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ORIGINAL RESEARCH

Dietary Habits, Anthropometric Values, and Microvascular Reactivity in Older Persons of Both Sexes Living at Retirement Home in Osijek, Croatia

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Purpose: To examine the correlation between dietary habits, anthropometric measurements, and microvascular reactivity with respect to sex in older adults (aged > 65 years) residing in organized accommodation within retirement homes.

Patients and Methods: Sixty-nine older persons who live in a retirement home in Osijek, Croatia volunteered to participate (34 men and 35 women) in this observational cross-sectional study. Study was performed in the period from May 1, 2024 to July 1, 2024. Subjects weight, height, waist circumference, hip circumference, blood pressure and heart rate were measured, and body mass index (BMI) and waist to hip ratio (WHR) were calculated. To assess microvascular endothelium-dependent vasodilation, skin microvascular post-occlusion reactive hyperemia (PORH) was assessed by Laser Doppler Flowmetry. Long-term dietary patterns and dietary habits were evaluated with validated EPIC-Norfolk food frequency questionnaire, in Croatian language. Study was approved by Ethical Committee of Faculty of Medicine Osijek (Class: 641-01/24-01/04, No: 2158-61-46-24-86).

Results: Mean age (standard deviation, SD) of 34 older men was 83.8 (5.4) years, and of 34 older women 83.6 (5.5) years. The mean BMI of all subjects was 27.1 kg/m2 classifying them as overweight. Both men (WHR 0.99 (0.07)) and women (WHR 0.90 (0.06) had significantly higher than normal WHR (normal WHR, men <0.90, women <0.80), suggesting the visceral type of obesity. The mean intake of NaCl was higher (NaCl g/day men 6.91 (1.43), women 6.93 (2.51)), and intake of vitamin D lower (vitamin D µg/day men 3.64 (1.35), women 3.47 (2.61)) than recommended values (NaCl g/day <5 g/day, vitamin D 15 µg/day). Men consumed significantly more alcohol (alcohol g/day men 1.48 (3.36) vs women 0.17 (0.39), P = 0.03), while women had higher carotene intake (β-carotene, µg/day men 2603 (1020) vs women 3478 (1580), P = 0.009). Microvascular reactivity was similar in women and men (PORH, R-O% men 85.2 (30.6) vs women 76.2 (31.5), P > 0.05). However, women had a significant negative correlation of waist circumference (R = −0.350, P =0.04) and WHR (R = −0.406, P = 0.02) to PORH.

Conclusion: Dietary habits were similar between older men and women, except for higher alcohol intake in men and higher carotene intake in women. In older women, microvascular reactivity was negatively associated with waist circumference and WHR, underscoring central obesity as a key cardiovascular risk factor in this population. Given the increased cardiometabolic vulnerability in postmenopausal women, measures of central adiposity should be routinely monitored in geriatric care.

Keywords: older persons, food frequency questionnaire, sex differences, microcirculation, post-occlusive reactive hyperemia

Introduction

Aging is a physiological process which encompasses significant deterioration in structure and function of the organism and requires various adaptations to maintain functionality. Individuals 65 years and over are considered old and are classified into three age subgroups: young-old adults (age 65—74 years), old-old (or middle-old) adults (age 75—84 years), and oldest-old adults (age 85 years and over).[1,2]

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Aging is frequently accompanied by various cardiometabolic diseases, such as metabolic syndrome, chronic cardiovascular diseases (eg atherosclerosis, hypertension) and chronic kidney diseases,[3] particularly in older people who predominantly live a sedentary lifestyle and often have dietary habits (the long-term dietary patterns and habits that an individual forms and maintains in their daily life) that are inadequate for their age.[4,5] A balanced intake of proteins, sugars and fats is a matter of healthy diet and contributes to the prevention of cardiometabolic diseases and eating habits should be adjusted to age. Overall, the World Health Organization (WHO) currently recommends that older persons consume nutrient-dense foods, such as fish, lean meat, liver, eggs, soy products and low-fat dairy products as a source of proteins, yeast-based products, fruits and vegetables, herbs and spices as a source of micronutrients, minerals and vitamins, and whole-grain cereals for complex carbohydrate intake, and nuts and seeds as a source of healthy, non-saturated fats. Water should be regularly consumed, especially in warm climates, to avoid dehydration.

It has been reported that older men (up to 73 years of age) preferred almost all types of meat, eggs, and vegetables while women consumed more frequently bread, biscuits, chocolate, coffee, milk, and dairy products, fresh fruits and vitamin supplements,[6] showing sex-related food choices. However, data on food intake in older population is very scarce. This population is particularly vulnerable, with a higher incidence of chronic non-communicable diseases,[7] thus dietary intake may be particularly important for the maintenance of stable health condition.

