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Assessing effects of diet alteration on selected parameters of chronically mentally ill residents of a 24-hour Nursing Home. Part I: Effects of diet modification on carbohydrate-lipid metabolism

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Summary

Aim. The study was aimed at finding out whether, and to what extent, it is possible to introduce and maintain proper nutrition habits in chronically mentally ill residents of a 24-hour Nursing Home.

Material and methods. The study involved 52 residents of a 24-hour Nursing Home (NH) for the chronically mentally ill. The study was carried out with a prospective method using questionnaires, nutrition-related interviews, anthropometric measurements, and analysis of selected blood biochemical indicators. Diet modification, accompanied by simultaneous health-promoting nutrition-related education, involved balancing the energy and nutrient contents, with a due consideration to gender and age as well as the major ailment and the accompanying disorders. Sources of the basic nutrients, i.e., proteins, carbohydrates and lipids, were replaced by recommended and/or health-promoting ones.

Results. Both female and male patients showed a statistically significant reduction in energy uptake, resulting primarily from a significant reduction in the uptake of lipids and simple carbohydrates. Changes in nutritional habits were reflected in statistically significant increase in the uptake of vitamins, minerals and liquids (in the form of water). Diet composition modifications translated into beneficial changes in concentrations of glucose, triacylglycerols, cholesterol (total as well as HDL and LDL fractions) in numerous patients examined.

Conclusions. The study showed chronic mental patients to be capable of adopting, with full acceptance and cooperation, proper nutritional habits. Changes in those habits were reflected in improved body functions, including carbohydrate-lipid metabolism indicators, also in schizophrenia patients treated with antipsychotics.

Key words: the mentally ill, nourishment, blood parameters

Introduction

Many years of customized health-promoting nutritional education coupled with diet corrections for post-mastectomy [1] and menopausal women [2, 3] as well as female participants of the Third Age University [4, 5] resulted in a number of beneficial health-related changes and effects. Therefore, on request of the "Razem" Family Support Association, which groups legal counsels and relatives of nursing home patients, and upon approval of the nursing home management, it was decided to investigate whether – and to what extent – it would be possible to implement dietary changes in chronically mentally ill residents of a 24-hour Nursing Home (NH). As shown by many studies, patients with chronic mental illnesses (e.g., schizophrenia or bipolar disorders) are affected by metabolic disorders occurring at a rate higher than that in the general population. The causes are sought not only in inappropriate diets and the lack of exercise but also in effects of the frequent insulin resistance [6] and in antipsychotic treatments [7, 8].

Material and methods

The study involved 52 individuals: 18 women aged 45–80 and 34 men aged 27–80, all patients of a Nursing Home (NH) for the chronically mentally ill. The study as well as the associated diet alterations were approved by the NH management; written consent of 33 non-incapacitated patients and 19 legal counsels of totally incapacitated ones was obtained, and the program was approved by the kitchen staff and by the Regional Chambers of Physicians' Bioethical Commission in Szczecin (No. 14/KB/V/2013).

The study was carried out using a prospective method involving questionnaires, diet assessment interviews, anthropometric measurements, and analyses of selected blood biochemical parameters. Information on the patients' health status (both current ailments and previous disease history), diagnosed mental disorders, medication and treatment, wellbeing self-assessment, destructive behaviors, etc. was provided by the primary care physicians, therapists and medical records.

Diet and nutrition

Before the actual study was commenced, each patient was interviewed (using the author's customized questionnaire) and indicated their preferences with regard to dishes and foods. This way, favored and disliked dishes (soups, meats, half-meat and meatless dishes as well as beverages) were revealed so that patients' diets could be modified and new menus developed accordingly. Before the supervised nutrition program began and prior to diet alteration [9], the patients had been receiving 3 or 4 meals a day: breakfast (at 08:30–10:30), mid-morning snack served only to diabetic patients (at 11:00), lunch (13:30–15:30), and supper (18:00). According to the Regulation of the Minister of Labor and Social Policy of 23 August 2012 [10] on nursing homes, each meal was being available for 2 hours, the last meal being served not earlier than at 18:00.

The diets were altered by balancing their energetic and nutritional components according to each patient's gender and age, with a due consideration to the major illness and accompanying disorders; in addition, sources of the basic nutrients (proteins, carbohydrates, and lipids) were changed to those recommended and health-promoting: pork meat and pork sausages as the animal protein sources were replaced by poultry and fish; high-fat dairy products (hard cheeses, cheese spreads) were substituted by natural cottage cheese and natural probiotic yoghurts; highly refined and processed carbohydrates were replaced by low glycemic index, wholemeal products (coarse groats, brown rice, wholemeal breads).

