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Dietary intake and adipose tissue level of specific fatty acids in a selected group from the Lower Silesia population

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Abstract

Purpose: The aim of the study was to assess the content of specific fatty acids in the diet and adipose tissue in a selected group of inhabitants of Lower Silesia in Poland.

Methods: The study group consisted of 95 inhabitants of Wroclaw and surrounding villages (22 men and 23 women from the urban area, 23 men and 27 women from the rural area). Fatty acid content in subcutaneous fat samples was assessed by gas-chromatography. Dietary assessment was carried out using food frequency questionnaire. Dietary intake was analyzed using computer programme The Food Processor SQL 10.5.2 produced by ESHA Research USA, with a Polish database.

Results: Mean daily energy and fatty acids intake was significantly higher among rural than urban inhabitants. Intake of alpha-linolenic acid (ALA), mainly from rapeseed oil, in urban inhabitants was 1.5 g/day in men and 1.6 g/day in women, and in rural inhabitants 2.6 g/day and 2.1 g/day, respectively. Dietary n-6 to n-3 ratio was higher among urban compared to rural inhabitants (6.7 vs. 5.5 among men and 6.4 vs. 5.5 among women, respectively). Content of ALA in adipose tissue was higher in rural women than in urban men (1.08% vs. 0.92% of total fat). Content of eicosapentaenoic acid (EPA) in adipose tissue in rural men (0.04% of total fat) and women (0.05% of total fat) was higher than in urban men (0.01% of total fat). The positive correlation (r=0.43) between the level of EPA in adipose tissue and percentage of energy from dietary EPA was observed among rural men. Overall, positive correlations were found between saturated (SFA) and polyunsaturated (PUFA) n-3 level in adipose tissue and percentage of energy from these fatty acids in a diet (r=0.20 and r=0.22, respectively).

Conclusions: Mean daily n-3 fatty acid intake in urban inhabitants was lower than the recommended daily consumption in Poland. The positive correlation between fatty acids level in adipose tissue and dietary fatty acid intake was observed only for EPA among rural men, and in the all-study population for SFA and PUFA n-3. A high n-6 to n-3 ratio in the study group was observed.

Key words

n-3 fatty acids, alpha-linolenic acid (ALA), EPA, DHA, adipose tissue, food frequency questionnaire (FFQ), Poland

INTRODUCTION

Cardiovascular mortality remains high in central and eastern European countries. In Poland, a significant decrease in mortality due to coronary heart disease has been observed since the 1990's. Between 1990 and 2002, cardiovascular mortality decreased by 38% in men and by 42% in women. In 1999, compared to 1990, saturated fatty acid intake decreased from 44.8 to 41.5 g/day, while consumption of polyunsaturated fatty acid increased from 14.8 to 23.3 g/day [1]. Zatonski et al. [2] found that after 1990 a significant decrease in butter intake in Poland was accompanied with considerable increase in consumption of vegetable fats, oils, and fresh fruits and vegetables. The authors suggested that the above-mentioned positive trend in the decline in cardiovascular mortality in Poland could be related to the enhanced consumption of vegetable fat, especially rapeseed oil [3] and soft margarines [1]. However, some eastern European countries, like Bulgaria, did not experience an improvement in cardiovascular mortality in the same time period. Interestingly, the most widely used oil in Bulgaria is sunflower oil [4]. Sunflower and rapeseed oils differ significantly in content of the alpha-linolenic acid (ALA), which belongs to the group of n-3 fatty acids and decreases the risk of cardiovascular disease [5, 6, 7]. The content of ALA in rapeseed oil is approximately 15 times higher than in olive oil [8] and 30 times higher than in

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sunflower oil [9]. Potential biological effects of ALA include inhibition of platelet aggregation, lowering of blood pressure, and improvement of lipid profile and anti-arrhythmic activity. These effects can be achieved with consumption of the group of long chain n-3 fatty acids, such as eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) [10, 11, 12]. N-3 fatty acids have also shown anti-inflammatory effects [13]. However, to ensure the beneficial effects of omega-3 fatty acids, the appropriate balance between n-6 and n-3 fatty acids must be kept [5, 14].