Normal aging includes vascular remodeling and vascular stiffness.[8,9] However, endothelial dysfunction is a hallmark of cardiometabolic diseases.[10] Impaired microvascular reactivity is associated with many diseases that increase mortality in older age. For example, coronary artery disease, is associated with microvascular endothelial dysfunction.[11] Age-related endothelial dysfunction is a pathophysiological process that ultimately leads to an increased risk of atherosclerosis and subsequent cardiovascular incidents.[12] Finally, there are strong links between a poorer post-occlusive reactive hyperemia (PORH), which is a manifestation of endothelial dysfunction, and chronic renal failure, the prevalence of which increases with age.[13] Importantly, dietary habits can significantly affect microvascular reactivity, eg increased intake of table salt has been demonstrated to impair endothelium-dependent microvascular reactivity in young, normotensive healthy persons,[14] while intake of food enriched with n-3 PUFAs can improve microvascular reactivity even in cardiovascular patients recovering from acute coronary incident.[15]

It is well accepted that anthropometric characteristics, such as body mass index (BMI) or waist or hip circumference of individuals are associated with the likelihood of various diseases, including cardiovascular diseases.[16] According to a study from South Korea, which followed 153,484 subjects from 2003 to 2010, people with an excessive or underweight BMI were associated with an increased risk of mortality, while those with moderate values had lower mortality.[16] Waist circumference (an indicator of visceral fat and central (abdominal) obesity,[8,17] and hip circumference have been shown to be more suitable predictors of obesity than BMI; however, one should consider both values.[18] Increased visceral fat is associated with disorders of glucose and lipid metabolism and also with increased insulin resistance.[19,20] In addition, the protective hormone adiponectin is decreased in individuals with increased visceral fat, and its low levels are correlated with type 2 diabetes, hypertension, cardiovascular disease, and malignant diseases.[8,21] Therefore, anthropometric values that can be easily determined play a key role in predicting morbidity and mortality, especially in older age.

Taken all together, the present study aimed to examine the correlation between dietary habits, anthropometric measurements, and microvascular reactivity with respect to sex in older adults (aged > 65 years) residing in organized accommodation within retirement homes.

Materials and Methods

Study Design and Participants

This was an observational cross-sectional study involving older individuals of both sexes over 65 years of age who currently reside in the Retirement Home Osijek, Drinska 10, Osijek, Croatia. Users of the Home were invited to participate voluntarily in the study via an advertisement, with exclusion criteria being conditions such as dementia, conditions that limited the completion of a food frequency questionnaire or laser Doppler flowmetry, or severe health conditions with high care dependency. The study included 71 volunteers (36 women, 35 men) in the period from May 1, 2024 to July 1, 2024. Each participant was informed about all the protocols and procedures included in the study and each subject gave written informed consent. The study protocol was in accordance with the standards established by the last revision of the Declaration of Helsinki, and approved by the Ethics Committee of Faculty of Medicine Osijek (Class: 641-01/24-01/04, No: 2158-61-46-24-86, Date: April 5, 2024). Two subjects were excluded from the study because they were unable to undergo the laser Doppler measurement, as they could not remain still during the recording process, which is essential for obtaining a reliable signal, so the final results of the 69 remaining subjects are presented.

Anthropometric and Arterial Blood Pressure Measurements

Anthropometric measurements (weight, height, waist circumference, hip circumference) were obtained using a tape measure and scale. Body mass index (BMI) and waist-to-hip ratio were calculated using the appropriate formula.

Arterial blood pressure (BP) and heart rate (HR) were measured using a digital blood pressure monitor (Omron M2, manufactured in 2018) for three consecutive times, and the arithmetic mean of the 3 times blood pressure (and pulse) measurements were calculated. Blood pressure was measured in a sitting position after resting for 5-minutes.[22]

Food Frequency Questionnaire

Dietary habits were determined using the EPIC-Norfolk food frequency questionnaire (FFQ) translated into Croatian, cross-culturally adapted, and validated.[23] For simplicity, the tables in the questionnaire were divided into types of food products and how often they were consumed during the past year. The FFQ itself is divided into two parts. The first part consists of a 130-line list of foods and the associated food portions. The foods are divided into 10 categories: (1) meat and fish, (2) bread and biscuits, (3) cereals, (4) potatoes, rice and pasta, (5) dairy products and fats, (6) sweets and snacks, (7) soups, sauces and spreads, (8) drinks, (9) fruit and (10) vegetables. The subjects were asked to fill in the appropriate frequency of the nine frequency categories that were offered to them. The second part of the questionnaire contains additional questions that partly ask for more detailed information about the foods that were answered in the first part (eg how well the meat was cooked). Data from the EPIC-Norfolk questionnaire was entered into an Excel spreadsheet and processed using the FFQ EPIC Tool for Analysis (FETA).[24] FETA provides free tools for calculating nutrients and foods from data collected from the EPIC-Norfolk questionnaire and generates average daily intakes of 46 nutrients and 14 major food groups.

