The Relationship Between Modified Nordic Diet and Resting Metabolic Rate Among Overweight and Obese Participants: A Cross Sectional Study

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Research

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Abstract

Objective: Obesity as a worldwide phenomenon is a multifactorial condition. Healthy diets have effect on obesity related factors like resting metabolic rate (RMR). In present study, we investigate association between adherence to modified Nordic diet and RMR among overweight and obese participants.

Methods: We enrolled 404 overweight and obese (BMI ≥25 kg/m2) women aged 18-48 years in this cross-sectional study. For each participant anthropometrics measurements, biochemical tests and blood pressure were evaluated. RMR was measured by indirect calorimetry. RMR/kg was also measured. Modified Nordic diet score was measured using a validated 147-item food frequency questionnaire (FFQ).

Results: Among all participants, the mean and standard deviation (SD) for age and body mass index (BMI) were 36.67 years (SD=9.10) and 31.26 kg/m2 (SD=4.29). There was a significant association between RMR/kg status and age, body mass index (BMI), RMR (P<0.001), respiratory quotient (RQ), fat percentage (P= 0.01), systolic blood pressure (SBP) (P= 0.03), and diastolic blood pressure (DBP) (P= 0.04), after adjustment for age, BMI, energy intake and physical activity. Participants with the highest adherence to modified Nordic diet had lower odds of hypometabolic status after adjusting for confounders and it was significant (odds ratio (OR) = 3.15, 95% CI= 0.97-10.15, P=0.05).

Conclusions: The present results indicate that adherence to modified Nordic diet is associated with lower odds of hypometabolic status in overweight and obese women. However more studies are needed to confirm our findings.

Trial registration: This article was not a trial research.

Introduction

Obesity is considered as a worldwide public health problem[1]. It is increasing globally and according to the World Health Organization (WHO), 39% (39% of men and 40% of women) of adults aged 18 or over were overweight, with 13% obese. If current trends continue, it is estimated that 2.7 billion adults will be overweight, over 1 billion affected by obesity, and 177 million adults severely affected by obesity in 2025[2]. Obesity is defined as excess body weight for height and a condition of excessive fat accumulation in adipose tissue[3]. Obesity increases the risks of hypertension, diabetes mellitus, coronary heart disease, osteoarthritis and is related to reproductive disorders, especially in women [4–9] and can be induced by some risk factors such as genetics, low physical activity, sedentary behavior, high-energy food intake, and low resting metabolic rate[10]. Resting metabolic rate (RMR), is important to understand because it is responsible for the largest portion (60–70%) of total energy needs[11]. One frequent hypothesis is that during periods of energy restriction like weight loss diets, there is a metabolic adaptation which can be defined as a reduction in resting metabolic rate (RMR). Recently researchers adjust RMR per kg body weight due to their belief that RMR is balanced by body weight[12]. Owen et al declared that as body weight increases, RMR decreases gradually[13]. In addition it has been published that the best cut-off point for RMR per kg body weight for predicting the risk of obesity is 20 kcal/24 h /kg [14]. As such, a marked increase in RMR will enhance the likelihood of a weight-loss, and diet interventions that may increase RMR would be attractive in subjects with obesity (15–17).

Beside the RMR effect, rising prevalence of obesity reflects the strong impact of lifestyle factors, such as diet as dietary patterns [15]. A dietary pattern approach reflects an individual's dietary behaviors so it could provide more detailed information about individual nutritional intake[16, 17]. As well, it's necessary to detect a beneficial dietary pattern to decrease obesity. Recent studies show that modified Nordic diet has emerged as a healthy eating option. This pattern tries to reflect the diet consumed in Nordic countries (Denmark, Sweden and Finland)[18]. Nordic diet is probably more acceptable and easier to adhere for populations in areas outside southern Europe. Local and cultural differences may cause various dietary patterns in different nations and countries. Against all expectations, you can find Iranians with adherence to dietary patterns like modified Nordic diet and we aimed to evaluate this adherence; so it was challenging for us and has not been done before with this purpose. Given its outspread adoption, in the present study we aim to evaluate the adherence to modified Nordic diet and health status. Recent studies have been shown that high adherence to this diet is associated with a healthier lifestyle[19].This led to the hypothesis that adherence to modified Nordic diet is associated with obesity; especially RMR among obese participants or with the risk factor of obesity.

To the best of our knowledge, no research has been done regarding the relationship between modified Nordic diet and RMR among overweight and obese participants. To address this gap, we investigated the association between modified Nordic diet and RMR among overweight and obese women in Tehran, Iran.