The aim of this study was to assess the content of certain fatty acids, especially ALA in diet and adipose tissue, in a selected group of the population of Lower Silesia in Poland.

METHODS

The study was conducted between 2008 and 2009. The study group consisted of 95 inhabitants of Wroclaw and surrounding villages. There were 22 men and 23 women from the urban area, and 23 men and 27 women from the rural area recruited. Anthropometric measurements included height, weight, waist and hip circumference. Additionally, serum total cholesterol, LDL-cholesterol (LDL-C), HDL-cholesterol (HDL-C), triglycerides (TG) and C-reactive-protein (CRP) were examined in all participants. Blood pressure was measured twice. Body mass index (BMI) and waist to hip ratio (WHR) were calculated. All participants were asked about smoking habits. Characteristics of the study group and results of measurements are presented in Table 1.

Table 1. Characteristics of the study group

Characteristic	Men		Women	
	Rural n=23	Urban n=22	Rural n=27	Urban n=23
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
Age (year)	50.9 (13.5)	53.0 (10.8)	56.6 (13.6)[a]	50.0 (9.0)[a]
BMI (kg/m^2)	30.9 (5.3)	29.7 (4.3)	29.8 (5.3)	27.5 (6.1)
Waist (cm)	108.1 (15.6)	101.5 (13.5)	96.7 (15.9)[a]	84.7 (10.9)[a]
WHR	1.01 (0.09)	0.97 (0.07)	0.90 (0.10)[a]	0.81 (0.08)[a]
SBP (mmHg)	149.6 (20.9)	146.6 (14.4)	139.9 (23.8)	140.4 (16.8)
DBP (mmHg)	87.3 (12.1)	88.1 (12.6)	81.1 (11.6)	84.6 (8.7)
Total Cholesterol (mg/dl)	199.7 (37.2)	197.5 (33.5)	192.0 (33.5)	203.5 (39.4)
Cholesterol HDL (mg/dl)	54.4 (18.0)	50.5 (10.9)	56.8 (15.4)[a]	69.2 (19.2)[a]
Cholesterol LDL (mg/dl)	101.4 (21.0)	116.2 (25.7)	101.4 (35.3)	114.2 (35.0)
Triglycerides (mg/dl)	224.3 (140.0)	153.4 (88.0)	174.7 (101.5)[a]	100.3 (44.6)[a]
CRP (mg/l)	6.3 (12.4)	2.2 (2.2)	2.5 (2.0)	3.0 (3.6)
Smoking (Yes/No)%	39.1/60.9[a]	4.5/95.5[a]	29.6/70.4	17.4/82.6
Have you ever smoked? (Yes/No)%	65.2/34.8	72.7/27.3	44.4/55.6	43.5/56.5
Smoking – No. of cigarettes	8.9 (12.7)[a]	0.9 (4.3)[a]	4.4 (7.4)	2.0 (5.2)

SD – standard deviation; BMI – body mass index; WHR – waist to hip ratio; SBP – systolic blood pressure; DBP – diastolic blood pressure; CRP – C-reactive protein; [a, b] – the same letters in a row means significant differences; p<0.05.

The methods used to assess and analyse fatty acid content in adipose tissue were based on those previously described by Petrova et al. [15]. Methods used for a subcutaneous adipose tissue biopsy were previously applied in a case-control study in Costa Rica [7, 16]. Adipose tissue samples were collected from the upper part of the buttock using a 16-gauge needle and disposable syringe. During the biopsy, local anaesthesia was not used. The area from which the samples of adipose tissue were collected was numbed with ice. Samples were stored at 4°C and transported to the laboratory where about 2 mg of adipose tissue were stored in -80°C with 1 ml mixture of hexane and isopropanol in Wheaton borosilicate glass vials with solid Teflon caps. Within 2 weeks, fat samples were transported over dry ice to the Harvard School of Public Health in Boston, where the content of fatty acids was analysed. The methyl esters of fatty acids were prepared as in a previously conducted study [15, 17]. For quantified methyl esters, gas chromatography was used. Identification of peak retention times and area percentages of total fatty acids was made by injecting known standards (NuCheck Prep, Elysium, MN), and analyzed with Agilent Technologies ChemStation A.08.03 software [15].