Animal fats (lard), vegetable fats (palm and coconut oils as well as hard margarines) and high n-6 fatty acid oils (corn, sunflower) were replaced by butter, soft margarines and n-3 fatty acid-rich rapeseed oil. Attention was paid to including natural choline sources into the diet (egg yolk, wholemeal cereals, beans, rice) and increased amounts of vegetables (including naturally fermented cabbage and cucumbers). The diets were enriched with seasonal local fruits, including apples, served in different ways (baked, cooked, mashed, etc., also as snacks between the main meals); natural herbs and spice mixes were used as well. Appropriate amounts of liquids were recommended, including water served in jugs with, e.g., lemon slices, mint leaves, etc., available at all times.

Fresh milk as well as highly processed, refined, canned products and caffeine-containing beverages were eliminated; consumption of coffee as well as kitchen salt and sucrose was restricted. In addition, upon consultation with the physician, supplementation with fish oil containing 3.6 μg vitamin D3 and 410 μg vitamin A, was applied from October through March.

The variety of meals was increased, and some of the preparation techniques were changed (e.g., meat cooking and frying was replaced by roasting and stewing). The new 10-day (decadal) menus included a mid-morning snack for all the patients, a fifth meal in the form of the afternoon tea with snacks was served, the suppers were cooked, and snacks available between meals consisted of seasonal fruits and vegetables instead of sandwiches. The changes, introduced gradually, over a longer time period, were fully accepted by the patients.

In addition, the occupational therapy was complemented by health-promoting nutritional education in the form of lectures adjusted to the patients' (and legal counsels') perception capabilities, talks, culinary therapy and cooking workshops. The overall effects of those activities were evaluated through role-playing games, multiple selection tests and repeated nutrition and diet contests.

Before the diet adjustment, the autumn/winter decadal menus were evaluated and the amount of food calculated. The calculations included also the amounts and types of additional foods consumed by the patients. Information on consumption of additional foods was provided personally by the non-incapacitated patients, whereas information on the totally or partly incapacitated patients was supplied by the primary care providers (i.e., members of therapeutic-caregiving teams and the nursing home staff). The amount of food left on plates after each meal, returned to kitchen, was weighed and subtracted from the total amount of food consumed by the patients.

The energetic and nutritional value of the food consumed during 30 days prior to diet adjustment was calculated, with a due consideration to losses occurring during meal preparation, using the software *Dieta 5.0* developed by the Institute of Nutrition and Food. The energy derived from the basic food components was broken down to: 15% contributed by proteins, 50/55/65% by carbohydrates, 20/30/35% by lipids, and < 10% by sucrose. The energetic value of the diet was compared to the average energy requirement (EER); the uptake of vitamins (A, B_1, B_2, B_6, B_{12}, niacin, folates, C) and minerals (Ca, P, Mg, Fe, Zn, Cu) was compared with the group average requirement (EAR), whereas the intakes of vitamins D_3 and E, minerals (K and Na) as well as water were compared with adequate intake (AI) commensurate with age and gender [11]. Consumption of dietary fibre and cholesterol was compared with the amounts recommended in prevention of obesity and other non-contagious diseases (> 25 g and < 300 mg, respectively) [12]. Following subtraction of losses in the consumed product groups (with a due consideration to snacks and remains left on plates), the values were compared with the model food rations recommended for appropriate age groups and gender [13].

To identify the limiting amino acids (AAs) (with a particular reference to AAs acting as precursors in neurotransmitter biosynthesis), the nutritional value of protein in the daily food rations was calculated from the Chemical Score value, computed using the formula: limiting AA content in 1 g test protein/limiting AA content in 1 g FAO model protein x 100 [14]. The Glycemic Load (GL) [15] was calculated for individual meals.

The daily food rations were adjusted with a due consideration to the daily monetary food allowance, relevant Regulation of the Minister of Labor and Social Policy on nursing homes [10], nutritional standards [11] and, obviously, patients' preferences. The adjustments allowed for new solutions and/or corrective actions to be introduced on the spot so that diets were adapted to the season and the associated change in availability of different foods.

The supervised nutrition program (involving monitoring the diet and nutrition throughout the period of study) [9] was possible because one of the co-authors was employed as a Nutrition Manager as well as acting as a legal counsel for two incapacitated residents.

The food intakes during 30 days in autumn/winter prior to diet adjustments, during 30 days in autumn/winter a year later and after the diet adjustment was completed were compared. In this work, effects of nutritional changes on the patients' carbohydrate-lipid metabolism were assessed.

