quantitative and qualitative variables. The association between dietary patterns (introduced in the analysis as scores and thus as continuous variables) and demographic variables was assessed using multiple linear regression analysis. Regression models were tested for collinearity by calculating variance inflation factors (VIF). A VIF value between 1 and 10 was considered as suggestive for the lack of collinearity. Logistic regression was used to assess the odds for the presence of obesity associated with each dietary pattern identified (introduced in separate models). For the regression analysis, employment status and educational level were re-coded as continuous variables and included as such in the regression analysis. Two-sided  $p < 0.05$  was considered statistically significant.

## RESULTS

As previously described elsewhere (17), we collected 2128 completed questionnaires for ORO study. Of these, 25 had no data on weight or height, 28 had missing data on age and 677 had incomplete data on food frequency questionnaire and were removed from the analysis presented here (Fig. 1). Therefore, the current analysis included questionnaires collected from 1398 persons, 18 to 94 years of age, the majority (76.7%) living in an urban area at the time of the questionnaire completion. The prevalence of overweight and obesity in the sample included in the analysis presented here was 50.6%; 23.5% had arterial

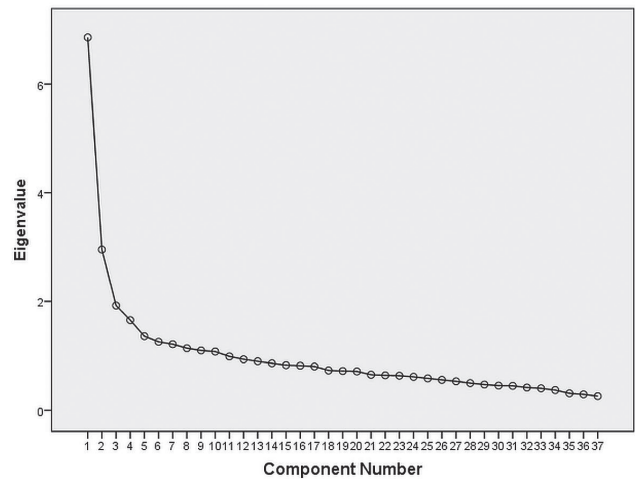


**Figure 1.** STROBE diagram showing participants flow. N, number of participants.

hypertension and 7.9% had diabetes (Table 2).

By principal component analysis we retained 3 principal components (factors) – dietary patterns explaining 31.4% of the diet variation (Fig. 2, Table 3). The Kaiser-Meyer-Olkin index had a value of 0.868 showing that the sampling was adequate for this analysis. Based on Bartlett’s test of sphericity ( $p < 0.001$ ) we rejected the null hypothesis that the correlation matrix was an identity matrix. The food group factor loadings for each dietary pattern are shown in Table 3. Dietary pattern identified by Factor 1, labelled High meat/high fat pattern, explained 18.3% of the diet variation and was characterized by a high intake of red meat, processed meat, poultry, potatoes, pasta and rice, eggs, fried food and fried potatoes. Dietary pattern identified by Factor 2, labelled Western pattern, explained 7.9% of the diet variation and was characterized by a high intake of processed meat, fast-food, snacks, sauces, sweets, nuts and fruits. Dietary pattern identified by Factor 3, labelled Prudent pattern, was characterized by a high intake of fish, vegetables, legumes, fruits and soy milk.

Overall models for multiple regression analysis aiming to identify factors associated with each of the 3 major dietary patterns are displayed in Table 4 and were significant for all dietary patterns, with F-values of 16.0 for High meat/high fat dietary pattern, 24.2 for Western pattern and 9.8 for Prudent pattern. High meat/high fat pattern was associated with male gender, lower educational level, living in a rural area, and current smoking. Western pattern was associated with younger



**Figure 2.** Scree plot for identification of dietary patterns by principal component analysis.

age, a higher level of physical activity and current smoking. Prudent pattern was associated with older age, female gender, a higher level of physical activity and not smoking status. Employment status was not related to the scores for any pattern (Table 4). All models were tested for multicollinearity and for all VIF displayed values  $>1$  and  $<10$ , showing no collinearity issues among variables included as predictors.