Dietary assessment was carried out using the food frequency questionnaire (FFQ), previously developed and validated for the Polish part of the PURE study [18]. FFQ consisted of 154 food items divided into the following parts: milk and dairy products, fruits, vegetables, meat and eggs, breads and cereals, mixed dishes, beverages and snacks. For each item, the average serving was described in measures used at home such as: 1 glass, 1 small plate, 1 tablespoon, 1 slice, etc. Participants were asked how often they had consumed each product during the past year, and the possible frequency answers included: never or less than once a month, 1-3 times a month, once a week, 2-4 times a week, 5-6 times a week, once a day, 2-3 times a day, 4-5 times a day and 6 or more times a day.

Analyses of dietary intake was conducted using computer programme The Food Processor SQL 10.5.2 produced by ESHA Research USA, with a Polish database [19].

STATISTICAL ANALYSIS

Statistical analysis was carried out with Statistica v. 9.1 PL software made by Statsoft Inc., USA. Mean and standard deviation (SD) were calculated to summarize results of the study. Continuous variables were compared using the nonparametric Mann-Whitney U test. Categorical variables were compared using the chi-square test. Pearson and Spearman correlations were applied to correlate adipose tissue (% total fat) and dietary fatty acids (% energy). For all analyses, the criterion for statistical significance was set at alpha=0.05.

ETHICS

The study was approved by the Ethics Committee of the Wroclaw Medical University.

RESULTS

Dietary intake assessed using FFQ was compared between rural and urban inhabitants. Results are presented in Tables 2 and 3. Mean daily energy intake was significantly higher among rural than urban inhabitants, both in men (3,102.2 vs. 2,102.1 kcal) and women (2,390.1 vs. 1,788.3 kcal). A significantly higher mean daily intake was observed of total fat, saturated fatty acids (SFA), monounsaturated fatty acids (MUFA) and polyunsaturated fatty acids (PUFA) among rural compared to urban inhabitants, both in men and women. Mean daily intake of oleic, linoleic, alpha-linolenic (ALA), eicosapentaenoic (EPA) and docosahexaenoic (DHA) acids were significantly higher among rural than urban inhabitants. Mean daily intake of protein and carbohydrates were also higher among rural than urban inhabitants (Tab. 2).

Table 2. Mean daily nutrient intake estimated as g per day

Nutrients (g/day)	Men		Women	
	Rural n=23	Urban n=22	Rural n=27	Urban n=23
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
Energy (kcal)	3102.2 (805.1)[a]	2102.1 (890.0)[a]	2390.1 (490.8)[b]	1788.3 (610.6)[b]
Protein	111.2 (31.9)[a]	82.1 (42.8)[a]	87.9 (15.9)[b]	71.2 (26.0)[b]
Carbo-hydrates	346.2 (98.7)[a]	264.3 (121.0)[a]	290.8 (68.0)[b]	233.1 (89.1)[b]
Total Fat	143.5 (38.2)[a]	80.4 (38.2)[a]	106.6 (25.6)[b]	72.6 (23.8)[b]
SFA	58.5 (19.1)[a]	32.3 (17.4)[a]	43.2 (13.9)[b]	30.0 (10.0)[b]
$C_{18:1n-9}$	51.1 (13.8)[a]	27.0 (12.8)[a]	37.2 (8.4)[b]	23.5 (8.3)[b]
MUFA	56.3 (15.2)[a]	29.6 (14.1)[a]	41.0 (9.4)[b]	25.8 (9.0)[b]
$C_{18:2n-6}$	15.8 (4.4)[a]	11.1 (5.6)[a]	12.5 (2.9)[b]	9.8 (3.4)[b]
PUFA n-6	16.2 (4.4)[a]	11.3 (5.7)[a]	12.7 (3.0)[b]	9.9 (3.5)[b]
$C_{18:3n-3}$	2.6 (0.6)[a]	1.5 (0.7)[a]	2.1 (0.5)[b]	1.6 (0.8)[b]
$C_{20:5n-3}$	0.08 (0.06)[a]	0.05 (0.03)[a]	0.06 (0.04)[b]	0.05 (0.06)[b]
$C_{22:6n-3}$	0.17 (0.10)[a]	0.10 (0.05)[a]	0.13 (0.07)[b]	0.09 (0.10)[b]
PUFA n-3	2.9 (0.7)[a]	1.7 (0.8)[a]	2.3 (0.5)[b]	1.7 (1.0)[b]
PUFA	19.1 (5.1)[a]	13.0 (6.4)[a]	15.1 (3.4)[b]	11.7 (4.2)[b]
n-6/n-3	5.5[a]	6.7[a]	5.5[b]	6.4[b]
Cholesterol (mg)	580.6 (173.2)[a]	302.2 (177.4)[a]	423.8 (126.5)[b]	263.1 (101.3)[b]
Fibre (g)	26.9 (10.3)	24.7 (11.2)	22.8 (6.9)	26.0 (11.7)