Biochemical assays

Blood samples were drawn between 07:30 and 08:00 under fasting conditions, from the basilic vein, by ND-employed nurses who knew the patients and were familiar figures for them, which ensured that the process proceeded smoothly.

Propylene vials with the blood samples were sealed and transported to the Central Laboratory of the District Hospital in Szczecin. The plasma was assayed for concentrations of glucose (GL), triacylglycerols (TG) (using the enzymatic-colorimetric method), total cholesterol (TC) (the enzymatic-colorimetric method), LDL and HDL cholesterol fractions (the enzymatic-colorimetric method). The assays were performed in a closed system (COBAS C6000 apparatus), using appropriate Roche Diagnostica reagents. Interpretation of glucose concentrations was based on recommendations of Dembińska-Kieć and Naskalski [16], whereas concentrations of lipid indicators were referred to the levels recommended by *European Heart Journal* [17]. The blood was assayed before diet modification and one year after the modified nutrition was implemented.

To assess effects of diet modification on indicators of carbohydrate-lipid metabolism, the patients were divided into two groups. Group I, patients diagnosed with schizophrenia, consisted of 33 individuals (15 women aged 45–80 and 18 men aged 27–80) treated, during the period of study, with, *inter alia,* the following antipsychotics: clozapine – 12 individuals (8 women and 4 men), olanzapine – 15 individuals (5+10), haloperidol – 3 individuals (1+2), risperidone – 3 (3+0), and quetiapine – 2 (0+2). Group II consisted of the remaining patients, diagnosed with personality disorders, hallucinations, Parkinson's disease, mental retardation, psychoorganic syndrome, amnesic Korsakoff syndrome, and alcohol dependence syndrome. The group consisted of 19 individuals (3 women aged 67–69 and 16 men aged 27–74) who were treated with, *inter alia*, hydroxyzine, lorazepam, diazepam, levomepromazine, valproic acid, carbamazepine, oxcarbazepine, vigabatrin, and risperidone.

Statistical analysis

Data on the energy and nutritional value of the diet as well as data on the measured blood parameters, collected prior to and after diet modification were checked for normality (the Shapiro-Wilk test) and homogeneity of variance (the Levene's test), and were tested for significance of differences (p £ 0.05 and p £ 0.01) using Student's t-test for paired samples; the tests were run with the statistical software Statistica® 9.0.

Results

Quantitative assessment of food uptake

Nutritional habits before and after diet modification were evaluated separately for male and female patients. Each time, 540 of female and 1020 male menus (a total of

1080 and 2040 menus, respectively) were analyzed. Prior to diet alteration, the mean energy content of the food consumed daily (including snacks and uneaten remains) by both men and women exceeded the recommended standard. This was accompanied by an excessive consumption of total protein (including animal protein), fats, cholesterol, and carbohydrates. Following diet modification, the mean energy content was significantly reduced, almost to the recommended standard in male patients, with a reduced contribution of protein, fats, cholesterol, and total carbohydrates, accompanied by an increased contribution of dietary fibre and liquids (water) (Table 1 and 2).

Table 1. **The content of energy and basic nutrients in daily food rations of women (including uneaten remains), n = 540, ± SD,% of the recommended norm**

Components	"before"	"after"	Significance of differences
	a	b	
Energy (MJ) (%)	12.5±1.2 155.4±15.9	10.1±0.9 125.7±15.0	a–b**
Total protein (g) (%)	93.0±6.5 129.5±13.6	86.4±6.2 120.5±14.0	a–b**
Animal protein (g) (%)	50.8±4.4 127.4±26.9	44.3±4.5 120.4±29.6	a–b**
Total fat (g) (%)	104.1±9.6 213.1±54.9	75.8±10.2 156.0±47.4	a–b**
Cholesterol (mg) (%)	349.3±38.8 116.4±12.9	276.4±25.4 92.1±8.5	a–b**
Total carbohydrates (g) (%)	453.3±50.3 156.2±21.1	388.9±36.9 134.6±20.7	a–b**
Fibre (g) (%)	36.6±8.3 105.1±28.4	46.0±8.4 132.6±32.6	a–b**
Liquids (ml) (%)	1987.7±263.3 99.4±13.2	2587.8±302.3 129.4±15.1	a–b**

** statistically significant difference $p \leq 0.01$

Table 2. **The content of energy and basic nutrients in daily food rations of men (including uneaten remains), n = 1,020, ± SD,% of the recommended norm**

Components	"before"	"after"	Statistically significant
	a	b	
Energy (MJ) (%)	12.9±2.3 133.3±26.3	10.3±1.3 106.2±16.7	a–b**