Measurement of Microvascular Reactivity – Post-Occlusive Reactive Hyperemia

All subjects had their microvascular reactivity measured non-invasively using a laser Doppler flow meter (MoorVMS-88 LDF, Axminster, UK).[25] The laser probe was attached to the skin of the volar side, on either the left or the right forearm, approximately 12–15 cm from the wrist, and where the basal flow was between 5 and 10 perfusion units (perfusion units – PU).[26] Subjects were tested in a relatively warm room (23.5 ± 1.5 °C) after approximately 30 minutes of acclimatization. According to the post-occlusive reactive hyperemia (PORH) protocol, their basal flow was first measured without occlusion for 1 minute. After the elapsed minute, the cuff located in the upper arm area was inflated 30–50 mmHg above the systolic blood pressure, thereby occluding the flow.[26] After another minute, the cuff was released and the measurement continued for another 2–3 minutes.

Microcirculatory blood flow was expressed in arbitrary PU (perfusion units). Analysis was performed using software obtained from the manufacturer of the LDF monitor (moorVMS-PC v4.0, Axminster, UK) which calculated the area under the curve (AUC) during baseline flow, occlusion, and reperfusion. The time interval taken for AUC assessment was always the same for the corresponding basic flow, occlusion and reperfusion, and lasted as long as the provoked vascular occlusion lasted - 1 min. Since the flow does not reach zero even when there is no perfusion, the flow values are expressed as a quotient of the standard comparator - the baseline flow. The final result was expressed as the difference between the percentage change in flow during reperfusion and occlusion compared to the initial value (R-O % increase). General procedures for measuring LDF PORH were carried out according to the protocol already described in the laboratory of the Department of Physiology and Immunology, Faculty of Medicine, Osijek.[14,25,26] A representative monitoring of the LDF of PORH with a pronounced assessment of R-O (and other parameters) was reported and described in our earlier work.[26]

Statistical Analysis

The data were presented descriptively and processed analytically. The sample size calculation included preliminary data obtained from 20 subjects (10 women and 10 men). To detect differences in the primary outcomes reported in our study (eg, LDF PORH), a sample size of 31 participants in each group was calculated, with a significance level of 0.05 and a statistical power of 80% for the Student's *t*-test. Numerical data (eg, anthropometric data, arterial BP, HR, FFQ data) were described by the arithmetic mean and standard deviation. Nominal data (eg, BMI-based categorization, medications) were presented using absolute and relative frequencies. The normality of the data distribution was assessed by the Kolmogorov–Smirnov normality test. Student's *t*-test was used to compare numerical data between men and women, and the Mann–Whitney *U*-test was used when the variables were not normally distributed. For nominal data, chi-square test was used to test differences between the groups. Analysis of covariance (ANCOVA) was also used to test difference in PORH between groups with BMI, WHR or WC as a covariate. The correlation between PORH and the corresponding parameters was determined by Pearson's or Spearman correlation tests, according to the normality of the distribution. SigmaPlot, version 11.2 (Systat Software, Inc., Chicago, IL, USA) was used for statistical analysis.

Results

In total, the results of 69 older participants (>65 years), 35 women and 34 men, are presented. The mean age of the subjects was 83.7 (SD 5.4) years. There was no significant difference in the mean age of women and men. There was no significant difference in the mean age of women and men (Table 1).

There was no significant difference in the BMI between women and men. The distribution in subgroups with normal, overweight and obese BMI was similar in women and men. However, waist circumference and waist-to-hip ratio (WHR)

Table 1 Anthropometric Data, Arterial Blood Pressure and Heart Rate of the Study Population

Variable	Groups		*P value*
Number of subjects (N)	69		
Age (years)	83.7 (5.4)		
	Women	Men	
Number (N)	35	34	
Age (years)	83.6 (5.5)	83.8 (5.4)	*0.88*[a]
Body weight (kg)	68.2 (10.6)	80.6 (11.4)*	*<0.001*[b]
Body mass index (kg/m^2) N of obese (>30) N of overweight (25–29.9) N of normal (18.5–24.9)	27.1 (4.9) 9 11 15	27.1 (3.4) 8 14 12	*0.95*[a]
Waist circumference (cm)	98.8 (11.8)	106.1 (10.1)*	*0.008*[a]
Waist-hip ratio	0.90 (0.06)	0.99 (0.07)*	*<0.001*[a]
Systolic BP (mmHg)	139 (21)	138 (19)	*0.87*[a]
Diastolic BP (mmHg)	71 (12)	71 (12)	*0.83*[a]
Mean BP (mmHg)	93 (14)	93 (13)	*0.97*[a]
Heart rate (beats/min)	76 (11)	71 (12)	*0.11*[a]

Notes: The results are expressed as the arithmetic mean and standard deviation (SD). Statistical test: [a]Student's *t*-test or [b]mann–Whitney *U*-test, * P<0.05.
Abbreviation: BP, blood pressure.