SD – standard deviation; SFA – saturated fatty acids; MUFA – monounsaturated fatty acids; PUFA – polyunsaturated fatty acids; $C_{18:1n-9}$ – oleic acid; $C_{18:2n-6}$ – linoleic acid; $C_{18:3n-3}$ – alpha-linolenic acid (ALA); $C_{20:5n-3}$ – eicosapentaenoic acid (EPA); $C_{22:6n-3}$ – docosahexaenoic acid (DHA); [a, b] – the same letters in a row means significant differences; p<0.05.

Significant differences between mean daily cholesterol intakes were also observed. Rural inhabitants, both men and women, consumed daily more cholesterol than those from urban area. The average values of dietary n-6 to n-3 ratio in the study group were significantly higher among urban than rural inhabitants, and averaged: 6.7 in urban men vs. 5.5 in rural men and 6.4 in urban women vs. 5.5 in rural women (Tab. 2).

Rural women, in comparison to urban women, had a significantly higher percentage of energy from total fat (40.0 vs. 36.8% of energy), MUFA (15.4 vs. 13.0% of energy) and oleic acid $C_{18:1n-9}$ (14.0 vs. 11.8% of energy). Significantly higher percentage of energy from total fat (41.9 vs. 34.6% of energy), SFA (17.0 vs. 13.8% of energy), MUFA (16.4 vs. 12.7% of energy), oleic acid $C_{18:1n-9}$ (14.9 vs. 11.6% of energy), ALA (0.8 vs. 0.6% of energy) and total n-3 fatty acids (0.9 vs. 0.7% of energy) was observed among rural compared to urban men. The percentage of energy from carbohydrates was higher among urban than rural men (45.8 vs. 41.3% of energy) (Tab. 3).

Table 3. Mean daily energy and nutrients intake estimated as percentage of energy in diets

Nutrient	Men		Women	
	Rural n=23	Urban n=22	Rural n=27	Urban n=23
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
Energy (kcal)	3102.2 (805.1)[a]	2102.1 (890.0)[a]	2390.1 (490.8)[b]	1788.3 (610.6)[b]
Protein (% of energy)	14.4 (1.8)	15.5 (3.1)	14.9 (2.2)	16.0 (2.1)
Carbohydrates (% of energy)	41.3 (5.9)[a]	45.8 (7.6)[a]	44.7 (4.8)	46.1 (4.5)
Total Fat (% of energy)	41.9 (4.8)[a]	34.6 (7.5)[a]	40.0 (4.0)[b]	36.8 (3.6)[b]
SFA (% of energy)	17.0 (3.5)[a]	13.8 (4.3)[a]	16.0 (2.9)	15.2 (2.5)
$C_{18:1n-9}$ (% of energy)	14.9 (1.7)[a]	11.6 (2.4)[a]	14.0 (1.5)[b]	11.8 (1.6)[b]
MUFA (% of energy)	16.4 (1.9)[a]	12.7 (2.7)[a]	15.4 (1.6)[b]	13.0 (1.8)[b]
$C_{18:2n-6}$ (% of energy)	4.7 (1.0)	4.8 (1.2)	4.8 (1.1)	5.0 (1.0)
PUFA n-6 (% of energy)	4.8 (1.0)	4.9 (1.2)	4.9 (1.1)	5.0 (1.0)
$C_{18:3n-3}$ (% of energy)	0.8 (0.1)[a]	0.6 (0.1)[a]	0.8 (0.1)	0.8 (0.2)
$C_{20:5n-3}$ (% of energy)	0.02 (0.01)	0.02 (0.01)	0.02 (0.02)	0.02 (0.02)
$C_{22:6n-3}$ (% of energy)	0.05 (0.02)	0.05 (0.02)	0.05 (0.03)	0.04 (0.04)
PUFA n-3 (% of energy)	0.9 (0.1)[a]	0.7 (0.1)[a]	0.9 (0.2)	0.8 (0.3)
PUFA (% of energy)	5.6 (1.1)	5.6 (1.3)	5.8 (1.2)	5.9 (1.1)
Cholesterol (mg/1,000kcal)	190.8 (45.6)[a]	143.5 (52.4)[a]	177.9 (41.7)[b]	147.3 (30.2)[b]
Fibre (g/1,000kcal)	8.6 (1.8)[a]	12.0 (3.1)[a]	9.7 (2.5)[b]	14.4 (4.1)[b]

