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Diet and selected elements of lifestyle in the Polish population before and during the COVID-19 pandemic – a population study

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Abstract

Introduction and Objective. The COVID-19 pandemic led to the introduction of sanitary restrictions in many countries which necessitated numerous lifestyle changes, especially in the diet. The study aimed to compare the diet and selected lifestyle elements in the Polish population during the COVID-19 pandemic.

Materials and method. The study group consisted of 964 individuals: 482 before the COVID-19 pandemic (composed using the Propensity Score Matching method) and 482 during the pandemic. The National Health Programme 2017–2020 results were used.

Results. During the pandemic increased, e.g. the intake of: total lipids (78.4 g vs. 83 g; p<0.035), saturated fatty acids (SFA) (30.4 g vs. 32.3 g; p=0.01), sucrose (56.5 g vs. 64.6 g; p=0.0001), calcium (602.5 mg vs. 666.6 mg; p=0.004), and folate (261.6 mcg vs. 284.7 mcg; p=0.003). When nutrient densities of pre-Covid-19 and COVID-19 diets were compared, some differences were noted; per 1,000 kcal the amounts decreased of plant protein (13.7 g vs. 13.1 g; p=0.001), carbohydrates (130.8 g vs. 128.0 g; p=0.021), fibre (9.1 g vs. 8.4 g; p=0.000), sodium (1,968.6 mg vs. 1,824.2 mg; p=0.000); while the amounts increased of total lipids (35.9 g vs. 37.0 g; p=0.001), SFA (14.1 g vs. 14.7 g; p=0.003), and sucrose (26.4 g vs. 28.4 g; p=0.001). The COVID-19 pandemic had no effect on alcohol consumption, the number of smokers increased (from 131 to 169), sleep duration during weekdays, and the number of persons with low physical activity (182 vs. 245; p<0.001).

Conclusions. Numerous unfavourable changes occurred in the diet and lifestyle during the COVID-19 pandemic, which may contribute to the exacerbation of health problems in the future. Nutrient density in the diet combined with well-designed consumer education may underlie the development of diet recommendations.

Key words

smoking, physical activity, nutrition, alcohol consumption, COVID-19

Abbreviations

BMI – Body Mass Index; **CAPI** – Computer Assisted Personal Interviews method; **CATI** – Computer Assisted Telephone Interviews method; **COVID-19** – group, respondents during COVID-19 pandemic; **DIETA 6.0** – 6.0 Diet Programme for Planning and Ongoing Evaluation of Individual and Collective Nutrition in Methodical Guide of Dietary Research; **GDP** – Gross Domestic Product; **KomPAN** – Dietary Habits and Nutrition Beliefs Questionnaire; **n-3 FA** – n-3 fatty acids; **NHP** – National Health Programme; **pre-Covid-19 group** – respondents before COVID-19 pandemic; **SFA** – saturated fatty acid

INTRODUCTION

The implementation and observance of the principles of healthy nutrition, physical activity, refraining from tobacco smoking and alcohol consumption appear to be difficult for the majority of people worldwide, even under the conditions of relative stability in life [1]. Inappropriate lifestyle, including dietary habits, the use of stimulants, physical activity and sleep hygiene, is manifested by the high incidence of numerous chronic non-communicable diseases, i.e. cardiovascular diseases, type 2 diabetes, obesity, some neoplastic diseases, leading to premature disability and death [2, 3, 4].

The COVID-19 pandemic which the world has faced since 2020 led to the introduction of sanitary restrictions in many countries which necessitated numerous lifestyle changes. In Poland, nationwide restrictions included staying at home, unless seeking medical care, providing care, purchasing food, attending work in an essential service, undertaking physical activity. All schools and universities transitioned to online home-based learning [5, 6].

Adherence to a well-balanced diet providing all necessary nutrients and the observance of other recommendations concerning healthy lifestyle have become essential from the viewpoint of health support and normal functioning of the immune system in the pandemic context. Immune function is related to numerous dietary components with the particular importance of vitamins D, C, A (including beta carotene), E, B6, B12, folic acid, zinc, copper, selenium, iron, amino acids, and n-3 and n-6 polyunsaturated fatty

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acids in various protective processes [2, 7]. Caring for a good nutritional status, including normal body weight, is a reasonable approach to the prophylaxis of SARS-CoV-2 infection and alleviation of its course.

Research showed that not everybody adapted to the new conditions to the same degree. As regards Poland, a particularly unfavourable effect of the COVID-19 pandemic was observed in the dietary habits of adults over the age of 40, persons living with children, persons living in regions with higher GDP (Gross Domestic Product), and those who had not eaten at home prior to the pandemic [8]. Adhering to dietary recommendations was also affected by psychological factors. The highest adherence to the principles of suitable nutrition was observed in case of individuals characterized by the ability to cope with difficult situations and quick adaptation to new, changing circumstances [9].