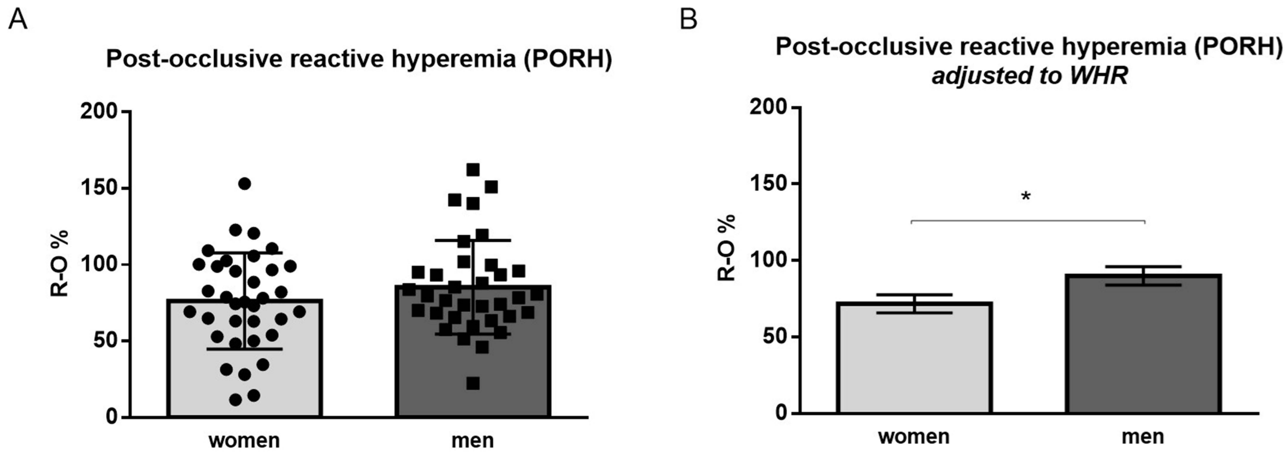

Figure 1 Post-occlusive reactive hyperemia (PORH) of the forearm skin microcirculation in older adults. PORH is expressed as the difference between the percentage change in flow during reperfusion and occlusion compared to the initial value (R-O% increase). Number of participants: women N=32, men N=30. (**A**) Statistical test: Student's *t*-test, PORH women 76.2 (31.5) vs PORH men 85.2 (30.6), P > 0.05. The results are expressed as the arithmetic mean and standard deviation (SD, error bars) with dots representing the values of individual measurements. (**B**) Statistical test: Analysis of covariance (ANCOVA) adjusted for waist-to-Hip ratio (WHR) PORH women 71.7 (5.9) vs men 89.9 (5.9), * P = 0.05. The results are expressed as the adjusted arithmetic mean and standard deviation (SD, error bars).

differed significantly between the sexes. Waist circumference was significantly smaller in women than in men, and the value of WHR was also significantly lower in women than in men (Table 1).

There was no significant difference in systolic, diastolic and mean arterial pressure values and heart rate between men and women (Table 1).

The results of post-occlusive reactive hyperemia (PORH) show that there was no statistically significant difference in microvascular reactivity of the forearm skin between women and men (Figure 1A). However, when the analysis was adjusted for waist circumference or WHR, PORH was significantly higher in older men than in women (P = 0.05) (Figure 1B). The daily macronutrient intake in the study population is shown in Table 2, while the daily micronutrient intake is shown in Table 3 along with the recommended daily allowance (RDA) values for each category for women and

Table 2 Daily Energy and Macronutrient Intake in Older Persons Assessed by EPIC-Norfolk Food Frequency Questionnaire (FFQ)

Variable	Groups				*P value*
	Women		Men		
N	35		34		
	FFQ	RDA	FFQ	RDA	
Energy (kcal)	1732 (545)	1628	1871 (395)	2017	*0.07*[b]
Energy (kJ)	7271 (2282)	6800	7859 (1662)	8400	*0.07*[b]
Total carbohydrates (g)	198 (56)		223 (61)		*0.08*[a]
Total carbohydrates (% E)	46.3 (5.3)	45–60% E	47.2 (4.9)	45–60% E	
Fiber (g)	13.2 (4.8)		12.5 (2.7)		*0.76*
Protein (g)	85 (35)		82 (11)		*0.57*[b]
Protein intake per body weight (g/kg)	1.25 (0.54)	0.66 g/kg	1.26 (0.55)	0.66 g/kg	
Total fat (g)	72 (28)		77 (17)		*0.09*[b]

(*Continued*)

Table 2 (Continued).

Variable	**Groups**				***P value***
	Women		**Men**		
N	**35**		**34**		
	FFQ	**RDA**	**FFQ**	**RDA**	
Total fat (%E)	37.2 (4.0)	20–35% E	37.2 (2.9)	20–35% E	
MUFA (g)	26 (11)		28 (7)		0.07[b]
PUFA (g)	13 (5)		13 (3)		0.62[b]
SFA (g)	26 (10)		28 (7)		0.09[b]
Cholesterol (mg)	369 (144)		388 (99)		0.18[b]
Alcohol (g)	0.17 (0.39)		1.48 (3.36)*		**0.03**[b]

Notes: Results are expressed as mean and standard deviation (SD). Statistical test: [a]Student's *t*-test or [b]mann–Whitney *U*-test, * P<0.05.
Abbreviations: FFQ, food frequency questionnaire; RDA, recommended dietary allowances; MUFA, monounsaturated fatty acids; PUFA, polyunsaturated fatty acids; SFA, saturated fatty acids.