SD – standard deviation; SFA – saturated fatty acids; MUFA – monounsaturated fatty acids; PUFA – polyunsaturated fatty acids; $C_{18:1n-9}$ – oleic acid; $C_{18:2n-6}$ – linoleic acid; $C_{18:3n-3}$ – alpha-linolenic acid (ALA); $C_{20:5n-3}$ – eicosapentaenoic acid (EPA); $C_{22:6n-3}$ – docosahexaenoic acid (DHA); [a, b] – the same letters in a row means significant differences; p<0.05.

Results of the composition of fatty acids in adipose tissue are presented in Table 4. Analysis showed that the content of ALA ($C_{18:3n-3}$) was significantly higher in rural women than in urban men (1.08 vs. 0.92% of total fat, p=0.0434). Content of EPA ($C_{20:5n-3}$) in rural men (0.04% of total fat) and women (0.05% of total fat) was higher than in urban men (0.01% of total fat) (p=0.0189 and p=0.0016, respectively). Overall content of the n-3 fatty acids in adipose tissue was significantly higher in rural women than in urban women (1.54 vs. 1.34% of total fat, p=0.0096) and urban men (1.54 vs. 1.31% of total fat, p=0.0182). The level of $C_{18:1}$ *trans* fatty acids in adipose tissue was significantly higher among urban men than rural women (1.83 vs. 1.44% of total fat, p=0.0277), while according to $C_{18:2}$ *trans* fatty acids, an adverse relationship

Table 4. Content of fatty acids in adipose tissue (% of total fatty acid methyl esters)

Fatty acids	Men		Women	
	Rural n=23	Urban n=22	Rural n=27	Urban n=23
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
Total SFA	24.96 (4.41)	23.62 (3.51)	23.13 (3.21)	23.40 (2.82)
$C_{18:1n-9}$	50.59 (4.30)	51.54 (2.73)	50.45 (2.72)	50.48 (2.58)
Total MUFA	58.15 (4.75)	58.91 (2.99)	58.59 (3.08)	59.33 (2.53)
$C_{18:2n-6}$	11.62 (2.71)	12.57 (1.87)	13.10 (2.91)	12.10 (1.28)
Total PUFA n-6	12.80 (2.50)	13.46 (1.89)	14.25 (2.90)	13.19 (1.20)
$C_{18:3n-3}$	0.89 (0.38)	0.92 (0.28)[a]	1.08 (0.28)[a]	0.93 (0.20)
$C_{20:5n-3}$	0.04 (0.05)[a]	0.01 (0.03)[a, b]	0.05 (0.05)[b]	0.03 (0.04)
$C_{22:6n-3}$	0.25 (0.23)	0.16 (0.11)	0.18 (0.09)	0.16 (0.10)
Total PUFA n-3	1.42 (0.41)	1.31 (0.34)[a]	1.54 (0.25)[a, b]	1.34 (0.27)[b]
Total PUFA	14.23 (2.74)	14.77 (2.06)	15.79 (3.05)	14.52 (1.38)
$C_{18:1}$ *trans*	1.57 (0.71)	1.83 (0.61)[a]	1.44 (0.55)[a]	1.69 (0.57)
$C_{18:2}$ *trans*	0.23 (0.06)[a, b]	0.30 (0.13)[a, c]	0.43 (1.03)[c]	0.31 (0.11)[b]