Materials And Methods

Study population

This cross-sectional study was performed on 404 women aged 18–48 years who were referred to health centers in Tehran, and using multistage random sampling. Participants were in good general health with Body Mass Index (BMI) 25 and more. Women with a history of diabetes, chronic diseases, cardiovascular disease, thyroid disease, liver or kidney disease, smoking, pregnancy, lactation, menopausal status, follow up diet during the last 6 months, consumption of alcohol, blood pressure and glucose-lowering drugs, alcohol consumption, weight fluctuations during previous month, as well as women with special energy consumption outside the range 800–4200 kcal/day excluded from this study. This study protocol was approved by the ethics committee of Tehran University of Medical Sciences (IR.TUMS.VCR.REC.1395.1597) and written informed consent was signed by all participants.

Dietary assessment, modified Nordic diet score computing

Usual dietary assessed using a validated semi-quantitative food frequency questionnaire (FFQ) included 147 food items and its validity and reliability has already been approved[20]. Participants were asked by trained interviewers to report their consumption frequency of each food item per day, week, month, or year [21]. Food intakes reported in household measures were then converted to grams of food per day using the nutritionist IV software[22]. Nutrients intakes were computed by Nutritionist IV software which was modified for Iranian foods based on the United States Department of Agriculture (USDA) food composition table.

The 6 dietary items included in modified Nordic diet score were: fish, cabbages (cabbage, broccoli/ cauliflower), whole grain bread, breakfast cereals, apples/pears, and root vegetables. All variables adjusted for energy intake. The medians for utilization of each food group were calculated. For each of the food items, zero point was given for taking below the median and one point was given for taking equal to or above the median. The total score was summed up for each participant and they were classified: 0–1 for low adherence, 2–3 for medium adherence and 4–6 for high adherence [23].

Demographic variables

Demographic questionnaires collect data about age, marital condition, education level, particular diets, medicine, medical history, and supplemental consumption which asked by trained interviewers.

Physical activity assessment

All participant's physical activity (PA) was assessed by a validated international physical activity questionnaire (IPAC) which was calculated as metabolic equivalent hours per week (METs h/week) [24]. Participants were asked by trained interviewers to report about all the vigorous and moderate activities during the last 7 days. To calculate the activity, the duration and frequency of activity days were multiplied. The sum of the scores was calculated as the total exercise per week[25].

Assessment of anthropometric measures

All participants were assessed for anthropometric measurements at the Nutrition and Biochemistry laboratory of School of Nutritional Sciences and Dietetics, TUMS. Height was recorded in the standing position by a wall-mounted audiometer with shoes removed. The researchers analyzed anthropometric measurements and body composition, including weight, BMI, fat mass index (FMI), fat-free mass index (FFMI), fat-free mass (FFM), body fat mass (BFM) and fat percentage (%) of the subjects using multi-frequency bioelectrical impedance analyzer InBody 770 scanner (Inbody Co., Seoul, Korea).

Participants were asked not to carry any electric devices and exercise extremely. Also, all the measurements were performed in a fasting condition when the participants were urinated before the body composition analysis for the best results. As stated in the manufacturer's instructions, subjects were required to remove their shoes and coats and stand on the scale and hold the handles of the machine[26]. Waist Circumference (WC) was assessed at smallest circumference between the lower end of the sternum (xiphoid process) and the umbilicus. Hip circumference of participants was also measured in the largest part of the hip. Waist to hip ratio (WHR) was also measured. All measurements were done by a trained nutritionist.

Assessment of blood pressure

Blood pressure (BP) measurements was performed by a trained physician using a standardized sphygmomanometer (Omron, Germany, European).

Biochemical Parameters

All participants’ blood samples were collected in the morning after 10–12 h fast. Serum was centrifuged and stored at -80°C. Fasting serum glucose was measured by Glucose Oxidase Phenol 4-Aminoantipyrine Peroxidase (GOD-PAP) method, triglyceride (TG) was evaluated by Glycerol-3phosphate oxidase Phenol 4-Aminoantipyrine Peroxidase (GPO-PAP) method. Total cholesterol was assessed by the cholesterol oxidase Phenol 4-Aminoantipyrine Peroxidase (CHOD-PAP). The measurement of low-density lipoprotein (LDL) and high density lipoprotein (HDL) were done by the direct method and immunoinhibition assay. Serum hyper sensitive C-reactive protein (hs-CRP) was evaluated by high-sensitivity immunoturbidimetric assay. Serum insulin concentrations were analyzed through enzyme-linked immunosorbent assay (ELISA) method (Human insulin ELISA kit, Monobind Inc., Lake Forest, USA). Liver enzyme (ALT, AST) measurements were done according to International Federation of Clinical Chemistry and Laboratory Medicine (IFCC) standardization. All of the measurements were taken at Nutrition and Biochemistry laboratory of the School of Nutritional Sciences and Dietetics and all assessments kits were from Pars Azmoon (Pars Azmoon Inc. Tehran, Iran).

