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Insights into diet, psychological distress, and personality traits among patients with lower-extremity lymphedema and overweight/obesity in comparison to patients with lifestyle-induced overweight/obesity and patients with normal body weight

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ABSTRACT

Obesity is a leading cause of cardiovascular diseases. There are significant and mutual associations between lymphatic dysfunction and obesity. This case-control study aimed to compare nutrient intake, depressive symptoms, and Eysenck's personality traits in patients with lower extremity lymphedema and overweight/obesity (n = 34) in comparison to patients with lifestyle-induced overweight/obesity (n = 30) and patients with normal body weight (n = 30). The study groups were evaluated using the Food Frequency Questionnaire (FFQ), Beck Depression Inventory-II, and Eysenck Personality Questionnaire-Revised (EPQ-R). Surprisingly, the study groups did not differ in any item in the FFQ, including total daily energy value and total intake of macronutrients, vitamins, or minerals. The group with lymphedema and overweight/obesity had higher scores on the depression scale, and the groups with lymphedema and overweight/obesity and lifestyle-induced overweight/obesity differed from the control group in Eysenck's psychoticism score; however, in all study groups, the scores of this trait were within the normal range. In conclusion, our study suggests that when FFQ is used, the problem of under-reporting of usual dietary intake among patients with lower extremity lymphedema and overweight/obesity, and lifestyle-induced overweight/obesity should be considered.

1. Introduction

Obesity is a leading cause of cardiovascular diseases, including arterial hypertension, atherosclerosis, stroke, heart failure, and arrhythmias, particularly atrial fibrillation and sudden cardiac death [1,2]. Obesity is an increasing public healthcare problem. According to the World Health Organization, in 2022, 43 % of adults aged 18 years and over were overweight, and 16 % were living with obesity. The worldwide prevalence of obesity more than doubled between 1990 and 2022 [3].

Obesity is caused by energy imbalance; however, it is not the result of a simple equation of subtracting energy expenditure during physical activity from energy intake in the diet. Obesity is a complex condition influenced by various factors, including genetics, diet, physical activity, hormonal and inflammatory status, and psychological and socioeconomic aspects [1,2]. The lymphatic system has recently been considered an essential regulator of metabolism and body mass. Although the lymphatic system's primary function is to maintain interstitial fluid homeostasis, the lymphatic vessels are also critical for lipids absorption from the intestine, play a role in adipogenesis, and, as part of the immune system, the lymphatic system also participate in inflammatory processes [4].

Lymphedema is a chronic condition characterized by the excessive accumulation of interstitial fluid due to the insufficiency of the lymphatic system. It most often affects the limbs, sometimes the genitals, but it can also affect other body parts. Primary lymphedema is an

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inherited or congenital condition, and secondary lymphedema results from insult, injury, or obstruction of the lymphatic system [5,6]. Cancer diseases and their treatment are the leading cause of lymphedema in Western countries.

The connection between obesity and lymphedema is significant and mutual [7]. Patients with lymphedema have a high tendency to be overweight/obese. The prevalence of overweight/obesity in individuals with lower limb lymphedema is approximately 75 % [8,9]. Lower physical activity and psychological factors, including mood deterioration, anxiety, and depression in patients with lymphedema, may play a role in weight problems. On the other hand, obesity may lead to obesity-induced lymphedema, and the risk of lymphedema increases with the patient's body mass index (BMI) [10,11]. Obesity negatively impacts lymphatic transport. However, the exact mechanisms by which obesity leads to lymphatic dysfunction are still being elucidated [6,10,12].

Weight loss interventions are an important part of lymphedema treatment [9,13,14]; however, although weight loss might improve lymphatic function, the possibility of achieving a complete reversal of developed lymphedema remains uncertain [10,12].

In order to develop interventions aimed at reducing body weight among patients with lymphedema, it may be important to assess their dietary habits and nutritional intake. The Food Frequency Questionnaire (FFQ) is a widely used tool in nutritional research to assess an individual's dietary habits. The FFQ, developed and validated for the population of the PURE study in Lower Silesia, is designed to collect information about the frequency with which specific foods or food groups are consumed over the last year. It provides quantitative data on dietary intake, allowing researchers to estimate the average daily nutrient intake. While FFQs are valuable tools, they do have limitations. They rely on the participant's memory and honesty, and the fixed response categories may not accurately capture variations in portion sizes [15].