SD – standard deviation; SFA – saturated fatty acids; MUFA – monounsaturated fatty acids; PUFA – polyunsaturated fatty acids; $C_{18:1n-9}$ – oleic acid; $C_{18:2n-6}$ – linoleic acid; $C_{18:3n-3}$ – alpha-linolenic acid (ALA); $C_{20:5n-3}$ – eicosapentaenoic acid (EPA); $C_{22:6n-3}$ – docosahexaenoic acid (DHA); [a, b, c] – the same letters in a row means significant differences; p<0.05.

was observed (0.30 vs. 0.43% of total fat, p=0.0423). Content of $C_{18:2}$ *trans* fatty acids in adipose tissue was significantly lower among rural men than urban men (0.23 vs. 0.30% of total fat, p=0.0017) and urban women (0.23 vs. 0.31% of total fat, p=0.0043) (Tab. 4).

A positive Pearson correlation (r=0.43, p=0.043) between EPA concentration in adipose tissue and percentage of energy from dietary EPA was observed among rural men (Tab. 5). Overall, positive significant Spearman correlations were found between the SFA level in adipose tissue and the percentage of energy from SFA in a diet (r=0.20, p=0.0470), and between total PUFA n-3 level in adipose tissue and percentage of energy from these fatty acids in the diet (r=0.22, p=0.0288).

Table 5. Correlation coefficients (r) between adipose tissue (% total fat) and dietary fatty acids (% of energy)

Fatty acids	Men		Women	
	Rural n=23	Urban n=22	Rural n=27	Urban n=23
Total SFA	0.03	0.36	0.02	0.13
$C_{18:1n-9}$	-0.48*	0.27	-0.13	0.22
Total MUFA	-0.53*	-0.03	-0.02	0.13
$C_{18:2n-6}$	0.13	0.21	-0.17	0.25
Total PUFA n-6	0.08	0.19	-0.17	0.33
$C_{18:3n-3}$	0.19	0.18	-0.14	0.11
$C_{20:5n-3}$	0.43*	0.04	-0.03	0.32
$C_{22:6n-3}$	0.09	0.10	-0.12	0.04
Total PUFA n-3	-0.07	0.18	-0.22	0.30
Total PUFA	0.10	0.21	-0.18	0.40

* – p<0.05; SFA – saturated fatty acids; MUFA – monounsaturated fatty acids; PUFA – polyunsaturated fatty acids; $C_{18:1\ n-9}$ – oleic acid; $C_{18:2\ n-6}$ – linoleic acid; $C_{18:3n-3}$ – alpha-linolenic acid (ALA); $C_{20:5n-3}$ – eicosapentaenoic acid (EPA); $C_{22:6\ n-3}$ – docosahexaenoic acid (DHA).

DISCUSSION

Analysis of eating habits in the study group showed that diet was not balanced. An undesirable distribution of macronutrients was observed, which was mainly connected with excess saturated fat intake. Such nutritional habits may increase risk of cardiovascular disease, mainly because the high percentage of energy from SFA is the strongest influence on LDL cholesterol level [20]. Other nutritional undesirable outcomes, such as low percentage of energy from PUFA, high n-6 to n-3 fatty acid ratio, and high cholesterol intake, were also observed in this study. Furthermore, a high average BMI and WHR were observed in men and women, both in the rural and urban areas.

An adverse diet composition in the Polish population has been observed in other studies. Consumption of more than 30% of energy from total fat was observed in the WOBASZ Project [21], in the POL-MONICA BIS study conducted in Warsaw [22] and former Tarnobrzeg Voivodeship [23], and in the Wroclaw population aged 40-50 years [24, 25]. In Bulgarian men and women, the percentage of energy from fat was also high and amounted to 36% [15].