When testing the association of obesity with identified dietary patterns, High meat/high fat pattern was associated with a higher probability for the presence of obesity (OR 1.2 [95%CI: 1.1-1.4]). Prudent pattern was associated with a lower probability for the presence of obesity (OR 0.8 [95%CI: 0.7-0.9]). No association of Western pattern with obesity was observed in the fully adjusted model (Table 5).

## DISCUSSION

In this analysis of a Romanian population sample, using an *a posteriori* principal component analysis, we identified 3 dietary patterns: a High meat/high fat pattern, a Western pattern and a Prudent pattern. Dietary patterns identified in our sample are similar to those previously reported in other populations, and which identified unhealthy and Western-type patterns and healthy/prudent patterns (21,24-26). These patterns identified show a change of the current diet from what had been previously identified as a typical Romanian diet – rich in cereals (40% of the caloric intake), milk and dairy products (13% of the caloric intake) and vegetable fats (11% of the diary caloric intake) and with a low consumption of meat and meat products and animal fats (9% and 2%, respectively, of the caloric

**Table 1.** Food groups generated from individual food items in the food frequency questionnaire (modified after 21)

Food group	Food items	Range of scores
Red meat	Beef; lamb; pork	2-18
Poultry	Chicken, turkey (with or without skin), poultry meat products	3-27
Meat products	pork sausages; beef sausages; pork and beef hotdog; hamburger; bacon, ham; salami	6-54
Fish	White fish; herrings, pilchards, tuna, sardines, salmon, mackerel; shellfish; tinned fish and fish sticks	5-45
Potatoes	Boiled, baked, mashed	1-9
Fried potatoes	Fried potatoes	1-9
Vegetables	Tomatoes, broccoli, collie flower, cabbage, carrots, aubergines, spinach, pepper, onion, vegetables mix	10-90
Legumes	beans, lentils, peas, chickpeas	2-18
Fruits	Apples; pears; plums, strawberries, oranges; bananas; other fruits (including fresh fruit juice, fresh and dried fruits)	12-108
Pasta and rice	All type of rice, pasta, pizza	4-36
Breakfast cereals	All types	1-9
White bread	White bread and other bakery products with white flower	1-9
Wholemeal bread	Brown and wholemeal bread; other bakery products of whole meal	1-9
Full-fat cheese	Pressed cheese, cheddar, cheese cream, cheese spread	2-18
Low-fat cheese	Cottage cheese	1-9
Full-fat milk	Full-fat milk, full-fat yogurt, cream	3-27
Semi-skimmed milk	Semi-skimmed milk	1-9
Skimmed milk	Skimmed milk	1-9
Biscuits	All types of biscuits, muffins, waffles, pancakes, cracknel	2-18
Chocolate and sweets	Chocolate (except for dark chocolate), sweets (all types, including jam and marmalade), sweet spreads	7-63
Dark chocolate	Dark chocolate	1-9
Eggs	Eggs (boiled, poached, fried, scrambled)	1-9
Soft drinks	Sweetened (sugar or diet) soft drinks, fizzy or not	3-27
Nuts	Salted or unsalted peanuts	1-9
Snacks	Pop-corn, pretzel, crackers	3-27
Sauces	Salad dressings, mayonnaise	2-18
Wine	Wine, red and white	2-18
Beer	Beer light and regular	2-18
Spirits	Spirits, liqueur	1-9
Fried foods	All types	1-4
Butter	Butter	0-1
Margarine	Margarine	0-1
Olive oil	Olive oil	0-1
Vegetable oil	Vegetable oil	0-1
Lard	Lard	0-1
Fast-food	Fast-food	1-4
Soy milk	Soy milk	1-9

intake) (15). Our results confirm a previous report of Imamura *et al.* (27), showing that between 1990 and 2010 there was an increase in the consumption of both healthy and unhealthy food items in Romania, similar to trends identified at global level. Due to different methods of assessment we could not establish whether the situation worsened or remained unchanged. Irrespective of the trend and given that 18.3% of the variation in the diet was explained by High meat/high fat pattern and 7.9% of the variation by Western pattern, it seems that unhealthy dietary choices remain an unmet need in the Romanian population despite

educational programs that had been implemented.