Resting Metabolic Rate (RMR) measurement

The RMR was measured using indirect calorimetry(METALYZERR 3B-R3, Cortex Biophysik GmbH, Leipzig, Germany) based on the device protocol and under overnight fasting condition. Indirect calorimetry which measures oxygen consumption and carbon dioxide production is a method of measuring RMR. During this test, participants were wearing a mask that completely covered everyone’s nose and mouth. The amount of inhaling and exhaled breath was transmitted by a filter attached to the mask. The device measured the concentration of $CO2$ and $O2$ using the ventilated hood and analyzed the amount of RMR. All measurements in indirect calorimetry were assessed in the morning, after a comfortable night’s sleep. Subjects were instructed to wear comfortable clothes and avoid drinking caffeine and severe exercising for at least 4 h before the test[27].We also measured RMR per kg and subjects were categorized into two groups, RMR/kg $\geq$ 20 kcal/24 h/kg considered as normal metabolic status and RMR/kg < 20 kcal/24 h/kg considered as hypometabolic status, according to the findings as reported previously in detail[28].

Statistical Analysis

Normality distribution was evaluated by applying Kolmogorov-Smirnov's test. For describing the baseline characteristics of the study population descriptive analysis was used. All dietary intakes including the macro- and micro-nutrients, foods, and food groups were adjusted for total energy intake. A score indicating adherence to the modified Nordic diet was calculated. All subjects were ranked according to the three modified Nordic diet adherence groups; 0–1 for low adherence, 2–3 for medium adherence and 4–6 for high adherence. One-way analysis of variance (ANOVA) and Chi-square tests were used to compare quantitative and qualitative characteristics of participants across different values of adherence to modified Nordic diet. The independent sample t test was used to demonstrate differences between RMR/kg status groups. Analysis of covariance (ANCOVA) was used for age, PA, BMI and total energy intake adjustment.

To determine the relationship between adherence to modified Nordic diet score and RMR/kg, binary regression was utilized through three models including a crude model, an age, BMI, energy intake and physical activity adjusted model (Model 1), and next model further adjusted for education, marital status, smoking and economic status (Model 2). All statistical analysis was performed using SPSS v23 software. Also P-value less than 0.05 was defined as the significance level.

Results

Study participant characteristics among different tertiles of modified Nordic diet adherence

All anthropometrical and clinical characteristics of 404 women are presented across the three modified Nordic diet adherence group in Table 1. The mean age, weight, height and BMI of women were 36.67 years (SD = 9.10), 81.29 kg (SD = 12.43), 161.22 cm (SD = 5.87), and 31.26 kg/m2 (SD = 4.29), respectively (Table 1).Our results demonstrated that there are significant association between adherence to modified Nordic diet and physical activity (P = 0.001), fat free mass (P = 0.03), hs-CRP (P = 0.05). These associations were observed between low and high tertile of modified Nordic diet adherence for PA and FFM, and between low and medium tertile of adherence for hs-CRP. The relationship between modified Nordic diet adherence and physical activity remained significantly (P < 0.001) even after adjusting for age, BMI, energy intake and physical activity; same as hs-CRP (P = 0.04). After the adjustment, the significant relationship of modified Nordic diet adherence categories with age (P = 0.01) revealed however the association with FFM (P = 0.51) disappeared. Other variables did not significantly differ between different tertiles of adherence to modified Nordic diet.

Participant characteristics among RMR /kg status

The distribution of variables according to the low and normal RMR/kg status are presented in Table 2. Participants with normal RMR/kg status, were younger (P = 0.005) and significantly lower in weight, BMI, fat percentage, BFM, FMI, and WC (P < 0.001 for all). These women with normal metabolic rate had also lower level of LDL (P = 0.01) and hs-CRP (P = 0.04). After the adjustment of age, BMI, energy intake and physical activity, the association between RMR/kg and blood pressure variables revealed; SBP(P = 0.03) and DBP (P = 0.03). The relationship of RMR/kg with weight, BFM, FMI, WC, LDL and hs-CRP were vanished after the adjustment.

Participant dietary intakes among different tertiles of modified Nordic diet adherence

Dietary intakes of participants according to modified Nordic diet score were shown in Table 3. Participants with high modified Nordic diet adherence consumed higher amount of carbohydrate (P = 0.03), protein, potassium, magnesium, zinc, copper, vitamin C, B6 and B9 (P < 0.001 for all). The high modified Nordic diet adherence group corresponded to higher consumption of vitamin B3 (P = 0.001), vitamin K (P = 0.002), vitamin B2 (P = 0.05), vitamin D (P = 0.03), dietary fiber (P = 0.01) and saturated fatty acid (P = 0.04). As we expected, a significantly higher consumption of fish (P < 0.001), high antioxidant fruits (P < 0.001), root vegetables (P < 0.001), cabbages (P < 0.001), whole grain bread (P < 0.001) and oatmeal (P < 0.001) were presented in highest levels of adherence to modified Nordic diet. All items were energy adjusted.