The study aimed to compare nutrient intake assessment using FFQ, the occurrence of depressive symptoms, and the personality traits among patients with lower extremity lymphedema and overweight/obesity, patients with lifestyle-induced overweight/obesity without lymphedema, and individuals with normal body weight.

2. Material and methods

2.1. Study group population

We evaluated 94 patients. The studied group consisted of 34 patients with lower extremity lymphedema and overweight/obesity (BMI > 25 kg/m2 and diagnosis of lymphedema stated by an angiologist were the inclusion criteria). The second group consisted of 30 individuals with overweight or obesity (BMI > 25 kg/m2 and absence of lymphedema were inclusion criteria). In comparison, the control group consisted of 30 individuals with normal body weight (BMI < 25 kg/m2 and absence of lymphedema were inclusion criteria).

The exclusion criteria for all groups included lack of consent to the study, pregnancy or lactation, active cancer treatment, severe cardiovascular, renal, or hepatic disorders, taking medications that may affect body weight (e.g. glucocorticosteroids), and severe psychological disorders. The group with overweight/obesity and normal body weight were matched by age and gender to the lymphedema group. All study participants were the patients hospitalized at the Department of Internal Medicine.

Every participant's weight and height were measured. Body Mass Index (BMI) was calculated using the formula BMI = weight [kg] / height $[m]^2$. Completing the surveys was voluntary, and the participants provided written consent to participate in the study and process their personal data.

2.2. Nutrients intake assessment

Participants' dietary patterns were evaluated using the Food Frequency Questionnaire (FFQ). The FFQ inquired about the frequency of consuming various foods, offering ten response options: never, 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 > six times a day. This country- and culture-specific FFQ focused on the average consumption during the year before the survey. It covered 154 food items categorized into 27 food groups (milk and low-fat dairy, high-fat cheese and cream, fats without oils, fruits, vegetables, legumes, chips, potatoes, red meat, processed red/mixed meat, low-fat poultry, high-fat/processed poultry, fish, unrefined grains, refined grains, mixed dishes, soups, juices, beverages, alcohol, sweets, chocolate, sugar and honey, nuts, seeds and raisins, eggs, coffee and tea).

To assess the macro- and micronutrient intake, the food records were transferred to ESHA's Food Processor® Nutrition Analysis software 11.7.217 database 11.7.1 (ESHA Research, Salem, OR, USA), which contains the Nutrient Tables of Foods database [16].

To make comparisons, the values utilized for the distinguished groups in this study were presented as a percentage of the recommended standard for each parameter evaluated in the FFQ questionnaire [17].

2.3. Beck depression inventory-II (BDI-II)

Beck Depression Inventory-II allows for the assessment of an individual's mental, physical, and social well-being. It is one of the most commonly used tools for identifying depressive symptoms, serving as an auxiliary function - a diagnostic guideline aiding professionals in making reliable assessments. The test mentioned above is a self-assessment scale that respondents complete independently to recognize symptoms of depression in themselves. BDI consists of 21 questions addressing aspects such as current mood, outlook on life, motivation for daily activities, feelings of hopelessness, sleep disturbances, irritability, and attitudes toward the future. Responses must pertain to the past 30 days. Respondents provide one of four possible answers for each question. Subsequently, the points should be summed up and compared to established norms [18,19].

A score in the range of 0–11 indicates an absence of depressive symptoms, with such a score potentially linked to a transient decline in well-being. A score between 12 and 19 forms the basis for consultation with a psychiatrist or psychologist, indicating mild depression, often addressed through psychotherapy. Scores falling within the range of 20–25 suggest individuals may be dealing with moderate depression, necessitating consultation with a specialist and cognitive-behavioral therapy combined with antidepressant medication. Higher values (26−63) signal severe depression, requiring the expertise of a psychiatrist. Treatment involves prolonged, intensive therapy, often initially in the form of inpatient care [18,19].