In our sample, High meat/high fat pattern was characterized by a high intake of red meat, processed meat, poultry, potatoes, pasta, rice, eggs, fried food and fried potatoes. This High meat/high fat pattern includes components of the so-called Western diet rich in red meat and processed meat. Additionally, it includes traditional food and dietary habits in 4 historical regions of Romania, especially in the countryside, where traditional diet differs from the one that is considered 'typical Romanian diet' and includes frequent consumption of meat, especially pork and

**Table 2.** Clinical and socio-demographic characteristics of the enrolled population (complete population)

	<b>Total N=1398</b>
Gender, n (%)	
Women	869 (62.1%)
Age, years [mean (SD)]	40.6 (15.8)
Weight, kg [mean (SD)]	74.0 (16.9)
BMI, kg/m <sup>2</sup> [mean (SD)]	25.7 (5.3)
Waist circumference, cm [mean (SD)]	
Women	82.5 (17.4)
Men	93.2 (15.4)
Overweight and obesity, n (%)	
Overweight	435 (31.1%)
Obesity	273 (19.5%)
Medical history, n (%)	
Myocardial infarction	23 (1.6%)
Angina pectoris	129 (9.2%)
Stroke	22 (1.6%)
Asthma	68 (4.9%)
Diabetes	111 (7.9%)
Hypertension	328 (23.5%)
Smoking, n (%)	339 (24.2%)
Living in urban area, n (%)	1072 (76.7%)
Education level, n (%)	
Primary school	20 (1.4%)
Gymnasium	93 (6.7%)
Secondary school	327 (23.4%)
Professional education	215 (15.4%)
University	733 (52.4%)
Employment status, n (%)	
Full time	810 (57.9%)
Part time (<30 hours/week)	100 (7.2%)
Unemployed	44 (3.1%)
Not capable of working (disease/handicap)	5 (0.4%)
Retired	223 (16.0%)
Student	126 (9.0%)
Homemakers	60 (4.3%)
Other	25 (1.8%)

n (%), number (percentage) of participants; SD, standard deviation; BMI, body mass index.

chicken, fried food, potatoes, and cheese (28). These observations were confirmed by the regression analysis which showed that High meat/high fat pattern was most likely chosen by those living in rural area, those of male sex, with a lower educational level and those who were current smokers.

The Western pattern identified in our study and characterised by high consumption of processed meat, as well as fast-food and refined sugars is similar to food items identified as Western pattern in studies performed in other populations (6-9). Fast-food consumption has shown an increasing trend in the Romanian population, with sociological studies reporting fast-food products consumption by up to 70% of the inhabitants of urban

regions (29). Analysing eating behaviour in the same population, we previously showed that unhealthy eating habits such as irregular meal consumption, eating while watching TV, working on computer or reading was more frequent in younger participants (18 to 39 years of age) than in the older ones and we hypothesized that the lifestyle of the younger groups of the Romanian population is switching to one similar to the one reported in Western populations (18). By identifying a dietary pattern including food items reported as characteristic to the so-called 'Western diet' in our population and associated with younger age, we confirm a switch towards this type of diet in the younger age groups of the Romanian population,