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Total protein (g) (%)	94.5±13.6 108.5±19.6	90.1±13.8 103.3±18.5	a–b**
Animal protein (g) (%)	53.6±9.1 139.7±27.9	47.7±11.5 129.1±26.1	a–b**
Total fat (g) (%)	110.0±27.6 185.7±72.8	75.2±10.8 126.5±39.5	a–b**
Cholesterol (mg) (%)	364.5±62.4 121.5±20.8	287.1±52.7 95.7±17.6	a–b**
Total carbohydrates (g) (%)	462.7±86.5 132.8±30.0	398.4±57.9 114.9±25.1	a–b**
Fibre (g) (%)	35.7±10.3 98.3±35.1	45.7±9.4 125.8±35.3	a–b**
Liquids (ml) (%)	2,143.7±548.2 85.7±21.9	2,647.4±454.7 105.9±18.2	a–b**

** statistically significant difference p ≤ 0.01

Despite a significant reduction of the amount of total protein, including animal protein, in the diet, contents of essential amino acids serving as neurotransmitter biosynthesis precursors still exceeded the upper limit of the recommended standard (Table 3).

Table 3. **The content of essential amino acids defining the biological value of protein in daily food rations (including uneaten remains), women (n = 540) and men (n = 1,020), x ± SD**

Essential amino acids (g/100)	Amino acid content in the standard protein/ content of amino acids in the studied diets	PDCAAS (CS x 0.9)		Significance of differences
		women % of the recommended norm		
		“before”	“after”	
		a	b	
Methionine + Cysteine	2.2	144.3±11.5	128.2±9.1	a–b**
Phenylalanine + Tyrosine	3.8	169.7±12.2	161.2±11.3	a–b**
Tryptophan	0.6	158.0±10.1	166.5±10.7	a–b**
men % of the recommended norm				
Methionine + Cysteine	2.2	145.2±22.1	134.9±26.3	a–b**
Phenylalanine + Tyrosine	3.8	172.0±25.4	167.5±30.3	a–b**
Tryptophan	0.6	166.0±31.4	171.2±25.4	Ns

** statistically significant difference p ≤ 0.01

After diet modification, significant changes were observed in proportions of major nutrients and the amounts of energy they supplied (Table 4).

Table 4. **Percentage of energy from basic nutrients in daily food rations (including uneaten remains), women (n = 540) and men (n = 1,020), x ± SD**

The percentage of energy from:	Women		Significance of differences	Men		Significance of differences
	"before"	"after"		"before"	"after"	
	a	b		a	b	
Proteins	13.9±0.5	15.0±0.5	a–b**	13.9±0.5	15.1±0.5	a–b**
Lipids	33.3±1.3	28.7±0.8	a–b**	27.1±0.8	28.6±0.7	a–b**
Carbohydrates	54.1±1.6	57.5±1.2	a–b**	54.4±1.6	57.9±1.2	a–b **
Sucrose	11.0±1.3	10.2±0.9	a–b**	11.4±1.2	10.5±0.8	a–b**

** statistically significant difference $p \leq 0.01$

The dietary alterations resulted in statistically significant changes in contents of vitamins and minerals in daily food rations. Tables 5 and 6 summarize changes in vitamins and minerals important for neurotransmitter biosynthesis and nervous system functioning – in female and male patients, respectively.

Table 5. **Content of selected vitamins and minerals in daily food rations (including uneaten remains), women n = 540, x ± SD, % of the recommended norm**

Components	"before"	"after"	Significance of differences
	a	b	
Folate (μg) (%)	440.2±34.2 137.6±10.7	536.9±49.4 167.8±15.4	a–b**
Vitamin D (μg) (%)	2.1±0.2 20.8±2.2	4.25±0.4 42.5±4.1	a–b**
Vitamin C (mg) (%)	93.2±40.1 155.3±66.9	14.6±26.2 246.0±43.7	a–b**
Vitamin B_1 (mg) (%)	1.6±0.2 179.0±18.4	1.6±0.1 179.0±15.7	Ns
Vitamin B_2 (mg) (%)	1.9±0.2 205.7±19.0	1.9±0.3 205.7±24.5	Ns
Vitamin B_6 (mg) (%)	2.3±0.2 178.7±22.8	2.6±0.3 202.6±24.2	a–b**
Calcium (mg) (%)	558.5±81.0 57.4±9.2	745.6±144.5 76.8±17.4	a–b**
Magnesium (mg) (%)	399.0±63.2 150.6±23.9	417.9±76.8 157.7±29.0	Ns
Iron (mg) (%)	16.6±2.3 268.6±43.6	18.6±1.2 301.2±45.8	a–b**