2.4. Eysenck personality questionnaire-revised (EPQ-R)

Eysenck Personality Questionnaire-Revised (EPQ-R) allows for determining fundamental dimensions of personality, which constitute a set of characteristics enabling adaptation to the environment. The Polish adaptation of EPQ-R was prepared by the Laboratory of Psychological Tests of the Polish Psychological Association [20].

The EPQ-R questionnaire is a pencil-and-paper test consisting of a question sheet, an answer sheet, and four keys. Thanks to clearly formulated questions, patients can independently complete them. The questionnaire takes 20–25 minutes to complete. Respondents should be familiar with the test instructions. After completing the personal information section, patients answer the questions by choosing one of two responses: YES/NO.

The interpretation of results in EPQ-R is based on a clear scoring system. Each scale-extraversion (E), neuroticism (N), psychoticism (P),

and lie (L)-has its own answer key. Responses that align with the key are scored one point, while those that don't are scored zero. The point ranges are as follows: 1–4 – low score in a given scale; 5–6 – average score in a given scale; 7–10 – high score in a given scale [20–22].

The EPQ-R, according to its authors, serves a crucial role in diagnosing tendencies toward arterial hypertension, diabetes, coronary heart disease, or heart attack. The relationship between personality and susceptibility to somatic diseases has been established based on high scores in the E and N scales. Conversely, the occurrence of cancer is linked to high N scale scores and low E scale scores. EPQ-R also aids in assessing physical condition, as indicated by low N scale scores and average E scale scores. Additionally, good mental health is presumably characterized by low P-scale scores. It was also suggested that EPQ-R analysis may also be useful in presenting prognoses in learning, which are determined by extraversion and neuroticism [20–22].

2.5. Statistical analysis

Results are presented as mean values ± standard deviation and median (Q2) and quartiles Q1 and Q3. The Kolmogorov-Smirnov test was used in order to check whether each sample was drawn from a normally distributed population. As the distribution of all variables differs from the normal distribution, the Kruskal-Wallis test as a non-parametric variant of classic ANOVA was used followed by a post hoc testing with the Dunn's test and the Sidak adjustment formula [23]. A Chi-squared test was used to check the hypothesis that the groups and gender are two independent categorical variables. All of the calculations using Statistical Toolbox 8.0 with MATLAB 7.0 (R14) (https://www.mathworks.com) and in-house tested and validated algorithms were performed on a personal computer (Intel(R) Pentium(R) M, 1.60 GHz with 2 GB RAM) using the Microsoft Windows XP (service pack 2) operating system.

3. Results

3.1. Clinical characterization

The characterization of the study groups has been presented in Table 1. The groups significantly differed in weight and BMI.

3.2. Dietary intake assessment

The research groups did not differ significantly in any item in the FFQ questionnaire. The total daily energy value and total intake of macronutrients, such as proteins, fats, and carbohydrates, were similar across all three evaluated groups. Also, the consumption of vitamins and minerals did not differ among the distinguished groups. In each of the evaluated groups, a too-low intake of carbohydrates, protein, polyunsaturated fatty acids, vitamin D, folate, potassium, and calcium was noted, compared to Polish nutrient recommendations. The detailed diet composition in each group is presented in Table 2. Compliance with the Polish recommended levels of nutrients in the study groups is presented in Fig. 1.

3.3. Beck depression inventory (BDI) and eysenck personality questionnaire-revised (EPQ-R)

The study groups differed statistically significantly in scores of depression assessed using the BDI. The group with lymphedema had a significantly higher level of depression compared to the other research groups. The research groups differed statistically significantly in terms of psychoticism. The groups with lymphedema and with overweight/obesity had higher levels of psychoticism in comparison to the group with normal body weight. The results of the BDI and EPQ-R are presented in Table 3.

4. Discussion

Surprisingly, the study groups did not differ in any item in the FFQ, including total daily energy value and total intake of macronutrients, such as proteins, fats, and carbohydrates, and also of vitamins and minerals.

Our results are consistent with clinical experience - patients with lifestyle-induced obesity often answer questions about their diet that they "really eat not much". Recent studies objectively demonstrated the existence of obesity-related under-reporting of usual dietary intake by examining urinary nitrogen as a biomarker of total protein intake [24,25]. Patients with obesity may under-report their usual dietary intake consciously but also unconsciously (in the mechanism of self-deception) [26]. The problem of under-reporting is one of the most persistent causes of bias in nutrition studies [27]. The FFQ questionnaire is based on subjective assessments of the quality and quantity of consumed food products and, therefore, is susceptible to such a bias. On the other hand, there is still no other method to asses total nutrient intake in individual patients than the interview with them.