Data from the analysis are comparable with results of the European Prospective Investigation into Cancer and Nutrition (EPIC) study, where a high mean total fat intake, expressed as a contribution to the total energy intake, was found in the majority of EPIC centres [26].

Data showed a high SFA intake in men and women, in both the urban and rural areas. The percentage of energy from SFA assessed in previous Polish studies exceeded the recommended 10%. However, this was lower than in the presented study and averaged between 10.9% in women from the POL-MONICA BIS Tarnobrzeg Project [23] and 13.6% in men from the WOBASZ study [21]. The percentage of energy from SFA in the Wroclaw population amounted to 11.7% in women aged 40 years and 13.5% in men aged 50 years [24, 25]. SFA accounted for 13% of energy in the diets of Bulgarians [15]. The percentage of energy from SFA in the Costa Rican population was significantly higher in nonfatal myocardial infarction (MI) cases than in the control group, but in both groups exceeded 10% [27].

Apart from high SFA consumption, data also showed a very high mean cholesterol intake in both men and women, except for women in the urban area. Daily cholesterol intake among women from other Polish studies varied between 232 – 289 mg/day, while among men it averaged above 300 mg/day [21, 22, 23, 24, 25].

Data showed an insufficient consumption of n-3 fatty acids according to Polish recommendations [28] in urban inhabitants. Urban men consumed, on average, 1.5 g/day of ALA and urban women consumed 1.6 g/day of ALA, while the recommended amount is 2 g/day. Besides, the intake of EPA and DHA in both urban men and women was 1.5 times lower than that recommended in Poland. In the INTERMAP study [29], the highest percentage of energy from n-3 fatty acids was found in Japan (1.35%) and in other countries varied between 0.55% in China and 0.75% in USA. In the presented study, it averaged 0.7% in urban men and 0.9% in both rural men and women, while in British adults it amounted to 0.74% in men and 0.75% in women [30].

Mean ALA intake expressed as a contribution to total energy intake in the presented study varied between 0.6% in urban men and 0.8% in both rural men and women, while in the INTERMAP study it ranged from 0.54% in China to 0.81% in Japan [29]. The percentage of energy from ALA assessed in Costa Rica was 0.57% in the MI cases group, which was significantly lower than in the control group (0.59%) [27].

Polyunsaturated fatty acids cannot be synthesised in the human body. Besides, they play an important role in health, especially as n-3 fatty acids have a protective effect in cardiovascular diseases [31]. Therefore, markers of these biologically-active fats are of particular interest [32].

In previous studies, the composition of adipose tissue was found to be a good biomarker of dietary fatty acid intake [17]. The profile of adult body fat reflects the profile of dietary fats, and the content of fatty acids in adipose tissue is a biomarker of the dietary fat intake during the preceding 1-3 years [32, 33, 34, 35]. However, the presented study showed only a few good correlations between the level of fatty acids in adipose tissue and their content in the diet.

Petrova at al. [15] observed a positive correlation between adipose tissue DHA and fish availability (r=0.88) and between adipose tissue ALA and ALA availability (r=0.92). A relationship between diet and adipose tissue composition was confirmed in a Bulgarian population where, on the one hand, the lowest ALA and fish availability was observed (1.1% of total vegetable oil and 57 g/week, respectively), and on the other hand, the lowest ALA and DHA in adipose tissue (0.34% and 0.11%) was noticed.

The mean adipose tissue content of ALA in the presented study was 0.96%. This level was similar to those observed in countries such as Finland, USA and Israel, but lower than in Norway, where the highest ALA availability has been reported [15]. The content of ALA in adipose tissue was almost twice as high in this study than in Costa Rican population (0.55%) [17]. ALA content in adipose tissue was also higher than in American women (1.01% vs. 0.77% American women) [36]. ALA concentration in adipose tissue among the European population amounted from 0.41% in Spain (Málaga) to 1.27% in Norway (Sarpsborg), but in the myocardial infarction group it was lower and amounted to 0.38% and 1.25%, respectively [37]. However, the lowest content of ALA in adipose tissue (0.34%) was observed among the Bulgarian population, which may be the result of the consumption mainly of sunflower oil in this country [15].