Table 3 Daily Vitamins and Micronutrients Intake in Older Persons Assessed by EPIC-Norfolk Food Frequency Questionnaire (FFQ)

Variable	**Groups**				**P value**
	Women		**Men**		
N	**35**		**34**		
	FFQ	**RDA**	**FFQ**	**RDA**	
Microelements					
Copper (mg)	1.83 (1.57)	1.6	1.65 (0.94)	1.6	0.57[b]
Iron (mg)	9.97 (3.92)	6	9.82 (1.94)	6	0.33[a]
Iodine (µg)	147 (79)	150	147 (42)	150	0.2[b]
Magnesium (mg)	221 (69)	300	219 (32)	350	0.24[b]
Manganese (mg)	2.07 (0.62)	3	2.08 (0.49)	3	0.61[b]
Phosphorus (mg)	1221 (487)	550	1235 (218)	550	0.20[b]
Selenium (µg)	76 (37)	70	77 (16)	70	0.16[b]
Nitrogen (g)	14 (6)		13 (2)		0.53[b]
Zinc (mg)	9.05 (3.30)	6.20	8.66 (1.24)	7.5	0.93[b]
Electrolytes					
Potassium (mg)	2697 (877)	3500	2625 (375)	3500	0.74[b]
Sodium (mg)	2773 (1006)	2000	2763 (572)	2000	0.46[a]
Calcium (mg)	711 (288)	750	786 (258)	750	0.17[b]
Chlorides (mg)	4061 (1423)	3100	4044 (798)	3100	0.42[b]

(*Continued*)

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Table 3 (Continued).

Variable	Groups				P value
	Women		Men		
N	35		34		
	FFQ	RDA	FFQ	RDA	
Vitamins					
Total carotene (μg)	3917 (1732)		2968 (1173)*		0.009[b]
α-carotene (μg)	674 (332)		496 (298)		0.06[b]
β-carotene (μg)	3478 (1580)		2603 (1020)*		0.009[b]
Vitamin A - retinol (μg)	2295 (2844)		1925 (1880)		0.50[b]
Vitamin A - retinol equivalents (μg)	2960 (2922)	3000	2433 (1928)	3000	0.78[b]
Vitamin B1 – thiamine (mg)	1.27 (0.43)	0.072 mg/MJ	1.21 (0.20)	0.072 mg/MJ	0.63[b]
Vitamin B2 - riboflavin (mg)	1.70 (0.96)	1.3	1.65 (0.61)	1.3	0.63[b]
Vitamin B3 - niacin (mg)	23 (9)	10	21 (3)	10.00	0.83[b]
Vitamin B6 – pyridoxine (mg)	1.76 (0.66)	1.3	1.60 (0.20)	1.5	0.79[b]
Vitamin B12 - cobalamin (μg)	12 (12)	4	10 (6)	4	0.8[b]
Total folates (μg)	238 (105)	250	215 (41)	250	0.66[b]
Vitamin C (mg)	80 (41)	80	67 (27)	90	0.28[b]
Vitamin D (μg)	3.47 (2.61)	15	3.64 (1.35)	15	0.08[b]
Vitamin E (mg)	12 (5)	11	11 (3)	13	0.65[b]

Notes: Results are expressed as mean and standard deviation (SD). Statistical test: [a]Student's *t*-test or [b]mann–Whitney *U*-test, *P<0.05.
Abbreviations: FFQ, food frequency questionnaire; RDA, recommended dietary allowance.

men.[27] Men consumed significantly more alcohol than women (P = 0.03). Women also consumed a higher amount of carotene than men (P = 0.009); in particular, women consumed more β-carotene per day than men (P = 0.009). Intake of other nutrients was not significantly different.

Compared to the RDA values, energy, protein and fat intakes were above the recommended values for both women and men.[27] Regarding micronutrients, iron and phosphorus intakes were above the RDA for both sexes. Potassium intake was lower and sodium and chloride intakes were higher than the RDA for both sexes. Intake of vitamin B3-niacin and vitamin B12-cobalamin was higher and intake of vitamin D was lower than RDA in both sexes.

Table 4 shows the daily intake of the main food groups as divided in the EPIC-Norfolk dietary questionnaire. Men consumed significantly more cereals and cereal products, alcoholic beverages, and more nuts and seeds compared to women.