Besides diet, it can be presumed that in patients with lymphedema, other factors may lead to higher BMI, including a sedentary lifestyle or psychological problems [28]. In the advanced stage of lymphedema and at higher BMI, there is an unfavorable circle between higher body weight and lower physical activity. Lymphedema of the lower limbs may significantly impair physical ability, and mobility may even be impossible in the advanced stages of the disease [14]. Our study showed higher scores on the depression scale in patients with lymphedema. That is consistent with previous studies [28]. The association between

Table 1
Characteristics of study groups.

Parameter	Lymphedema with overweight/obesity n = 34 mean ± SD / Me (Q1, Q3)	Overweight/obesity n = 30 mean ± SD / Me (Q1, Q3)	Control group with normal body weight n = 30 mean ± SD / Me (Q1, Q3)	Kruskal- Wallis H/ Chi-Square test values	P-value
Age [years]	61.24 ± 10.98 63 (56, 68)	60.93 ± 10.85 62 (51, 69)	59.87 ± 14.56 61 (51, 68)	0.229*	0.892
Male [n; %]	9 (26.47 %)	7 (23.33 %)	7 (23.33 %)	0.112**	0.945
Weight [kg]	123.85 ± 38.48 118.50 (98.0, 150.0) #	91.93 ± 12.92 90 (84, 100)	62.80 ± 8.49 60 (58, 67)	63.379*	**< 0.001**
Hight [cm]	166.79 ± 10.60 165 (159, 172)	167.83 ± 7.90 165 (163, 172)	167.03 ± 8.26 165 (162, 170)	0.333*	0.846
BMI	44.40 ± 12.48 #ƒ 41.30 (36.40, 51.00)	32.67 ± 4.48 #ƒ 32.40 (28.90, 35.20)	22.43 ± 1.74 22.85 (21.20, 24.00)	70.162	**< 0.001**

- statistically significant difference versus control group in the multi-comparison Dunn-Sidak post-hoc testing; ƒ - statistically significant difference versus obesity group in the multi-comparison Dunn-Sidak post-hoc testing; statistically significant results are in bold

* Kruskal - Wallis test;

** Chi-Square test;

Table 2
Daily nutrient intake among participants of the study population based on Food Frequency Questionnaire (FFQ).