Association of modified Nordic diet adherence and RMR/kg Status

The relationship between modified Nordic diet and RMR/kg is displayed in the crude and two adjusted binary regression models in Table 4. Participants who were in the highest level of modified Nordic diet adherence compared to the lowest level; which considered as a reference group, had lower odds of hypometabolic status in both adjusted models, although this was statistically insignificant in Model 1 after adjusting for age, BMI, energy intake and physical activity (OR = 1.39, 95% CI = 0.52–3.71, P = 0.50). After further controlling for education, marital status, smoking and economic status, significant association between modified Nordic diet adherence and RMR/kg was demonstrated; when comparing the highest group versus the lowest one (OR = 3.15, 95% CI = 0.97–10.15, P = 0.05). The results of P for trend among crude model, model 1 and model 2 were 0.78, 0.57 and 0.07 respectively. The result of P for trend in model 2, after adjustment for all confounders, represented that the more participants adhered to modified Nordic diet, the lower odds of hypometabolic status they had, even though it wasn't significant.

Discussion

To the best of our knowledge, this cross-sectional study is the first to examine associations between modified Nordic diet adherence and resting metabolic rate among obese and overweight women in Iran. The results showed a positive relationship between adherence to modified Nordic diet and RMR/kg status. People in highest tertile of modified Nordic diet adherence have tended to show significant lower odds of hypometabolic status in comparison to the lowest tertile of adherence, after adjusting for confounders in Model 2.

Participants with higher resting metabolic rate had significantly lower body weight, BMI, WC, fat percentage and FMI as obesity factors. Previous studies have suggested that dietary components as micronutrients and macronutrients can affect metabolic rate. As researchers mentioned, more consumption of dietary fiber and vegetables, can increase energy expenditure[29, 30].

Modified Nordic diet composition with more fiber and higher food volume leads to slower gastric emptying with increased mastication and slower eating pattern[31], factors that all induce a decrease in desire to eat and feeling of hunger[32]. In addition, high vegetable and dietary fiber content of modified Nordic diet may lead to early satiation or sensation of satiety which limit weight gain in overweight and obese participants. In a clinical trial study, a 26-week controlled dietary intervention induces weight loss, although it was not designed for reducing participants body weight[33]. In a randomized controlled trial by

Adamsson et al. after 6 weeks intervention, body weight significantly decreased in Nordic group in comparison with control group [34]. Nordic diet may also improve other anthropometric measurements including body mass index(BMI), waist circumference and fat mass as reported in numerous studies before[35–38]. In a cross-sectional study by Daneshzad et al. findings indicated a decrease in waist circumference in the highest adherence of modified Nordic diet compared to lowest level, but it was insignificant. They also detected that the odds of higher BMI was significantly lower in the highest tertile of adherence in comparison to the lowest one [39]. The concomitant reduction in weight, BMI and waist circumference in Darwiche et al study indicate that anthropometric improvement can be induced by Nordic diet[36].

Recent studies indicated that increased intake of dietary protein may significantly contribute to appetite control[40]. Due to the lower carbohydrate content of modified Nordic diet, energy distribution is optimized by a higher ratio of protein. Evidence shows an improved body composition (an increased FFM and decreased FM) and metabolic profile by high protein diets[41]. More importantly high protein intake directly activate nucleus tracts solitaries in the brain which cause gastric emptying delay[42]. A high-protein diet also elevate energy expenditure, increase body temperature and oxygen consumption; which can promote satiety[43–45]. Other results declare that concentration of peptide-YY (PYY) and glucagon like peptide-1 (GLP-1) decrease due to high protein intake[45, 46]. Baba et al. have studied about the effect of protein on Resting Energy Expenditure(REE) and investigated that after 4 weeks; reduction of REE in high protein diet was 12% less than low protein diet[47]. Although in Luscombe et al. study they did not find any effect of diet composition on REE[48]. De Jonge et al. also declared that the significant decrease in RMR status after weight loss was not related to diet composition[49]. Results of Bandini et al. research demonstrated that no significant changes in resting metabolic rate (RMR) were occurred in response to a high-fat vs. a high-carbohydrate diet[50].

Potentially positive effects of modified Nordic diet should not be oversighted. All food items constituting the modified Nordic diet have health-improving qualities. Abundant use of grain products as a great source of dietary fiber, consumption of fish, fruits and vegetables make this hypothesis that Nordic diet may also have anti-inflammatory aspects[51], however research findings are controversial. Also obesity has long been regarded as a low-grade chronic inflammation[52]. Montemayor et al. observed that hs-CRP was significantly related to anthropometric markers of obesity, such as weight, BMI and WC[53] while Drabsch et al. did not confirm this hypothesis that CRP is associated with RMR as a mediator[54]. Askarpour et al also found an inverse association between dietary inflammatory index and RMR/FFM [55]. Moreover a systematic review meta-analysis of clinical trials mentioned that adherence to the Nordic diet does not affect the concentration of hs-CRP[56]. Adamsson et al. failed to assess any significant effect of Nordic diet intervention on CRP[34]. Interventional research of Uusitupa et al. presented that CRP level did not change after intervention[57]. On the other hand, our findings indicate that adherence to Nordic diet is inversely related to circulating CRP and this relationship stayed significant after adjusting for confounders. Some studies have shown a significant decrease of hs-CRP[33, 58], even after adjusting for weight loss[33]. In Fritzen et al. research hs-CRP level decreased significantly after 26 weeks of Nordic diet intervention just in women group (39). It is noteworthy that our results cannot conclude to anti-inflammatory aspects of Nordic diet, since other inflammatory markers were not included in our study and there are not enough investigations about this issue yet.