**Table 3.** Factor loadings and variance explained by the three dietary patterns identified

	High meat/high fat pattern	Western pattern	Prudent pattern
Red meat	<b>0.583</b>	0.148	0.159
Poultry	<b>0.482</b>	0.161	0.052
Processed meat	<b>0.670</b>	<b>0.461</b>	-0.001
Fish	0.085	0.224	<b>0.428</b>
Potatoes	<b>0.534</b>	-0.003	0.247
Fried potatoes	<b>0.665</b>	0.300	-0.014
Vegetables	0.187	0.157	<b>0.666</b>
Legumes	0.217	0.229	<b>0.652</b>
Fruits	0.067	<b>0.456</b>	<b>0.485</b>
Pasta, rice	<b>0.442</b>	0.318	0.245
Breakfast cereals	0.013	0.026	0.030
White bread	0.103	-0.155	0.135
Wholemeal bread	-0.021	-0.033	0.097
Full fat cheese	0.282	0.359	0.049
Low fat cheese	0.148	0.016	0.115
Full fat milk	0.013	0.156	0.115
Semi-skimmed milk	-0.031	0.060	0.128
Skimmed milk	0.048	0.038	-0.011
Eggs	<b>0.502</b>	-0.163	0.145
Biscuits	0.157	0.108	0.114
Chocolate, sweets	0.369	<b>0.521</b>	0.130
Black chocolate	-0.042	0.257	0.118
Soft drink	0.097	0.267	-0.141
Nuts	0.091	0.711	0.132
Snacks	0.152	<b>0.690</b>	0.191
Sauces	0.105	<b>0.637</b>	0.143
Wine	0.081	0.085	0.069
Beer	0.111	0.155	-0.003
Spirits	0.098	0.015	0.053
Fried food	0.597	0.186	-0.145
Butter	-0.100	0.199	0.000
Margarine	-0.018	0.018	-0.040
Olive oil	-0.088	0.018	0.043
Vegetable oil	0.013	-0.026	-0.118
Lard	0.341	-0.031	0.224
Fast-food	0.296	<b>0.484</b>	-0.334
Soy milk	-0.145	0.154	<b>0.587</b>
<b>Variance explained</b>	18.274	7.870	5.208

**Table 4.** Multiple linear regression analysis for the association between dietary pattern scores, demographic characteristics, physical activity, and smoking status of the study population

	High meat/high fat pattern	Western pattern	Prudent pattern
Age	-0.009	-0.218 <sup>a</sup>	0.172 <sup>a</sup>
Gender	0.174 <sup>a</sup>	0.015	-0.096 <sup>a</sup>
Education	-0.087 <sup>a</sup>	0.006	0.035
Living area	-0.156 <sup>a</sup>	0.019	-0.008
Employment status	-0.034	-0.044	0.023
Physical activity	0.006	0.114 <sup>a</sup>	0.115 <sup>a</sup>
Current smoking	0.099 <sup>a</sup>	0.104 <sup>a</sup>	-0.097 <sup>a</sup>

<sup>a</sup>The association was statistically significant at 0.05 level.

Variables coding: gender: women=1/men=2; education: primary school=1/ gymnasium=2/ secondary school=3 / professional education=4/ university=5; living area: rural=1/ urban=2; employment status: full time=1 / part time (<30 hours/week)=2 / unemployed=3 / not capable of working (disease/ handicap)=4/ retired=5 / student=6 / homemakers=7/ other=8; current smoking: no=1 / yes=2; age and physical activity scores were included as continuous variables.

**Table 5. Association between obesity and individual factor scores for each dietary pattern**

	<b>OR</b>	<b>95% CI</b>
<i>Unadjusted analyses</i>		
High meat/high fat pattern	1.2	1.1-1.4
Western pattern	0.8	0.7-0.9
Prudent pattern	0.9	0.8-1.0
<i>Adjusted analyses<sup>a</sup></i>		
High meat/high fat pattern	1.2	1.1-1.4
Western pattern	1.01	0.9-1.2
Prudent pattern	0.8	0.7-0.9

OR, odds ratio; CI, confidence interval. <sup>a</sup>Regression analyses adjusted for age, gender, education, living area, employment status, current smoking and physical activity.

irrespective of gender education or living area.

As a positive finding in our population, we identified a Prudent pattern characterized by a high intake of fish, vegetables, legumes, fruits, and soy milk. Women of older age were more likely to choose a Prudent pattern. These results are consistent with previous studies which showed that women are more likely to follow a healthy dietary pattern (30-32). The Prudent pattern was also associated with educational level – a higher educational level was associated with a higher likelihood for a person to follow this pattern and make healthier food choices.