The daily intake of table salt and the molar ratio of sodium to potassium (Na/K ratio) are presented in Table 5. Although no significant differences were found for the presented variables (P ≥ 0.05), it is important to consider these data for a comprehensive understanding of dietary habits. Sodium chloride intake was similar between women and men. However, it is higher than the WHO recommended intake of 5 g/day. Potassium intake also was not significantly different between women and men but in both sexes, it was lower than WHO recommended intake of potassium (RDA potassium 3.5 g/day.[28] Finally, the Na/K ratio is similar between women and men. However, the molar Na/K ratio was 3 times higher than the recommended ratio of Na/K of ≤0.6 mg/mg.[29]

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Table 4 Food Group Intakes in Older Adults Assessed by EPIC-Norfolk Food Frequency Questionnaire (FFQ)

Variable	Groups		P value
	Women	Men	
N	35	34	
Cereals and cereal products (g)	248 (91)	296 (108)	0.05*
Eggs and egg dishes (g)	14 (11)	16 (11)	0.33
Fats and oils (g)	22 (12)	25 (14)	0.38
Fish and fish products (g)	65 (100)	47 (24)	0.64
Fruit (g)	171 (117)	158 (112)	0.72
Meat and meat products (g)	150 (68)	141 (41)	0.61
Milk and dairy products (g)	213 (183)	253 (193)	0.38
Soft drinks (g)	327 (156)	450 (271)	0.06
Nuts and seeds (g)	0.12 (0.49)	1.06 (2.48)	0.02[*,a]
Potatoes (g)	67 (34)	65 (35)	0.67
Soups and sauces (g)	190 (81)	161 (62)	0.39
Savory and sweet snacks (g)	25 (31)	29 (27)	0.15
Vegetables (g)	213 (118)	167 (68)	0.06
Alcoholic drinks (g)	2.34 (6.24)	15.3 (28)	0.03[*,a]

Notes: Results are expressed as mean and standard deviation (SD). Statistical test: [a]Student's *t*-test *P<0.05.

Table 5 Daily Salt Intake an Na/K Ratio in Older Adults Assessed by EPIC-Norfolk Food Frequency Questionnaire (FFQ)

Variable	Groups		P value
	Women	Men	
N	35	34	
Table salt (g)	6.93 (2.51)	6.91 (1.43)	0.46[a]
Sodium (mmol)	120.6 (43.8)	120.2 (24.9)	0.46[a]
Potassium (mmol)	69.0 (22.4)	67.1 (9.6)	0.74[b]
Molar Na/K ratio	1.76 (0.34)	1.80 (0.31)	0.68[a]

Notes: The results are expressed as the arithmetic mean and standard deviation (SD). Statistical test: [a]Student's *t*-test or [b]mann–Whitney *U*-test.

Table 6 presents correlations between PORH and blood pressure, anthropometric characteristics and daily salt intake, and alcohol consumption in women and men. There was no significant correlation between PORH and systolic, diastolic and mean BP, body weight, BMI, mean daily salt or alcohol intake. However, PORH significantly negatively correlated with waist circumference (R = −0.35, P = 0.04) and WHR (R = −0.406, P =0.02) in women. PORH did not significantly correlate with any of the aforementioned parameters in men. There was no correlation between systolic BP and salt

Table 6 Correlation Between Microvascular Reactivity and Hemodynamic, Anthropometric, and Nutritional Parameters in Older Adults

Variable	Women		Men	
	R	P	R	P
	PORH		PORH	
Systolic BP	−0.308[a]	0.09	−0.072[a]	0.71
Diastolic BP	−0.181[a]	0.32	−0.146[a]	0.44
Mean BP	−0.274[a]	0.13	−0.119[a]	0.53
Body weight	−0.308[a]	0.09	−0.253[a]	0.18
Body mass index	−0.235[a]	0.2	−0.348[a]	0.06
Waist circumference	−0.350[a]	0.04*	−0.318[a]	0.09
Waist-hip ratio	−0.406[a]	0.02*	−0.115[a]	0.55
Daily salt intake	0.184[b]	0.31	−0.031[a]	0.87
Daily alcohol intake	−0.277[b]	0.13	0.014[b]	0.94

Notes: Statistical test: [a]Pearson's or [b]Spearman correlation; *P<0.05.
Abbreviations: R, correlation coefficient; PORH, post-occlusive reactive hyperemia; BP, blood pressure.

intake in both women (R = −0.056, P = 0.751) and men (R = −0.112, P = 0.525). Also, systolic BP did not correlate with alcohol consumption in both women (R = 0.100, P = 0.565) and men (R = −0.064, P = 0.718). There was also no correlation between average daily calorie intake and microvascular reactivity in both women (R = 0.127, P = 0.487) and men (R = −0.158, P = 0.405).