Numerous studies published recently have characterized lifestyle, including dietary habits, during the COVID-19 pandemic [3, 10, 11]. The methodology of the majority of the studies was based on qualitative methods of the dietary habit assessment determining the frequency of consuming individual groups of products, and the direction of changes in their consumption during the pandemic (more frequently, less frequently, no changes). However, available literature does not include research assessing the energy and nutritional value of the diet prior to and during the pandemic in the same population with the use of recommended/standardized quantitative methods of dietary habit assessment.

The study aimed to compare the dietary habits and selected elements of lifestyle in the Polish population and to demonstrate whether the nutritional value of their diets changed during the COVID-19 pandemic. Moreover, an attempt was made to determine the direction of such changes based on the characteristics of nutrient densities in pre-COVID-19 and COVID-19 diets. Changes concerning selected elements of the lifestyles of Polish adults before and during the COVID-19 pandemic were additionally analyzed.

MATERIALS AND METHOD

Study design ang participants. The study used data from the National Health Programme (NHP) 2017–2020 conducted by the Faculty of Health Sciences of the Medical University of Warsaw, and financed by the Ministry of Health. The NHP study included 2 representative groups of Polish inhabitants, totalling 4,000 participants (2,000 individuals aged 18–65 years and 200 individuals aged 65 and older). The design and methods of the study are presented in detail in a separate paper (12).

Analyses. The analyses conducted throughout this study were based on data obtained from the respondents during the COVID-19 pandemic (June-August 2020) – COVID-19 group. The group of respondents from the period preceding the COVID-19 pandemic (June-August 2019) – pre-COVID-19 group – was selected with the use of the PSM (Propensity Score Matching) method. PSM is a statistical matching technique that attempts to estimate the effect by accounting for the covariates. The following variables were used as covariates in matching cases in pre-COVID-19 group: gender, age, level of education, marital status, financial situation and Body Mass Index (BMI). The study included respondents aged 19 – 75. The upper age limit was assumed due to the possible limitations of the elderly regarding contact via telephone (no mobile phone number, difficulty concentrating). Each group included 482 individuals aged 19–75.

Data collection. Prior to the pandemic, all data had been collected at the respondents' homes with the Computer Assisted Personal Interviews (CAPI) method. Anthropometric measurements were performed by a trained interviewer. During the pandemic, however, it was impossible for the interviewers to contact the respondents directly. The CAPI method was changed to the method of Computer Assisted Telephone Interviews (CATI). Anthropometric data (height, weight) were obtained on the basis of self-measurements by the respondents, based on detailed instructions received during the first interview [12].

Instruments – assessment of dietary habits and elements of lifestyle. The method of dietary habit assessment was based on the guidelines of the European Food Safety Authority in relation to the EU Menu project [13, 14], and on the recommendations of the Committee of Human Nutrition Science of the Polish Academy of Sciences [15, 16]. The interview concerning food consumption over the past 24 hours was conducted twice at an interval of at least 5 days in order to account for the variability of eating habits within the week. Interviews were administered on different days of the week. The interviewers used the CAPI technique supported by DIETA 6.0, an application developed at the National Food and Nutrition Institute in Warsaw and used for research purposes in Poland [17].

Data concerning selected elements of lifestyle (level of physical activity, tobacco smoking, alcohol consumption and sleep duration) were collected with the use of questions from the Dietary Habits and Nutrition Beliefs Questionnaire (KomPAN) questionnaire developed by the experts of the Committee of Human Nutrition Science of the Polish Academy of Sciences [18].

Body weight and height measurements. Prior to the pandemic, the body weight and height of the respondents had been measured according to generally accepted principles. During the pandemic, the data concerning body weight and height were recorded as declared by the respondents. The above-mentioned data were used to calculate body mass index (BMI, kg/m²) [13].

Ethical considerations. The survey was approved by the Medical University of Warsaw Bioethical Board (AKBE/163/17 and AKBE/164/17), and carried out in accordance with the requirements of the Personal Data Protection Act [19].

Data analysis. The nutritional value of the diet was presented as the absolute nutrient content and as nutrient density. Nutrient density was determined using the average of the daily intake of nutrients per 1,000 kcal intake.

Descriptive statistics were used to characterize the study sample. The mean (M) and standard deviation (SD) were calculated for interval variables. The number (n) and frequency (%) were calculated for categorical and ordinal variables.

Depending on the type of variable used for testing null hypotheses concerning the lack of differences between the compared groups (pre-COVID-19 vs. COVID-19), the following tests were used: Pearson's chi-squared test (categorical variables), Wilcoxon-Mann-Whitney test (ordinal variables) and Student's t-test (interval variables). The mean difference (MD) and 95% confidence interval were calculated. The mean difference measures the absolute difference between the mean values in two different groups. Two-sided P<0.05 was considered statistically significant for all null hypotheses tested.