The strengths of this research are that no studies have been investigated about the association between modified Nordic diet and RMR/kg in this population. Utilization of advanced equipment and adjustment of major confounding factors should be notices.

This study also has some limitations: it was cross-sectional, hence causality cannot be evaluated. Small population and the same-sex sample also limit the statistical power. Dietary assessment by FFQ questionnaire can result over- or under-reporting food intake. Due to low adherence to Nordic diet in Iranian population, we could not use the original Nordic diet scored and we replaced the modified Nordic diet score. Due to the different culture and dietary intakes, our results are not possible to generalize through the country.

Conclusion

In conclusion, our findings indicate a positive association between modified Nordic diet and RMR among overweight and obese women, however more randomized controlled trials or carefully controlled case-control studies are needed to confirm these findings.

Abbreviations

ALT: Alanine aminotransferase, AST: Aspartate aminotransferase, BP: blood pressure, BMI: body mass index, CHOD-PAP cholesterol oxidase Phenol 4-Aminoantipyrine Peroxidase, DBP: diastolic blood pressure, FFQ: food frequency questionnaire, FFMI: fat free mass index, FMI: fat mass index, GOD-PAP: Glucose Oxidase Phenol 4-Aminoantipyrine Peroxidase, GPO-PAP: Glycerol-3-phosphate oxidase Phenol 4-Aminoantipyrine Peroxidase, hs-CRP: serum hyper sensitive C-reactive protein, HDL-C: high density lipoprotein cholesterol, IPAQ: International Physical Activity Questionnaire, LDL: low density lipoprotein cholesterol, OR: odds ratio, PA: physical activity, PUFA: polyunsaturated fatty acid, RQ: respiratory quotient, SBP: systolic blood pressure, Total-Chol: Total cholesterol, TG: triglyceride cholesterol, TUMS: Tehran University of Medical Sciences, WC: waist circumference, WHR: waist to hip ratio.

Declarations

Ethics approval and consent to participate

This study approved by the ethics committee of Tehran University of Medical Sciences (TUMS) with the following identification: IR.TUMS.VCR.REC.1395.1597. All participants signed written informed consent forms.

Consent for publication

All authors listed approved the final manuscript and consent for publication.

Availability of data and materials

The data are not publicly available because of containing information that could compromise the privacy of research. Data are available from the authors upon reasonable request and with permission of Khadijeh Mirzaei.

Competing interests

The authors declare that there are no competing interest.

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Authors' contributions

The project was designed by GK and AM; AM collected the samples and analyzed the data; GK wrote the paper; FS reviewed and edited the paper; KM conducted research and had primary responsibility for final content. All authors read and approved the final manuscript.

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Tables

Table 1

Participant characteristics among modified Nordic diet adherence tertiles.