Parameter	Lymphedema with overweight/ obesity n = 34 mean ± SD / Me (Q1, Q3)	Overweight/obesity n = 30 mean ± SD / Me (Q1, Q3)	Control group with normal body weight n = 30 mean ± SD / Me (Q1, Q3)	Kruskal- Wallis H test value	P-value
Energy value [kcal]	1636.57 ± 652.64 1596.95 (1038.3, 2049.0)	1758.02 ± 486.11 1792.65 (1511.5, 1933.3)	1629.21 ± 599.26 1675.50 (1230.10, 2040.10)	1.906	0.386
Total protein [g]	66.09 ± 23.42 63.55 (45.30, 80.80)	71.00 ± 19.12 71.75 (61.20, 81.00)	65.99 ± 19.96 67.20 (59.20, 80.30)	1.541	0.463
Total carbohydrates [g]	205.87 ± 97.93 198.50 (124.80, 242.60)	207.77 ± 52.74 196.70 (171.00, 241.20)	205.26 ± 78.15 198.3 (156.5, 261.3)	0.175	0.916
Fiber [g]	25.38 ± 10.76 25.50 (17.00, 32.70)	24.50 ± 6.95 23.80 (18.50, 27.90)	23.36 ± 7.76 22.20 (18.00, 28.30)	0.454	0.797
Total fat [g]	69.84 ± 29.54 62.60 (49.0,0 80.70)	79.93 ± 30.99 75.60 (60.60, 100.20)	69.57 ± 32.18 71.15 (44.60, 85.50)	2.694	0.260
SFAs [g]	27.64 ± 14.44 24.55 (17.70, 32.70)	31.45 ± 12.55 28.75 (22.40, 42.80)	27.14 ± 15.94 25.60 (14.40, 35.10)	2.873	0.238
MUFA [g]	25.31 ± 10.46 21.55 (17.60, 29.80)	30.29 ± 14.09 27.95 (21.20, 37.70)	25.83 ± 11.35 27.25 (16.80, 32.10)	2.412	0.299
PUFA [g]	11.60 ± 5.24 10.75 (8.20, 13.30)	11.88 ± 4.34 11.75 (9.20, 14.60)	11.48 ± 5.24 10.30 (8.10, 14.60)	0.779	0.667
Cholesterol [mg]	284.52 ± 121.63 243.85 (210.20, 355.90)	340.73 ± 169.24 320,05 (229.10, 396.70)	270.99 ± 126.33 260.50 (164.90, 333.80)	3.820	0.148
Vitamin A [μg]	1840.73 ± 1512.99 1863.95 (353.80, 2901.40)	1782.06 ± 1346.93 1481.90 (556.70, 2906.60)	1767.67 ± 1578.58 1650.90 (362.30, 2896.80)	0.492	0.782
Vitamin D [μg]	2.38 ± 1.08 2.15 (1.70, 3.00)	2.65 ± 1.35 2.45 (1.60, 2.80)	2.06 ± 0.83 1.90 (1.60, 2.40)	3.253	0.197
Vitamin E [mg]	12.28 ± 5.28 11.10 (8.00, 15.90)	11.33 ± 3.37 10.85 (9.80, 13.60)	11.10 ± 4.45 10.75 (7.30, 13.10)	0.852	0.653
Vitamin B1 [mg]	1.16 ± 0.51 1.10 (0.80, 1.40)	1.32 ± 0.41 1.30 (1.10, 1.50)	1.23 ± 0.38 1.25 (0.90, 1.50)	2.883	0.237
Vitamin B2 [mg]	1.88 ± 0.82 1.65 (1.30, 2.40)	1.84 ± 0.55 1.80 (1.40, 2.20)	1.75 ± 0.72 1.65 (1.30, 2.20)	0.488	0.783
Vitamin B3 [mg]	19.77 ± 7.42 20.00 (14.10, 24.70)	19.55 ± 6.15 18.70 (14.80, 23.80)	20.61 ± 5.50 21.85 (18.00, 24.90)	1.389	0.500
Vitamin B6 [mg]	2.00 ± 0.67 2.10 (1.30, 2.50)	1.96 ± 0.44 2.00 (1.70, 2.30)	1.93 ± 0.49 1.90 (1.70, 2.30)	0.614	0.735
Folate [mg]	308.73 ± 131.61 311.35 (204.60, 413.30)	325.38 ± 86.09 314.75 (265.10, 380.30)	315.83 ± 94.28 322.90 (244.40, 384.40)	0.251	0.882
Vitamin B12 [mg]	5.97 ± 3.60 5.25 (2.50, 8.90)	5.82 ± 3.26 5.85 (2.80, 8.10	5.41 ± 3.49 5.40 (2.20, 7.20)	0.426	0.808
Vitamin C [mg]	180.30 ± 113.59 159.65 (99.90, 215.10)	150.27 ± 60.86 139.40 (106.60, 171.60)	160.46 ± 67.21 148.35 (119.20, 182.70)	0.541	0.763
Sodium [mg]	1670.32 ± 693.10 1609.35 (1133.1, 2182.40)	1723.85 ± 599.09 1735.30 (1251.00, 2072.10)	1647. 05 ± 777.64 1527.65 (1008,10, 2182,10)	0.422	0.810
Potassium [mg]	3813.75 ± 1324.35 3898.65 (2496.00, 4601.40)	3496.67 ± 759.32 3483.25 (3082.60, 3952.00)	3683.57 ± 1082.06 3592.80 (2806.00, 4522.40)	1.256	0.534
Calcium [mg]	720.10 ± 436.54 637.70 (352.80, 901.30)	654.19 ± 244.94 610.35 (472.10, 781.50)	637.48 ± 412.44 598.25 (346.00, 764.80)	1.328	0.515
Phosphorus [mg]	1225.65 ± 477.37 1207.90 (805.20, 1485.90)	1260.40 ± 300.90 1322.15 (1072.40, 1439.40)	1176.12 ± 398.18 1144.15 (921.20, 1379.50)	1.657	0.437
Magnesium [mg]	341.08 ± 130.85 345.65 (230.90, 418.10)	342.35 ± 83.66 348.90 (271.30, 412.10)	345.05 ± 106.23 352.55 (267.30, 424.50)	0.145	0.930
Iron [mg]	13.52 ± 4.68 13.35 (10.50, 16.70)	14.00 ± 3.47 14.05 (11.40, 16.20)	13.42 ± 3.92 14.05 (11.20, 15.70)	0.362	0.834
Zinc [mg]	9.54 ± 3.33 9.70 (6.30, 11.70)	10.33 ± 2.52 10.35 (8.60, 11.80)	9.31 ± 2.75 9.10 (7.90, 11.00)	2.426	0.297
Copper [mg]	1.50 ± 0.62 1.40 (1.00, 1.80)	1.42 ± 0.31 1.40 (1.30, 1.70)	1.47 ± 0.52 1.50 (1.10, 1.80)	0.056	0.973
Manganese [mg]	5.40 ± 2.27 5.30 (3.30, 7.10)	5.51 ± 2.14 4.70 (4.10, 6.90)	4.76 ± 2.14 4.35 (3.30, 6.70)	2.243	0.326