All statistical calculations were performed using the STATISTICA software version 13.3 (TIBCO Software, Palo Alto, CA, USA).

RESULTS

Study participant characteristics. The study included the total of 964 individuals: 482 in the period before the COVID-19 pandemic (June-August 2019) and 482 during the COVID-19 pandemic (June-August 2020). PSM-matched groups were comparable as regards the gender, level of education, marital status, financial situation (Tab. 1), average age, and the mean value of BMI (Tab. 2).

Table 1. Study group characteristics

Variable	pre-COVID-19 (n = 428)		COVID-19 (n = 428)		Chi²	p-value[1]
	n	%	n	%		
Gender						
Males	253	52.49	253	52.49	0.000	1.000
Females	229	47.51	229	47.51		
Education						
primary/junior high school	32	6.64	28	5.81	0.383	0.944
vocational	183	37.97	188	39.00		
secondary	184	38.17	181	37.55		
tertiary	83	17.22	85	17.63		
Marital status						
single (never married) women	76	15.77	82	17.01	3.232	0.357
married/a cohabitation relationship	336	69.71	312	64.73		
divorced/separated	22	4.56	26	5.39		
widow	48	9.96	62	12.86		
Financial situation						
good	438	90.87	443	91.91	0.330	0.566
poor	44	9.13	39	8.09		

[1] Pearson's chi-squared test

Table 2. Age and BMI characteristics of the study group

Variable	pre-COVID-19		COVID-19		t	p-value[3]
	M[1]	SD[2]	M	SD		
Age (years)	53.79	15.69	53.91	17.59	-0.106	0.915
BMI (kg/m²)	27.32	4.79	27.01	4.21	1.059	0.290

BMI, body mass index
[1] mean
[2] SD standard deviation
[3] Student's t-test

During the COVID-19 pandemic, the mean energy value of the diet was higher. The intake of the following macronutrients was also higher: total protein, plant and animal protein, total lipids, saturated fatty acids (SFA) and n-3 fatty acids (n-3 FA), total carbohydrates, absorbable carbohydrates and sucrose (Tab. 3). However, a statistically significant difference was only observed regarding mean total lipid consumption (78.4 g vs. 83 g, p=0.035), saturated fatty acids (30.4g vs. 32.3g; p=0.01) and n-3 acids (1.96g vs. 2.24g; p=0.0001). A significant increase was noted regarding the mean percentage share of total lipids in the energy value of the diet (32.1% to 33.1%; p=0.014). The increased mean consumption of saturated fatty acids was accompanied by a significant increase in mean cholesterol consumption, i.e. 332.3g – 356.4g (p=0.039). A significant increase in mean sucrose consumption was also noted during the pandemic. Its dietary content rose from 56.5g – 64.6g (p=0.0001).

Table 3. Supply of energy and selected macronutrients in pre-Covid-19 and COVID-19 diets

Variable	pre-COVID-19		COVID-19		t	p-value[3]
	M[1]	SD[2]	M	SD		
Energy (kcal/d)	2138.32	818.33	2233.09	674.35	-1.957	0.051
Total protein (g)	81.19	33.49	82.64	24.46	-0.765	0.444
animal protein (g)	51.27	25.08	52.44	19.07	-0.812	0.417
plant protein (g)	28.95	11.67	29.06	10.32	-0.159	0.874
Total lipids (g)	78.38	38.31	83.12	30.64	-2.117	0.035
saturated fatty acids (g)	30.45	15.02	32.82	13.43	-2.583	0.010
n-3 fatty acids (g)	1.96	1.34	2.24	1.29	-3.309	0.001
cholesterol (mg)	332.29	182.17	356.39	177.98	-2.071	0.039
Total carbohydrates (g)	275.30	98.82	284.35	91.53	-1.470	0.142
absorbable carbohydrates (g)	257.01	94.28	266.18	88.35	-1.554	0.121
sucrose (g)	56.62	32.37	64.57	42.09	-3.274	0.001
dietary fibre (g)	18.29	6.78	18.06	6.27	0.536	0.592
Total protein energy (%)	15.38	3.06	15.13	2.99	1.274	0.203
Total lipid energy (%)	32.08	6.62	33.11	6.35	-2.453	0.014
Energy from absorbable carbohydrates (%)	48.95	7.07	48.13	6.90	1.801	0.072

[1] mean
[2] SD standard deviation
[3] Student's t-test

When the nutrient densities (amounts of nutrients per 1,000 kilocalories of energy intake) of pre-Covid-19 and COVID-19 diets were compared, some additional significant differences were noted (Tab. 4). A significantly lower mean consumption of the following components was noted during the pandemic: plant protein (13.13g/1,000 kcal vs. 13.73g/1,000 kcal; p=0.001), total carbohydrates (128.04g/1,000 kcal vs. 130.76g/1,000 kcal; p=0.021) and dietary fibre (8.4g/1,000 kcal vs. 9.08g/1,000 kcal; p=0.000). Significantly higher mean consumption was observed during the pandemic regarding total lipids (37.04g/1,000 kcal vs. 35.89g/1,000 kcal; p=0.001), SFA (14.66g/1000 kcal vs. 14.11g/1,000 kcal; p=0.003), n-3 FA (1.01g/1,000 kcal vs. 0.9g/1,000 kcal; p=0.001) and sucrose (28.4g/1,000 kcal vs. 26.36g/1,000 kcal; p=0.001).