Variables	Modified Nordic diet adherence			P value*	P value**
	Low (n=73)	Medium (n=160)	High (n=171)		
Quantitative variables ¥					
Demography					
Age(year)	36.42 ± 9.51	35.85 ± 9.10	37.54 ± 8.89	0.23	**0.01$^{\Psi}$**
Weight(kg)	78.40 ± 11.17	81.52 ± 12.86	82.32 ± 12.41	0.07	0.46
Height(cm)	160.10 ± 5.70	161.56 ± 5.87	161.38 ± 5.90	0.18	0.91
PA(METs h/week)	605.21 ± 498.31	805.34 ± 610.36	1434.82 ± 1498.56	**0.001** [a]	**<0.001$^{\Psi}$**
Body Composition					
BMI(kg/m²)	30.81 ± 4.58	31.16 ± 4.40	31.54 ± 4.06	0.45	0.86$^{\Psi}$
Fat percentage (%) #	42.25 ± 5.38	42.49 ± 5.48	41.94 ± 5.49	0.65	0.58
BFM (kg) #	33.71 ± 8.45	34.96 ± 9.27	34.96 ± 8.38	0.55	0.23
FFM (kg) #	45.20 ± 4.75	46.36 ± 5.79	47.25 ± 5.93	**0.03** [b]	0.51
FFMI #	17.59 ± 1.52	17.73 ± 1.57	18.89 ± 10.11	0.20	0.17
FMI #	13.24 ± 3.52	13.48 ± 3.55	13.48 ± 3.18	0.87	0.28
WHR #	0.93 ± 0.04	1.50 ± 7.19	0.93 ± 0.05	0.47	0.58
WC (cm) #	98.20 ± 9.59	99.62 ± 10.56	100.19 ± 9.80	0.37	0.68
RMR (kcal/day)	1538.91 ± 274.98	1595.30 ± 255.25	1570.56 ± 258.23	0.43	0.73
RMR per kg	19.88 ± 3.60	19.77 ± 2.97	19.34 ± 3.01	0.43	0.99
RMR per BSA	848.52 ± 138.63	856.48 ± 103.07	845.48 ± 113.55	0.74	0.79
RQ	0.86 ± 0.03	0.85 ± 0.04	0.85 ± 0.04	0.58	0.206
Blood pressure					
SBP (mmHg)	109.46 ± 12.46	109.95 ± 15.58	113.28 ± 14.86	0.13	0.34
DBP (mmHg)	78.86 ± 10.32	77.25 ± 10.29	77.42 ± 10.56	0.64	0.14
Blood Parameters					
FBS (mg/dl)	87.45 ± 11.26	87.36 ± 9.84	87.60 ± 8.99	0.98	0.78
Tolal cholesterol (mg/dl)	190.62 ± 36.95	180.88 ± 35.46	186.91 ± 35.53	0.28	0.83
TG (mg/dl)	106.50 ± 47.84	121.10 ± 65.88	127.94 ± 76.91	0.23	0.23
HDL (mg/dl)	46.57 ± 10.05	46.32 ± 9.83	46.78 ± 11.88	0.95	0.27
LDL (mg/dl)	91.45 ± 22.22	95.33 ± 24.25	96.52 ± 24.67	0.51	0.28
AST (U/L)	16.95 ± 5.21	18.01 ± 7.77	18.45 ± 8.41	0.56	0.86
ALT (U/L)	16.95 ± 8.22	20.07 ± 12.90	19.88 ± 15.82	0.44	0.90
hs. CRP (mg/l)	6.00 ± 5.58	3.80 ± 4.72	4.29 ± 4.15	**0.05** [c]	**0.04**
Qualitative variables €					
Marital status (n)				0.62	0.76
Single	21 (19.3)	47 (43.1)	41 (37.6)		
Married	51 (17.8)	112 (39.2)	123 (43)		
Education				0.54	0.75

Illiterate	0 (0)	3 (75)	1 (25)		
Diploma	11 (22.4)	20 (40.8)	18 (36.7)		
Bachelor and higher	61 (17.8)	136 (39.8)	145 (42.4)		
ES				0.26	0.09
Poor	8 (34.8)	8 (34.8)	7 (30.4)		
Moderate	43 (41.7)	31 (30.1)	29 (28.2)		
Good	38 (40.9)	18 (19.4)	37 (39.8)		

¥: Data are presented as Mean ± SD. €: Data are presented as n (%). Ψ: Put out the collinear variable from general linear models (GLM) as confounders.

#: BMI considered as collinear and this variable adjusted for age, physical activity and total energy intake.

Modified Nordic diet score classification: 0-1 point for low adherence, 2-3 points for medium adherence and 4-6 points for high adherence.

Abbreviations: PA: physical activity; BMI: body mass index; BFM: body fat mass; FFM: fat free mass; FFMI: fat free mass index; FMI: fat mass index; WHR: waist to hip ratio; WC: waist circumference; RMR: resting metabolic rate; RQ: respiratory quotient; SBP: systolic blood pressure; DBP: diastolic blood pressure; TG: triglyceride; HDL: high-density lipoprotein; LDL: low-density lipoprotein; AST: aspartate aminotransferase; ALT: Alanine aminotransferase; hs_CRP: high sensitivity C-reactive protein; ES: economic status.

*P values resulted from ANOVA analysis. P value < 0.05 is significant.

**P values presented resulted from ANCOVA analysis and were adjusted for age, BMI, energy and physical activity.

a: association between low tertile and high tertile; medium tertile and high tertile of modified Nordic diet adherence, resulted by Tukey analysis.

b: association between low tertile and high tertile of modified Nordic diet adherence, resulted by Tukey analysis.

c: association between low tertile and medium tertile of modified Nordic diet adherence, resulted by Tukey analysis.

Table 2

Distribution of variables among RMR/kg status.