Table 7 shows the categories of medications consumed by the subjects. The most commonly used medications were blood pressure-lowering medications (antihypertensives). Women have taken significantly more analgesics (the chi-

Table 7 Overview of Prescribed Types of Medications in Study Population

Type of Medication	Groups	
	Women	Men
	N (total 35)	N (total 34)
Analgesics	16 (46%)	6 (18%)*
Antacids	18 (51%)	7 (21%)
Anxiolytics and sedatives/hypnotics	20 (57%)	5 (15%)
Antipsychotics and antiepileptics	3 (9%)	2 (6%)
Antiarrhythmics and angina pectoris medications	18 (51%)	16 (47%)
Antibiotics	0	0
Antilipemics	6 (17%)	10 (29%)
Anticoagulants and thrombolytics	10 (29%)	10 (29%)
Antidepressants	6 (17%)	2 (6%)

(*Continued*)

Table 7 (Continued).

Type of Medication	Groups	
	Women	Men
	N (total 35)	N (total 34)
Antihypertensives	25 (71%)	23 (68%)
Antihistamines	6 (17%)	2 (6%)
Diuretics	9 (26%)	5 (15%)
Hormones and corticosteroids	3 (9%)	1 (3%)
Immunosuppressive and antitumor medications	2 (6%)	1 (3%)
Laxatives	3 (9%)	1 (3%)
Vitamins and iron	10 (29%)	6 (18%)
Gout medications	4 (11%)	4 (12%)
Asthma medications	2 (6%)	1 (3%)
Bone and cartilage supplements	1 (3%)	0
Antidiabetics	8 (23%)	6 (18%)
Parkinsonism and other neurological diseases medications	2 (6%)	0
COX enzyme inhibitors	19 (54%)	10 (29%)*
Prostate medications	0	9 (26%)
Medications against vertigo	2 (6%)	1 (3%)
Glaucoma medications	0	2 (6%)

Notes: The results are presented using absolute and relative frequencies. Statistical analysis: chi-square test, *P<0.05.
Abbreviation: N, number of subjects taking a certain type of medication.

square is 6.256, P = 0.012) and COX-inhibitors (the chi-square is 4.380, P = 0.036) than men. Other categories of medications were equally taken by both sexes.

Discussion

The present study aimed to examine the correlation between dietary habits, anthropometric values, and microvascular reactivity, taking into account sex differences, in older persons, residents of retirement homes. The salient findings of the present study are: a) among older adults residing in the retirement home, 57% of the female participants and as many as 70% of the male participants were either overweight or obese; b) alcohol intake was significantly higher in men compared to women. In both sexes, the intake of total energy, protein, fat, and sodium chloride exceeded the recommended dietary guidelines; c) both women and men had lower intake of potassium and vitamin D than recommended; and d) a significant negative correlation of WHR and waist circumference with PORH was observed in women, and microvascular PORH was significantly higher in men than in women when analysis was adjusted to WHR.

The results indicate that anthropometric values in both men and women exceeded the limits recommended by the World Health Organization (WHO) for optimal health.[30] In both sexes, the average BMI and waist-to-hip ratio (WHR) were above the WHO-recommended thresholds (BMI < 25.0 kg/m²; WHR < 0.85 for women and < 0.90 for men).[31] These findings suggest an increased accumulation of visceral fat, which contributes to central obesity and the development of atherosclerosis.[8] The observed prevalence of overweight and obesity in this population may be attributed to excessive caloric and protein intake, slightly elevated fat consumption, and a sedentary lifestyle associated with advanced age and residence in a retirement home.

Overweight / obesity is a well-known risk factor for cardiovascular and cardiometabolic diseases. To estimate these risks in the elderly, assessment of macrovascular indices, such as carotid-femoral pulse wave velocity (cf-PWV) has become widely used. For example, in metabolically healthy overweight or obese individuals, WHR shows a significantly positive correlation with the cf-PWV values in older women, but not in men.[32] Among common anthropometric indicators—BMI, waist circumference (WC), and waist-to-hip ratio (WHR) - WC and WHR are more strongly associated with microvascular function than BMI. This is because WC and WHR better reflect central (abdominal) obesity, which is more closely linked to endothelial dysfunction and microvascular impairment.[33] Several studies suggest that waist-to-height ratio (WHR) may be the most sensitive predictor of microvascular dysfunction, as it accounts for both central fat distribution and body size, offering a more accurate reflection of cardiometabolic risk.[34] WHR has been shown to correlate with microvascular alterations, such as reduced capillary density and impaired endothelial-dependent vasodilation. In contrast, BMI, while commonly used, does not distinguish between fat and lean mass and may underestimate risk in individuals with higher central adiposity. To our knowledge, the present study is the first of this kind to determine microvascular reactivity in older individuals. Results of the present study showed that although overweight/obese, women had lower body weight, waist circumference, and thus lower WHR compared to men. However, the forearm skin post-occlusive reactive hyperemia (PORH) (a measure of microvascular reactivity and blood flow) was similar in both older women and men, but when analysis was adjusted to WC or WHR men had significantly higher PORH than women. This can be explained by the loss of protective effects of estrogen, a female sex hormone that has long been established as protective to blood vessels in women of reproductive age.[35] One of our previous studies on young healthy individuals indicated that young women in their reproductive phase had significantly higher microvascular reactivity compared to young men.[25] Furthermore, the effect of estrogen has been demonstrated in the HUNT3: Fitness study which showed that women have a precipitous decline in brachial artery flow-induced dilation as they approach menopause (from age 45 onwards), which correlates with a progressive decline in circulating estrogen concentrations.[36,37] Therefore, potentially, lack of protective effects of estrogens in older women contributed to even lower microvascular reactivity in women than in men. The other important potentially contributing factor is that women have taken significantly more analgesics and cyclooxygenases (COX) inhibitors than men. It is well-accepted that COX metabolites contribute to physiological regulation of microvascular blood flow. For example, in a randomized controlled trial, attenuated PORH in young women on a high salt diet was restored to normal by non-selective COX inhibitor indomethacin, but not by COX-2 inhibitor celecoxib, suggesting that COX-1 derived vasoconstrictor metabolites have important role in the regulation of microvascular blood flow during high salt intake.[14]