Analysis of the nutritional value of the diet during the COVID-19 pandemic revealed an increase in the mean supply of all studied minerals (Tab. 5), with the exception of sodium, and with statistically significant changes observed only for

Table 4. Nutrient densities of pre-COVID-19 and COVID-19 diets – selected macronutrients

Variable	pre-COVID-19		COVID-19		MD[3]	95%CI		t	p-value[4]
	M[1]	SD[2]	M	SD		Lower limit	Upper limit		
Total protein (g/1,000 kcal)	38.30	7.62	37.69	7.43	-0.61	-1.56	0.34	1.26	0.210
animal protein (g/1,000 kcal)	24.14	7.90	24.05	7.45	-0.09	-1.06	0.89	0.12	0.860
plant protein (g/1,000 kcal)	13.73	2.82	13.13	2.83	-0.60	-0.96	-0.24	3.3	0.001
Total lipids (g/1,000 kcal)	35.89	7.33	37.04	7.06	1.15	0.23	2.06	-2.47	0.014
saturated fatty acids (g/1,000 kcal)	14.11	3.83	14.66	4.00	0.55	0.06	1.05	-2.20	0.028
n-3 fatty acids (g/1,000 kcal)	0.90	0.47	1.01	0.52	0.11	0.05	0.17	-3.45	0.001
cholesterol (g/1,000 kcal)	156.53	70.39	162.89	74.14	6.36	-2.81	15.52	-1.36	0.174
Total carbohydrates (g/1,000 kcal)	130.76	18.65	128.04	17.82	-2.71	-5.03	-0.40	2.30	0.021
absorbable carbohydrates (g/1,000 kcal)	124.68	17.69	119.59	17.24	-2.08	-4.30	0.13	1.85	0.065
sucrose (g/1,000 kcal)	26.36	11.60	28.40	13.96	2.04	0.41	3.67	-2.46	0.014
dietary fibre (g/1,000 kcal)	9.08	3.15	8.40	2.83	-0.68	-1.06	-0.30	3.50	0.000

[1] mean
[2] SD standard deviation
[3] MD – mean difference
[4] Student's t-test

calcium and magnesium: 600.5 mg vs. 666.6 mg; p=0.004 and 297.6 mg vs. 3 12.6 mg; p=0.017, respectively.

Table 5. The supply of minerals in the habitual diets of study participants

Variable	pre-COVID-19		COVID-19		t	p-value3
	M[1]	SD[2]	M	SD		
Sodium (mg) (in raw and ready-made products)	4067.68	1594.85	4001.09	1376.88	0.692	0.489
Potassium (mg)	3133.23	1032.62	3251.94	931.31	-1.869	0.062
Calcium (mg)	602.52	342.58	666.57	349.18	-2.865	0.004
Magnesium (mg)	297.60	100.85	312.57	93.36	-2.385	0.017
Iron (mg)	12.07	6.34	12.63	6.74	-1.321	0.187
Zinc (mg)	9.89	4.02	10.15	3.56	-1.046	0.296

[1] mean
[2] SD standard deviation
[3] Student's t-test

Analysis of the obtained data calculated by 1,000 kcal showed that the COVID-19 pandemic contributed to an increase in the mean calcium and iron content per 1,000 kcal of the diet, and a decrease in the mean supply of the remaining minerals. However, the only statistically significant change was observed regarding the supply of sodium. Its mean amount calculated per 1,000 kcal of the diet diminished from 1,986.6 mg to 1,824.2 mg (p=0.000) (Tab. 6).

An increase in the mean dietary content of all analyzed vitamins was noted during the COVID-19 pandemic (Tab. 7). A statistically significant change was observed in the case of vitamin E (10.0 mg vs. 10.9 mg; p=0.005), riboflavin (1.57 mg vs. 1.77 mg; p=0.002), niacin (20.3 vs. 22.0; p=0.016), vitamin C (88.6 vs. 107.9; p=0.000) and folate (261.6 vs. 284.7; p=0.003).