SFAs - saturated fatty acids; MUFA - monounsaturated fatty acids; PUFA - polyunsaturated fatty acids

depression and higher body mass index also has been well documented [29]. The group with lymphedema and lifestyle-induced obesity differed from the group with normal body weight in the psychoticism score in the Eysenck questionnaire. However, it should be noted that the levels in all study groups were within the normal range [20–22].

In conclusion, our study shows that questionnaire FFQ may have limitations when used among patients with lower extremity lymphedema and lifestyle-induced obesity. Therefore, it should be used with taking into account the problem with under-reporting of usual dietary intake in these groups of patients. Luckily, in establishing a reductional diet, nutrient intake assessment is not obligatory. To implement a hypocaloric diet, it is necessary to assess the basal metabolic rate using an appropriate equation for obese patients with obesity [30], evaluate the level of physical activity, and introduce the deficit of the total daily energy. It is also essential to assess the patient's conditions based on objective methods, including BMI and waist-to-hip measurement and body composition, and to consider the diagnoses of concomitant diseases, preferably based on the patient's medical documentation. Assessment of basic laboratory tests, such as blood count, thyroid-stimulating hormone (TSH), lipid profile, fasting glycemia, liver enzyme activity, creatinine, and vitamin D concentration in the blood, may indicate nutritional deficiencies and concomitant diseases leading