Level of education has been used as a surrogate of socio-economic status. Previous studies reported an association between a lower level of education, an unhealthy dietary pattern and a higher educational level-healthy dietary pattern (33-36). We observed similar choices in our sample – the High meat/high fat pattern was associated with a lower educational level, while the Prudent pattern was associated with a higher educational level among participants. The link between education and dietary choices has been shown in multiple population surveys performed in Western Europe, USA, Australia, Canada, and Asia (33-36). The relationship is complex and seems to be mediated by the individual knowledge of positive and negative influences of exercise and diet and how the nutritional information is applied in daily lives, but it has also been hypothesized that a higher educational level may be associated with additional psycho-social and economic skills (37-39).

Another important finding of this analysis is the association of obesity status with identified dietary patterns. In the population included in this analysis we showed that High meat/high fat pattern was associated with 20% higher odds of having obesity. Also, Prudent pattern was associated with 20% lower odds of having obesity. These associations were independent of age, sex, educational level, living area, employment status, smoking status and physical activity and are consistent

with previous reports in other populations which showed that a higher consumption of a diet rich in fried foods, meat and processed meat was associated with obesity while those following a prudent pattern were less likely to be obese (7,8). We did not find any associations between Western pattern and the odds of having obesity. Given that this pattern was associated with a younger age and a higher level of physical activity, we hypothesize that the lack of association can be explained by both parameters. On the one hand the younger age of the participants following a Western pattern may identify a group in which, although a high caloric intake is present, it has not yet been validated as obesity due to short time elapsed from the onset of a high caloric intake. We did not collect any data on the weight trend before study enrolment, and in these participants, it is plausible to assume that weight may have increased, and the maintenance of the Western dietary pattern may result in obesity onset in the future. On the other hand, in our sample the Western dietary pattern was associated with a higher physical activity. This may offset the higher caloric intake usually associated with a Western-like diet. However, irrespective of the presence of obesity at the study enrolment, a Western-like dietary pattern has been shown to represent a risk factor for the future development of obesity and non-communicable chronic diseases, such as cardiovascular diseases, type 2 diabetes and cancer (40). Thus, based on our results, persons more likely of following a High meat/high fat and a Western pattern should be targeted by educational programmes promoting healthier diets and informing on the risks associated with unhealthy dietary patterns identified.

Our study has several limitations that should be acknowledged. We removed from the current analysis 677 participants with incomplete data on food frequency and these incomplete data may reflect dietary under-reporting. Also, 76% of the persons included in the analysis were residents in urban areas. This may limit the extension of our findings for persons from



rural areas. We did not validate the Romanian version of the Global Physical activity questionnaire against accelerometry, and this can be also considered a study limitation. This was a cross-sectional study, and thus a causality between dietary patterns identified and obesity cannot be established. Prospective studies enrolling Romanian population are needed to confirm a causal relationship between dietary patterns identified and obesity development. Also, this study design may have influenced the odds of presence of obesity associated with the dietary patterns which were close to 1 and not influenced by demographic variables that are known to be associated with obesity. Another limitation is linked to researcher decisions required by principal component analysis used. Although food items were grouped based on previous literature reports (21), the choice of the number of components retained in the analysis may have introduced some degree of subjectivity which may have influenced the association between dietary patterns and demographic characteristics.

**In conclusion**, this study provides additional information on the dietary patterns in adults from an Eastern European country, including participants from all age categories, genders, and educational levels from Romania. By principal component analysis using an *a posteriori* approach we identified 3 dietary patterns and population characteristics associated with each of them. We also identified demographic characteristics of persons following each of dietary patterns identified and odds of having obesity of these persons. This investigation of dietary patterns may represent a starting point for development of public health strategies targeting specific groups with the aim of improving nutrition and preventing future development of obesity and its complications.

#### Conflict of interest

All authors declare that they received fees from the Coca-Cola Foundation through Research Consulting Association for the conduct of the study.

All procedures performed in this study involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. The study was approved by the National Bioethics Committee for Medicine and Medical Devices. All participants signed an informed consent before any study procedure.

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