Table 7. Supply of vitamins in the habitual diet of the respondents

Variable	pre-COVID-19		COVID-19		t	p-value[3]
	M[1]	SD[2]	M	SD		
Vitamin A (μg)	1179.39	1371.11	1376.78	2145.31	-1.695	0.090
Vitamin E (mg)	9.99	5.38	10.92	4.88	-2.804	0.005
Thiamine (mg)	1.25	0.74	1.29	0.71	-0.865	0.387
Riboflavin (mg)	1.57	0.71	1.77	1.26	-3.157	0.002
Niacin (mg)	20.34	10.11	22.02	11.36	-2.421	0.016
Vitamin B6 (mg)	1.81	0.96	1.87	1.19	-0.934	0.351
Vitamin C (mg)	88.58	86.15	107.85	81.24	-3.564	0.000
Folate (μg)	261.63	104.15	284.72	130.69	-3.021	0.003

[1] mean
[2] SD standard deviation
[3] Student's t-test

Table 8 presents data concerning changes in the mean supply of the discussed vitamins calculated per 1,000 kcal of the diet during the pandemic. This method of data

Table 6. Supply of minerals in the habitual diet of the respondents – calculated per 1,000 kcal

Variable	pre-COVID-19		COVID-19		MD[3]	95%CI		t	p-value[4]
	M[1]	SD[2]	M	SD		Lower limit	Upper limit		
Sodium (mg)	1968.60	577.13	1824.20	496.40	-144.40	-212.63	-76.17	4.153	0.000
Potassium (mg)	1561.33	499.25	1508.29	402.98	-53.04	-110.54	4.45	1.811	0.071
Calcium (mg)	292.33	138.24	305.67	136.50	13.34	-4.08	30.76	-1.503	0.133
Magnesium (mg)	146.46	40.46	143.71	35.77	-2.75	-7.60	2.09	1.117	0.264
Iron (mg)	5.72	2.07	5.75	2.70	0.03	-0.28	0.33	-0.179	0.858
Zinc (mg)	4.71	1.06	4.66	1.54	-0.05	-0.22	0.11	0.624	0.533

[1] mean
[2] SD standard deviation
[3] MD mean difference
[4] Student's t-test

Table 8. Supply of vitamins in the habitual diet of the respondents – calculated per 1,000 kcal

Variable	pre- COVID-19		COVID-19		MD[3]	95%CI		t	p-value[4]
	M[1]	SD[2]	M	SD		Lower limit	Upper limit		
Vitamin A (μg)	599.16	703.74	610.82	773.02	11.66	-82.11	105.42	-0.244	0.807
Vitamin E (mg)	4.78	1.98	4.96	1.92	0.18	-0.06	0.43	-1.450	0.147
Thiamine (mg)	0.59	0.31	0.59	0.33	0.00	-0.04	0.04	0.032	0.974
Riboflavin (mg)	0.76	0.30	0.82	0.57	0.06	0.00	0.12	-1.987	0.047
Niacin (mg)	9.77	3.63	9.91	4.46	0.14	-0.38	0.66	-0.534	0.594
Vitamin B6 (mg)	0.88	0.34	0.86	0.56	-0.01	-0.07	0.04	0.478	0.632
Vitamin C (mg)	47.09	57.75	52.07	42.66	4.98	-1.46	11.41	-1.518	0.129
Folate (μg)	129.26	49.21	131.23	55.45	1.98	-4.67	8.63	-0.584	0.560

[1] mean
[2] SD standard deviation
[3] MD – mean difference
[4] Student's t-test

presentation showed that a statistically significant change in the dietary supply referred only to riboflavin, whose mean content changed from 0.76 mg before the pandemic to 0.82 during the COVID-19 pandemic (p=0.047).

Selected lifestyle factors. Regarding alcohol consumption, the respondents declared that the COVID-19 pandemic had no significant impact on its mean consumption. Only a slight, statistically insignificant increase was noted regarding mean alcohol consumption, i.e. 6.15g/day – 7.5g/day (Tab. 9).

Table 9. Consumption of alcohol in the habitual diet of the respondents

Variable	pre-COVID-19		COVID-19		t	p-value[3]
	M[1]	SD[2]	M	SD		
Alcohol (g)	6.15	14.93	7.53	13.99	-1.475	0.141

[1] mean
[2] SD standard deviation
[3] Student's t-test

The number of respondents who declared that tobacco smoking significantly increased during the pandemic went up: 131 – 169 individuals (p=0.008) (Tab. 10).

Table 10. Tobacco smoking among respondents

Tobacco smoking	pre-COVID-19		COVID-19		Chi[2]	p-value[1]
	n	%	n	%		
No	351	72.8	313	64.9	6.988	0.008
Yes	131	27.2	169	35.1		

[1] Pearson's chi-squared test

Analysis of the obtained results revealed that the pandemic had no significant influence on sleep duration on weekdays. However, fewer respondents slept 7–8 hours/day at the weekend (311 vs. 295; p=0.010).

During the pandemic, low physical activity was declared by significantly more individuals (182 vs. 245; p<0.001) (Tab. 11).