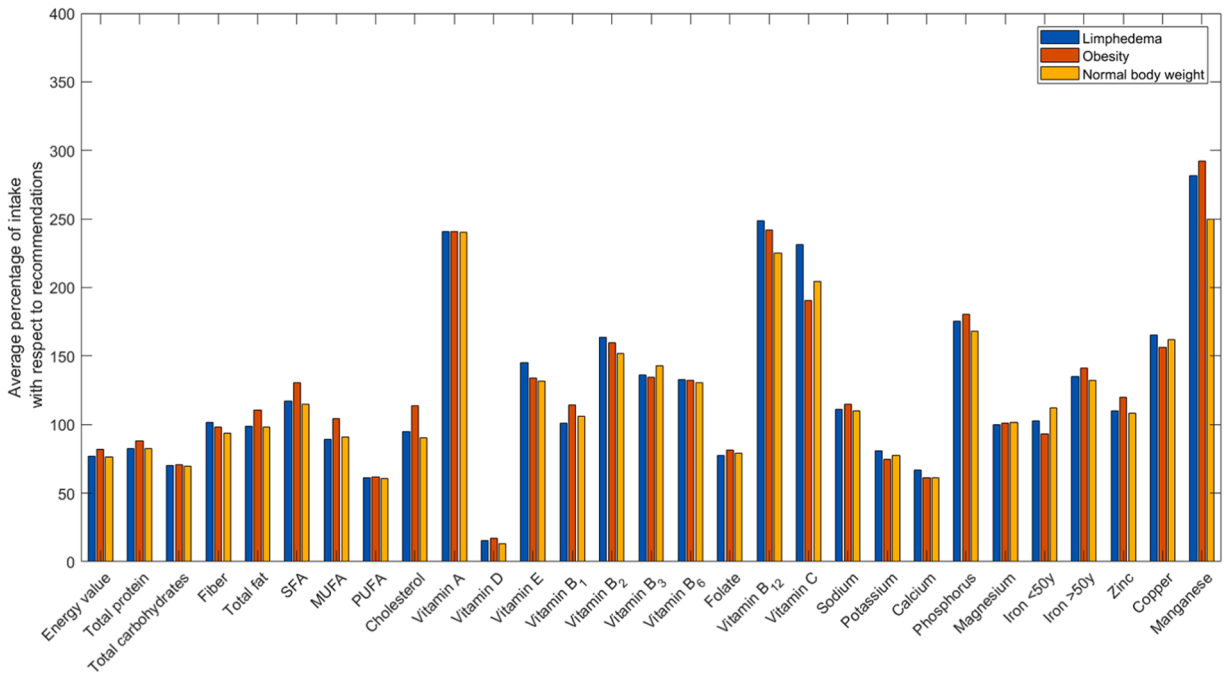

Fig. 1. Compliance of nutrients intake with Polish recommendations [%] in study groups.

Table 3
Psychological characteristics of the study groups. The scores in beck depression inventory (BDI) and eysenck personality questionnaire-revised (EPQ-R).

Parameter	Lymphedema with overweight/ obesity n = 34 mean ± SD / Me (Q1, Q3)	Obesity n = 30 mean ± SD / Me (Q1, Q3)	Control group with normal body weight n = 30 mean ± SD / Me (Q1, Q3)	Kruskal- Wallis H test value	P-value
BDI-II	13.65 ± 7.12	9.07 ± 7.05	9.43 ± 6.67	7.281	**0.026**
(Beck' scale)	13.50 (9.00, 18.00) ˆ	7.50 (4.00, 16.00)	7.50 (4.00, 16.00)		
Neuroticism (N)	6.38 ± 2.97	5.37 ± 3.26	6.33 ± 3.41	2.475	0.290
	6.50 (4.00, 8.00)	5.00 (3.00, 6.00)	6.00 (4.00, 9.00)		
Psychoticism (P)	3.20 ± 1.74	3.53 ± 2.36	2.30 ± 1.42	6.113	**0.047**
	3.00 (2.00, 4.00) #	3.00 (2.00, 6.00) #	2.00 (2.00, 3.00)		
Lie (L)	7.85 ± 2.72	6.77 ± 2.93	7.47 ± 2.71	2.856	0.240
	9.00 (6.00, 10.00)	7.50 (4.00, 9.00)	8.00 (6.00, 9.00)		
Extraversion (E)	7.26 ± 3.09	7.53 ± 3.33	7.73 ± 3.59	0.672	0.714
	8.00 (5.00, 9.00)	8.00 (6.00, 10.00)	8.50 (6.00, 11.00)		

ˆ - statistically significant difference versus obesity group in the multi-comparison Dunn-Sidak post-hoc testing; # - statistically significant difference versus control group in the multi-comparison Dunn-Sidak post-hoc testing; statistically significant results are in bold

to obesity or caused by excessive body weight.

Ethical statement

The study was conducted in accordance with the Declaration of Helsinki and approved by the Bioethics Committee at Wroclaw Medical University, Poland (KB - 456/2019).

Authors agreement

All authors have read and approved the final version of the manuscript being submitted. The manuscript is the authors' original work, has not been published and is not being considered for publication elsewhere, in whole or in part, in any language, except as an abstract.

CRediT authorship contribution statement

Jeziorek Małgorzata: Writing – original draft, Visualization, Investigation. **Stanimirova Ivana:** Visualization, Formal analysis. **Kania Gabriela:** Resources, Data curation. **Szuba Andrzej:** Supervision, Resources. **Konikowska Klaudia:** Methodology. **Chachaj Angelika:** Writing – original draft, Resources, Project administration, Methodology, Investigation, Conceptualization.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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