Adipose tissue content of DHA in our study (0.19%) was similar to those assessed in Germany, UK, Spain and Israel [37]. In other European countries, the lowest content of DHA in adipose tissue was found in the Netherlands and Switzerland, while the highest in Norway and Finland [37]. The highest DHA content in adipose tissue and, at the same time, the highest fish availability in Norway, has also been described by Petrova et al. [15]. Low fish consumption resulted in a low DHA level in adipose tissue in Bulgaria (0.12% in men and 0.10% among women) [15]. EPA and DHA content in adipose tissue was similar between this study, Costa Rican and American studies [17, 36].

Content of SFA in adipose tissue in the study group was lower than that assessed in the Costa Rican population, while content of MUFA was higher [17]. Moreover, n-6 fatty acids content in adipose tissue in the study was lower than in Costa Rica, while n-3 was higher.

Subcutaneous adipose tissue was a good biomarker of fat intake, especially PUFA, n-3 and *trans* fatty acids among postmenopausal US women [36]. The positive correlation between intake of very long-chain n-3 fatty acids and its content in adipose tissue was also noticed by Pedersen et al. [38]. Moreover, long-chain n-3 fatty acids were associated with decreased risk of myocardial infarction, while for *trans* fatty acids, linoleic and alpha-linolenic acid, the opposite effect was observed.

The mean level of $C_{18:1}$ *trans* fatty acids in adipose tissue among the study group (1.62%) was higher than in Bulgaria [15] and Spain [39], while it was lower than in Costa Rica [17], Israel, the Netherlands, Norway, and the UK [39]. Content of $C_{18:1}$ *trans* fatty acids in adipose tissue assessed among women was also lower than among US women (1.55 vs. 2.86%) [36]. A similar content of $C_{18:1}$ *trans* fatty acids in adipose tissue compared with this study was assessed in the EURAMIC study in Finland, Germany, Russia and Switzerland [39]. The mean level of $C_{18:2}$ *trans* fatty acids in adipose tissue among the study group (0.32%) was similar to that assessed in Bulgaria [15], while it was more than 4-fold lower than in Costa Rican [17] and US women [36].

The content of fatty acids in adipose tissue was also analysed as a factor connected with cancer incidents. Maillard et al. [40] found an inverse correlation between risk of breast cancer and content of n-3 fatty acid in breast adipose tissue. This relationship was noticed for alpha-linolenic acid and DHA. The authors also observed that a proper balance between n-3 and n-6 fatty acid in adipose tissue may also have an influence on breast cancer. The potential role of n-3 fatty acids in reducing the risk of cancer has also been described by other authors [41, 42, 43].

One of the limitations of the presented study was the small size of the study population which represented only region of Poland; therefore, the results cannot be interpreted for the whole Polish population. Body weight changes are related to changes of content of adipose tissue fatty acids [34]. However, FFQ and anthropometric measurements were carried out only once, and the study design did not intend collecting data on changes in body mass and food intake of the participants.

According to the HEM Project report [4], the quality of diet in Poland improved after the period of transition, which was connected mainly with the globalization of the food market. Availability of vegetable oils (especially rapeseed and sunflower oils) and fish increased. However, results of the presented study could suggest that despite favourable dietary changes in Poland, the consumption of food products that are sources of polyunsaturated fatty acids, especially n-3 fatty acids, is still insufficient.

CONCLUSIONS

We observed an n-6 fatty acids to n-3 fatty acids ratio higher than 5:1, especially in the diets of urban inhabitants. The average content of alpha-linolenic acid and EPA+DHA in diets of urban inhabitants was below Polish Nutritional Guidelines. Increased consumption of fish rich in polyunsaturated fatty acids and oils rich in alpha-linolenic acid, e.g. rapeseed oil, would increase the intake of these compounds, especially among urban inhabitants, and decrease risk of CVD and other diseases in the study group. In the presented study, a positive correlation between the level of fatty acids in adipose tissue and dietary fatty acid intake was observed only for EPA among rural men, and in the all- study population for SFA and PUFA n-3. Therefore, further studies (especially with larger study groups) are necessary to explain the relationship between dietary intake and adipose tissue composition.

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