Table 11. Sleep and physical activity among respondents

Variable	pre-COVID-19 (n = 482)		COVID-19 (n = 482)		z	p-value[1]
	n	%	n	%		
Hours of sleep on weekdays						
6 or fewer hrs/day	124	25.7	98	20.3		
7 - 8 hrs/day	323	67.0	361	74.9	-1.067	0.286
9 and more hrs/day	35	7.3	23	4.8		
Hours of sleep at the weekend						
6 or fewer hrs/day	80	16.6	64	13.3		
7 - 8 hrs/day	311	64.5	295	61.2	-2.576	0.010
9 and more hrs/day	91	18.9	123	25.5		
Physical activity						
Low	182	37.8	245	50.8		
Moderate	259	53.7	231	47.9	5.009	<0.001
High	41	8.5	6	1.2		

[1] Wilcoxon–Mann–Whitney test

DISCUSSION

Healthy lifestyle is associated with lower all-cause mortality, longer lifespan and good frame of mind [20]. Unhealthy behaviours (low-quality diet, lack,of physical activity, tobacco smoking and alcohol consumption) belong to the main factors contributing to the global burden of the disease [21]. The provision of a proper diet well-adjusted to the needs of the body is of particular importance during the COVID-19 pandemic, both in terms of the prophylaxis of SARS-CoV-2 infection and alleviating its course. The activity of the immune system increases during the infection which is associated with increased metabolism requiring the sources of energy and substrates for the biosynthesis of regulatory molecules which are ultimately available from the diet. High nutrient density of the diet has a key role in supporting the immune system and reducing the risk of infections as it provides balance between beneficial nutrients and components which should be limited. The beneficial nutrients whose supply should be increased are: protein, dietary fibre, n-3 unsaturated fatty acids, vitamins (D, A, E, C and group B vitamins) and minerals (Zn, Fe, Se). Conversely, free or added carbohydrates, saturated fats and sodium should be limited [7].

Research on nutrition during the pandemic published so far usually included analysis of the consumption of groups of products and/or its changes, compared to the pre-pandemic period. The present study provided information not only on the content of energy and selected nutrients in the diet during the COVID-19 pandemic, but also compared the data with those from before the pandemic in the same populations.

In epidemiological studies, the composition of diets is frequently expressed as the absolute content of components per person per day, the share of macronutrients in the provision of energy and as nutrient density, i.e. the consumption of nutrients in grams or milligram per 1,000 kcal of energy consumption [22, 23]. The present study incorporated all the above-mentioned indices of diet assessment.

Data analysis revealed numerous changes in the nutritional value of the diet and other elements of lifestyle during the COVID-19, with the domination of unfavourable changes.

Higher mean energy supply was noted in the diet of the study population (at the limit of statistical significance) and significantly higher mean percentage of individuals with low physical activity. The results obtained in this study are similar to the results published by other authors which showed that over a third of Polish adults increased their food consumption, and over 40% diminished their physical activity over the first three months of the pandemic. This contributed to an increase in the incidence of overweight, which may soon trigger further increase in the rates of obesity and numerous concomitant diseases, e.g. cardiovascular pathologies, other metabolic diseases, and some types of cancer [3, 5]. Furthermore, overweight patients with SARS-Cov-2 infection were at an 86% higher risk of developing severe pneumonia, while the risk of obesity rose by 142% [24]. Notably, in a long-term perspective, quarantine may increase susceptibility to the development of obesity, the risk factor for developing severe COVID-19 due to exposure to stress [25, 26]. Stress may lead to the consumption of larger amounts of high-energy foods. Moreover, it lowers the tendency to be physically active and disturbs sleep. Many people tend to eat in the case of stress of unclear character which triggers the dominant feeling of anxiety [27]. Psychological factors also influence adherence to dietary recommendations. It was demonstrated that individuals characterized by the ability to cope with difficult situations and quickly adapting to new changing circumstances, have the highest adherence to the principles of suitable nutrition [9].

An unfavourable direction of changes was observed in the study population regarding the consumption of fats. The diet was characterized by a significantly higher mean percentage of total lipid content energy value of the diet, high total lipid content and the amount of saturated fatty acids in grams/person/day. Similar changes were noted when nutrient densities were compared. The obtained data indicated that the increased total lipid consumption was accompanied by an increased consumption of saturated fatty acids. The phenomenon is unfavourable due to a number of negative consequences related to the increased supply of those substances, including elevated low-density lipoprotein in the blood and a higher risk of developing ischemic heart disease [28]. It needs to be emphasized that the health consequences of SFA consumption are also linked to the complex matrix of products which include SFA. Notably, whole-fat dairy, unprocessed meat, and dark chocolate are SFA-rich foods but are not associated with an increased risk of cardiovascular diseases [29, 30]. Thus, it would be interesting to analyze data collected during an NHP study in terms of the sources of individual diet components.