Variables	RMR/kg		P value*	P value**
	Hypometabolic (RMR < 20 (kcal/day/kg))	Normal (RMR > 20 (kcal/day/kg))		
Quantitative variables ¥				
Age(year)	37.82 ± 7.71	34.94 ± 8.66	**0.005**	**0.04** Ψ
Weight(kg)	84.85 ± 14.00	76.77 ± 9.18	**<0.001**	0.32
Height(cm)	160.85 ± 6.01	161.99 ± 5.83	0.12	0.25
PA(METs h/week)	1145.82 ± 1759.29	1310.58 ± 2519.97	0.54	0.60 Ψ
Body Composition				
BMI(kg/m²)	32.77 ± 4.64	29.26 ± 3.27	**<0.001**	**<0.001** Ψ
Fat percentage (%) #	43.81 ± 4.98	39.39 ± 5.31	**<0.001**	**0.01**
BFM (kg) #	37.63 ± 9.54	30.56 ± 6.24	**<0.001**	0.24
FFM (kg) #	47.31 ± 6.01	46.05 ± 5.02	0.07	0.09
FFMI #	19.25 ± 11.51	17.53 ± 1.31	0.10	0.30
FMI #	14.54 ± 3.56	11.74 ± 2.56	**<0.001**	0.06
WHR #	0.93 ± 0.04	1.50 ± 7.19	0.93 ± 0.05	0.15
WC (cm) #	102.87 ± 10.44	95.03 ± 7.93	**<0.001**	0.35
RMR (kcal/day)	1453.16 ± 254.70	1701.42 ± 209.97	**<0.001**	**<0.001**
RMR per BSA	766.19 ± 87.92	938.49 ± 79.33	**<0.001**	**<0.001**
RQ	0.84 ± 0.041	0.86 ± 0.040	**0.005**	**0.01**
Blood pressure				
SBP (mmHg)	111.85 ± 14.41	111 ± 13.36	0.63	**0.03**
DBP (mmHg)	77.51 ± 9.03	78.01 ± 10.08	0.68	**0.04**
Blood Parameters				
FBS (mg/dl)	88.47 ± 9.77	86.86 ± 9.07	0.21	0.42
Total cholesterol (mg/dl)	188.59 ± 34.09	182.32 ± 36.01	0.19	0.54
TG (mg/dl)	127.10 ± 73.17	117.77 ± 70.31	0.34	0.46
HDL (mg/dl)	46.51 ± 11.54	47.90 ± 10.85	0.36	0.88
LDL (mg/dl)	98.88 ± 25.23	91.07 ± 22.03	**0.01**	0.21
AST (μKat/L)	17.60 ± 7.72	18.33 ± 7.48	0.48	0.06
ALT (μKat/L)	19.22 ± 13.75	19.26 ± 12.74	0.98	0.15
hs. CRP (mg/l)	4.99 ± 4.70	3.69 ± 4.57	**0.04**	0.70
Qualitative variables €				
Marital status (n)			1.00	0.81
Single	35 (56.5)	27 (43.5)		
Married	131 (57.5)	97 (42.5)		
Education			0.52	0.85
Illiterate	2 (66.7)	1 (33.3)		
Diploma	26 (65)	14 (35)		
Bachelor and higher	138 (55.9)	109 (44.1)		

ES			0.90	0.68
Poor	16 (53.3)	14 (46.7)		
Moderate	75 (57.7)	55 (42.3)		
Good	67 (57.8)	49 (42.2)		

¥: Data are presented as Mean ± SD. €: Data are presented as n (%).Ψ: Put out the collinear variable from general linear models (GLM) as confounders.

#: BMI considered as collinear and this variable adjusted for age, physical activity and total energy intake.

Abbreviations: PA: physical activity; BMI: body mass index; BFM: body fat mass; FFM: fat free mass; FFMI: fat free mass index; FMI: fat mass index; WHR: waist to hip ratio; WC: waist circumference; RMR: resting metabolic rate; RQ: respiratory quotient; SBP: systolic blood pressure; DBP: diastolic blood pressure; TG: triglyceride; HDL: high-density lipoprotein; LDL: low-density lipoprotein; AST: aspartate aminotransferase; ALT: Alanine aminotransferase; hs_CRP: high sensitivity C-reactive protein; ES: economic status.

* P values resulted from T-test analysis. P value < 0.05 is significant.

**P values presented resulted from ANCOVA analysis and were adjusted for age, BMI, energy and physical activity.

Table 3

Dietary intakes of participants in different tertiles of modified Nordic diet adherence.