The WHO recommends limiting daily salt intake to 5 g because salt is associated with increased mortality and morbidity in hypertension.[38–40] and chronic renal failure.[41] In addition, high salt intake is related to endothelial dysfunction.[41,42] In present study, the intake of salt was slightly above the recommended daily salt intake for both men and women. Potassium intake was lower than recommended values, and Na/K ratio was 3 times higher than recommended. However, there was no correlation of salt intake and BP values to microvascular reactivity (ie PORH), probably, because the majority of the participants have been taking antihypertensive medications. On the other hand, it is interesting that men consumed significantly more cereals and nuts and seeds, which are rich in polyunsaturated fatty acids (PUFAs), particularly n-3, which could preserve their microvascular reactivity. Increased intake of n-3 PUFAs is related to beneficial effects on microvascular reactivity in young men.[43] This has been implied, too, by the results of study on young-old individuals of both sexes (mean age: 65.7 ± 6.2 years), where the consumption of oily fish was protective of progression of white matter hyperintensities of presumed vascular origin.[44]

Men also drink more alcohol than women. This is in agreement with study on Hungarian elderly urban population by Rurik[6] which is similar to our studied population of north-eastern part of Croatia due to cross-border proximity. The reasons are multifactorial, including primarily various social factors and historical perceptions of alcohol. Alcohol itself is a known factor in hypertension and contributes to acute and chronic damage to blood vessels.[45] The most common alcoholic beverage consumed by Europeans (including Croatians) is beer, and the mean daily alcohol intake worldwide is 32.8 grams.[45,46] The older participants in present study did not consume even close to these worrying values (even in the male cohort), but they have been also more susceptible to the negative effects of alcohol due to their age and comorbidities.

Interestingly, women in present study consumed more vegetables overall; women had specifically a significantly higher intake of β-carotene compared to men. The carotenoid group of food has important health benefits because of it has antioxidant properties, protecting cells from inflammatory processes and carcinogenesis through its role as a precursor molecule for vitamin A. β-carotene has also been found to be protective of type 2 diabetes, dyslipidemia, and obesity.[47] β-carotene typically has the highest provitamin A activity and is found in vegetables such as carrots, broccoli, kale, peppers, spinach, and pumpkin.[47]

On the other hand, both women and men had very low estimated intake of vitamin D. Vitamin D has significant impacts on physiological processes that go beyond of its effects on bones and calcium/phosphorus homeostasis. For example, higher serum vitamin D levels have been associated with lower serum markers of oxidative stress in humans.[48] Oxidative stress is underlying endothelial dysfunction and contributes to vascular aging.[49] Lower levels of vitamin D have been associated with impaired vascular reactivity in type 2 diabetic patients.[50] Recent study demonstrated that older postmenopausal overweight women had a weak, significant negative correlation of vitamin D levels and oxidative stress.[51] Furthermore, in study on women and men aged 72.2 ± 7.8 years women had increased production of hydrogen peroxide (H_2O_2) and oxidized LDL (oxLDL) compared to men and although their nitric oxide (NO) production was increased, its bioavailability was reduced.[52] Taken all together, increasing vitamin D intake may be beneficial to vascular health of women particularly, but of men, too.

Study limitations: A potential limitation of this study is that only selected variables were measured (anthropometric data, blood pressure, heart rate, and dietary intake via FFQ), while potentially relevant covariates such as marital status, educational level, and socioeconomic status were not collected. The absence of these data may limit the ability to fully account for confounding factors that could influence the observed associations.

Conclusion

Dietary habits were similar between older men and women, except for higher alcohol intake in men and higher carotene intake in women. In older women, microvascular reactivity was negatively associated with waist circumference and waist-to-hip ratio, underscoring central obesity as a key cardiovascular risk factor in this population. Given the increased cardiometabolic vulnerability in postmenopausal women, measures of central adiposity should be routinely monitored in geriatric care.

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Disclosure

The authors report no conflicts of interest in this work.

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