Moreover, it is worth highlighting that diet modulates the composition of the intestinal microbiota and influences the functioning of the immune system. It has been suggested that changing a diet rich in saturated fats into a diet containing monounsaturated fatty acids might reduce the number of bacteria which produce endotoxins with the highest inflammatory potential, thereby diminishing the severity of an inflammatory reaction to COVID-19 in susceptible individuals, e.g. obese ones [31].

Analysis of the profile of fatty acids in the diet during the COVID-19 pandemic revealed a significantly higher supply of n-3 fatty acids calculated both in grams and in grams per 1,000 kcal of the diet. Notably, the assessment of dietary habits also comprised components obtained from dietary supplements. According to other authors, the sales of diet supplements and nutraceutics went up due to their perceived activity in 'immune support' [32]. N-3 fatty acids may be capable of modulating the adaptive immune response, although data obtained from available randomized control trials are insufficient to determine whether their supplementation might offer additional benefits significant from the viewpoint of COVID-19 treatment [33].

Analysis of the consumption of total protein in the study population revealed no significant differences in its supply during the COVID-19 pandemic compared to the previous period. However, it was demonstrated that the amount of plant protein expressed as a gram of protein per 1,000 kcal of the diet was significantly lower during the pandemic. The change may indicate a less favourable dietary pattern during the pandemic associated with the lower consumption of plant-based products, which, apart from plant protein, contain a variety of protective compounds supporting the human body. A study which included health care workers from 6 countries, highly exposed the participants to SARS-CoV-2 infection because of their contact with COVID-19 patients. The study showed that adherence to plant-based diets or diets from the spectrum of plant-based ones (plant-based or pescatarian diets) was associated with the respective reduction by 73% and 59% regarding the chances of developing moderate to severe COVID-19-like diseas, compared to persons who did not adhere to such diets [34].

A significantly higher consumption of sucrose in grams/person/day was another unfavourable change observed during the pandemic. The analysis of nutrient density also revealed significantly higher sucrose consumption, with a significant reduction in the consumption of total carbohydrates and fibre. The excessive intake of easily absorbable carbohydrates, including sucrose, and low dietary fiber consumption, contribute to higher glucose concentrations in the blood. Hyperglycaemia may be responsible for higher susceptibility to SARS-CoV-2 infection, and a more severe course of the disease. A high glucose level also facilitates the development of hyaline membranes in the pulmonary tissue and triggers respiratory failure, which contributes to death in COVID-19 patients. Excessive sugar in the diet is accumulated in the body as adipose tissue and may have a role in developing obesity, which in turn increases the risk of a the participants severe course of the disease [35].

Apart from macroelements, microelements (minerals and vitamins in particular) play a fundamental role in maintaining health, preventing and treating various diseases [36, 37]. Analysis of the nutritional value of diets during the COVID-19 pandemic demonstrated the increased mean supply of all studied minerals in grams/person/day, with the exception of exception of sodium, with statistically significant changes being observed only in the case of calcium and magnesium supply. The amount of sodium was significantly lower when calculated by 1,000 kcal of the diet. The obtained results concerning sodium supply did not reflect the total supply of this component in the diet. The calculations only comprised sodium included in raw and ready-made products, but did not comprise sodium included in salt used for the preparation of meals made at home, and salt added to products at the table.

In Poland, an increase in the mean dietary content of all analyzed vitamins was noted during the COVID-19 pandemic. A statistically significant change was observed regarding vitamin E, riboflavin, niacin, vitamin C and folate. When calculating vitamin content per 1,000 kcal of the diet, it was demonstrated that a favourable, statistically significant change in the supply occurred only in the case of riboflavin.

While the coronavirus pandemic (COVID-19) and lockdown could trigger dysfunctional responses such as anxiety or depression, it could also lead to an increase in unhealthy behaviours, such as excessive drinking or smoking [38]. Some people were made to undertake actions to prevent and limit the use of stimulants. In both cases, the results of such actions may differ and be hard to evaluate, especially if research methodologies varied. Palmer et al. [39] reported that COVID-19 restrictions decreased alcohol consumption in the majority of studied individuals, but a small proportion increased their consumption.

The current study revealed that alcohol consumption hardly changed in the Polish population during the COVID-19 pandemic, although another Polish study showed an increase in alcohol consumption in 14.6% of participants, with a higher tendency to drink more being observed among alcohol addicts [40]. It is worth mentioning that the study was conducted during the pandemic and the questions were asked about the pre-COVID-19 period which might have affected the study results. The results obtained in the present study are consistent with the results of a large study conducted in the European population which included over 36,000 respondents consuming alcohol. It demonstrated that 42% of the participants reported no change in alcohol consumption [41]. Moreover, a study conducted in Australia showed that just over half (N=825, 55.3%) of the participants reported no change in alcohol consumption [42]. A cross-sectional American study demonstrated that 27.0% of studied participants reported that there had been no change in their drinking behaviour pre- and post-COVID-19, and 12.8% declared that their drinking had decreased [43].