Variables	Modified Nordic diet adherence			P value*	P value**
	Low (n=73)	Medium (n=160)	High (n=171)		
Energy (kcal/d)	2080.39 ± 632.61	2514.71 ± 767.23	3008.79 ± 741.26	**<0.001**	-
Carbohydrate (g/d)	289.23 ± 96.02	351.16 ± 113.78	432.45 ± 117.97	**<0.001**	**0.03**
Protein (g/d)	67.68 ± 21.36	84.65 ± 27.09	108.96 ± 29.79	**<0.001**	**<0.001**
Fat (g/d)	77.17 ± 29.25	93.54 ± 36.86	105.04 ± 32.44	**<0.001**	**0.003**
Trans fatty acid (g/d)	0.0005 ± 0.001	0.0006 ± 0.002	0.0010 ± 0.002	0.25	0.22
SFA (g/d)	23.36 ± 9.88	27.45 ± 11.41	31.70 ± 11.43	**<0.001**	**0.04**
Cholesterol (mg/d)	215.65 ± 103.32	254.54 ± 110.55	296.07 ± 110.92	**<0.001**	0.38
PUFA (g/d)	16.42 ± 9.19	20.21 ± 10.16	21.63 ± 8.68	**0.001**	0.08
Dietary fiber (g/d)	36.43 ± 18.81	43.30 ± 20.17	56.47 ± 20.07	**<0.001**	**0.01**
Sodium(mg/d)	3691.58 ± 1746.51	4412.66 ± 1657.03	4919.27 ± 1734.17	**<0.001**	0.41
Potassium (mg/d)	3056.18 ± 1075.04	4066.22 ± 1398.84	5630.65 ± 1565.56	**<0.001**	**<0.001**
Iron (mg/d)	19.85 ± 13.96	25.77 ± 21.35	30.13 ± 22.36	**0.002**	0.88
Calcium (mg/d)	1023.96 ± 438.88	1164.02 ± 486.77	1487.57 ± 542.75	**<0.001**	0.09
Magnesium (mg/d)	329.84 ± 106.28	441.70 ± 140.36	577.46 ± 162.80	**<0.001**	**<0.001**
Zinc (mg/d)	9.92 ± 3.41	12.47 ± 4.25	15.97 ± 4.71	**<0.001**	**<0.001**
Copper (mg/d)	1.47 ± 0.53	1.84 ± 0.58	2.45 ± 0.74	**<0.001**	**<0.001**
Vitamins					
C (mg/d)	123.25 ± 82.52	163.25 ± 112.56	243.98 ± 110.39	**<0.001**	**<0.001**
D(mcg/d)	1.49 ± 1.38	1.75 ± 1.27	2.38 ± 1.78	**<0.001**	**0.03**
E (mg/d)	13.66 ± 8.497	17.55 ± 9.88	18.01 ± 8.05	**0.002**	0.39
B1 (mg/d)	1.76 ± 0.57	2.03 ± 0.73	2.42 ± 0.69	**<0.001**	0.23
B2 (mg/d)	1.81 ± 0.73	2.10 ± 0.80	2.66 ± 0.83	**<0.001**	**0.05**
B3 (mg/d)	19.67 ± 6.75	24.64 ± 8.69	31.18 ± 10.42	**<0.001**	**0.001**
B6 (mg/d)	1.57 ± 0.44	1.99 ± 0.62	2.69 ± 0.68	**<0.001**	**<0.001**
B9 (mcg/d)	493.29 ± 147.10	580.66 ± 183.01	719.04 ± 172.36	**<0.001**	**<0.001**
B12 (mcg/d)	3.61 ± 2.70	3.97 ± 1.99	5.06 ± 2.64	**<0.001**	0.49
K (mcg/d)	177.30 ± 177.38	258.47 ± 270.48	366.74 ± 332.56	**<0.001**	**0.002**
Modified Nordic diet components					
Fish (g/d)	5.89 ± 10.36	9.13 ± 8.31	15.15 ± 14.51	**<0.001**	**<0.001**
Apples, pears/high antioxidant fruits (g/d)	63.30 ± 44.32	111.09 ± 84.17	179.31 ± 117.23	**<0.001**	**<0.001**
Root vegetables (g/d)	45.21 ± 22.20	66.78 ± 40.66	118.46 ± 58.89	**<0.001**	**<0.001**
Cabbages (g/d)	147.83 ± 97.48	251.56 ± 205.44	412.25 ± 199.80	**<0.001**	**<0.001**
Rye/ wholegrain breads (g/d)	22.51 ± 25.68	62.68 ± 69.10	77.78 ± 88.40	**<0.001**	**0.002**
Oatmeal (g/d)	28.62 ± 15.61	45.15 ± 34.36	77.09 ± 53.50	**<0.001**	**<0.001**

All values are presented as mean and SE. Abbreviations: SFA: saturated fatty acids; PUFA: poly-unsaturated fatty acids.

*P values resulted from ANOVA analysis. P value < 0.05 is significant.

**P values presented resulted from ANCOVA analysis and were adjusted for energy (kcal).

Table 4

Association between adherences to modified Nordic diet and RMR/kg status in the crude and adjusted model.

Variables	Modified Nordic diet adherence			P trend
	Low (n=73)	Medium (n=160)	High (n=171)	
Crude	1	0.97 (0.47-2.00)	0.91 (0.45-1.83)	0.78
P value	0.95	0.95	0.80	
Model 1	1	1.37 (0.53-3.51)	1.39 (0.52-3.71)	0.57
P value	0.77	0.50	0.50	
Model 2	1	2.42 (0.82-7.12)	3.15 (0.97-10.15)	0.07
P value	0.15	0.10	**0.05**	

All values are presented as odds ratio (OR) and 95% Confidence intervals (95% CI).

Model 1: Adjusted for age, BMI, energy and physical activity.

Model 2: Adjusted for age, BMI, energy, physical activity, education, marriage, smoking, diet resistance, age at onset of obesity and economic status.

P value < 0.05 is significant.

The lowest tertile of modified Nordic diet adherence considered as a reference group.

RMR/kg > 20 (kcal/day/kg) was included in linear regression as RMR status.