The number of respondents who declared tobacco smoking significantly increased during the pandemic. The obtained results underlie questions concerning the group of individuals in which such an unfavourable increase was noted, and whether those who had just started smoking continued the habit. This requires further, more in-depth analyses of collected study results, and a new study targeting this group of people, especially that the analysis of data obtained in 38 European countries revealed a negative association between smoking prevalence and COVID-19 occurrence at the population level [44]. Moreover, a meta-analysis published in ***Arch Bronconeumol***. [45] revealed that current and past smoking produced a more serious clinical form of COVID-19, and more frequently led to intensive care admission, intubation, and death. It is worth noting that favourable changes occurred in some populations. In Australia, nearly 93% of studied participants reported no change or reduction in smoking status since the onset of the COVID-19 pandemic [42]. Similar changes were observed in Italy where 3.3% of smokers decided to quit smoking [46]. The COVID-19-related lockdown imposed in the United Kingdom contributed to a slight increase in the number of smokers – 15.9% – 17%. Simultaneously, a statistically significant increase was noted in the number of people attempting to quit smoking [47].

The length and quality of sleep is a very important factor influencing health status. Alterations in daily routines and engaging in social and leisure activities at relatively fixed times are all important timekeepers for sleep-wake cycles [48]. The regularity of the sleep-wake cycle is important for optimizing health, and the function of the circadian system and biological clock [49]. The present study focused of the comparison of sleep duration before and during the pandemic. The pandemic and related restrictions did not influence sleep duration on weekdays. However, significant unfavourable changes were observed at the weekend when the percentage of individuals sleeping 7–8 hours significantly decreased. Conversely, the number of individuals sleeping at least 9 hours might partially be due to the limited possibility of enjoying entertainment outside the home. This may be supported by a study from Australia which showed negative changes concerning sleep duration in 40.7% of participants [42]. It should be assumed that the negative change was associated with reduced sleep duration.

Negative lifestyle changes during the pandemic also include deterioration of the level of physical activity of the respondents. Prior to the pandemic, the percentage of individuals characterized by moderate physical activity (53.7%) slightly dominated in the study group. During the pandemic, the number of people characterized by low physical activity increased and this activity pattern became more common (50.8%). The number of persons with moderate physical activity significantly decreased (47.9% vs. 53.7%). The results may be affected by numerous factors, such as the change of the rhythm and model of professional activity (off-line/on-line), closed gyms and entertainment facilities, or quarantine. Considering the importance of normal activity for health, the situation should be monitored and effort should be made to encourage an increase in the level of activity. Similar observations were made in the ECLB-COVID19 International Online Survey [50] which claimed that the COVID-19 home confinement had a negative effect on all PA intensity levels (vigorous, moderate, walking and overall). Additionally, daily sitting time increased from 5 to 8 hrs per day. In this context, it is worth mentioning a Spanish study [51] which showed that vigorous physical activities and walking time significantly decreased by 16.8% and 58.2%, respectively. Furthermore, it was noted that the Spanish adult population, especially young people, students and very active men, decreased daily self-reported physical activity and increased sitting time during the COVID-19 pandemic.

Strengths and Limitations. This study has some strengths and limitations that should be acknowledged. To the best of the authors' knowledge, this study presents the characteristics and comparison of lifestyle, including dietary habits, during the COVID-19 pandemic in populations comparable regarding specific variables. This was possible due to the use of data obtained from respondents during the COVID-19 pandemic (June-August 2020) and the pre-pandemic period (June-August 2019). The respondents were selected with the PSM (Propensity Score Matching) method, a statistical matching technique that attempts to estimate the effect by accounting for fixed covariates. Furthermore, contrary to previously presented studies in this area, the present study used the quantitative methods of dietary habit assessment. This facilitated the presentation of the energy and nutritional value of the diet as the absolute content of components per person per day, and as nutrient density, and not only as the frequency of the consumption of individual product groups. Most of the study (75%) was conducted with the CAPI method.

Although this study provides an insight into how the pandemic influenced the lifestyle in Polish residents there is also a limitation that needs to be emphasized. The CAPI method was replaced with the CATI method during the pandemic. The CAPI method is a way to obtain more reliable data concerning the consumed amounts, e.g. by using albums with the photographs of products and meals.

CONCLUSIONS

Numerous unfavourable changes occurred in diet and lifestyle during the COVID-19 pandemic, which may contribute to the exacerbation of health problems in the future. The issue is gaining importance from the viewpoint of public health because of the prolonged pandemic. Nutrient density in the diet combined with well-designed consumer education may underlie the development of diet recommendations.

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