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Zinc (mg) (%)	14.7±2.4 215.8±36.0	13.5±2.4 198.8±35.3	a–b**
Copper (mg) (%)	1.7±0.2 187.4±25.7	1.8±0.3 232.0±26.4	a–b**

** statistically significant difference p ≤ 0.01

Table 6. **Content of selected vitamins and minerals in daily food rations (including uneaten remains), men n = 1,020, ± SD, % of the recommended norm**

Components	"before"	"after"	Significance of differences
	a	b	
Folate (µg) (%)	452.2±76.6 141.3±23.9	546.3±67.5 170.7±21.1	a–b**
Vitamin D (µg) (%)	3.3±2.3 32.8±22.6	5.15±2.2 51.53±22.4	a–b**
Vitamin C (mg) (%)	100.0±62.3 133.3±80.0	166.6±63.3 222.1±84.4	a–b**
Vitamin B_1 (mg) (%)	1.6±0.3 147.7±24.2	1.6±0.2 147.6±23.3	Ns
Vitamin B_2 (mg) (%)	1.9±0.3 173.7±28.9	1.9±0.3 173.6±29.8	Ns
Vitamin B_6 (mg) (%)	2.3±0.5 177.2±36.7	2.7±0.5 208.9±39.0	a–b**
Calcium (mg) (%)	595.6±157.3 70.5±19.4	739.9±186.0 87.7±23.9	a–b**
Magnesium (mg) (%)	395.4±81.9 113.3±23.3	424.2±66.9 121.6±18.8	a–b**
Iron (mg) (%)	16.5±3.1 275.7±52.1	18.7±2.8 312.1±47.3	a–b**
Zinc (mg) (%)	14.2±2.9 209.4±43.3	13.5±2.4 199.4±35.0	a–b*
Copper (mg) (%)	1.7±0.4 188.8±39.3	1.9±0.3 208.2±34.0	a–b**

* statistically significant difference p ≤ 0.05; ** statistically significant difference p ≤ 0.01

Diet modification was also reflected by a statistically significant reduction in the total daily glycemic load, despite an additional meal (the afternoon tea). Most important in this respect was, however, consumption of additional foods as snacks (Table 7).

Table 7. **The impact of changes in the diet on the value of the diet glycemic load (including uneaten remains) (± SD)**

Meal	Women (n = 540)		Significance of differences	Men (n = 1,020)		Significance of differences
	"before"	"after"		"before"	"after"	
Breakfast	61.1±15.9	55.3±7.2	*	64.6±13.3	56.5±6.4	*
Mid-morning snack	6.1±8.8	3.2±5.3	-	3.7±7.5	2.4±4.8	-
Dinner	43.5±0.3	43.5±0.01	-	43.6±0.2	43.5±0.01	-
Afternoon snack	0.0±0.0	12.1±0.01	**	0.0±0.0	13.2±0.04	**
Supper	62.8±18.1	58.9±6.9	-	65.6±16.1	59.9±6.1	-
Snacks	76.6±37.4	48.2±20.6	**	84.5±58.0	53.1±33.6	**
24 hours	250.1±46.7	221.2±22.3	**	262.1±61.7	228.6±35.2	**

* – statistically significant difference $p \leq 0.05$; ** statistically significant difference $p \leq 0.01$

Analysis of the results allowed to conclude that changes in dietary habits produced beneficial changes in carbohydrate-lipid metabolism indicators in many NH patients, including those afflicted by schizophrenia who were treated with antipsychotics.

All group I females showed a statistically significant reduction in glucose level down to the recommended reference range. The glucose level reduction was accompanied by statistically non-significant reductions in mean triacylglycerol, total cholesterol and LDL cholesterol concentrations as well as by a slight increase in HDL cholesterol (Table 8). The changes observed in group II females (3 individuals) were not meaningful because the analyzed indicators did not deviate from the reference range before and after diet modification. Noteworthy, however, was a reduction in total cholesterol, which included reductions in both LDL and HDL fractions (Table 9).

The beneficial changes observed in group I males in the form of reduced levels of glucose, triacylglycerols, total cholesterol and LDL cholesterol were statistically significant. The HDL cholesterol concentrations were similar before and after diet correction (Table 8). Group II males showed beneficial, statistically significant changes in the form of reduced glucose level only, while the reduction in total cholesterol was – like in group II females – primarily a result of a reduced HDL cholesterol concentration (Table 9).

The mean values summarized in Table 8 and 9, both in group I and II, tend to mask certain, frequently very favorable individually, changes in examined blood parameters.

Table 8. **Impact of diet correction on selected parameters of carbohydrate-lipid metabolism of NH patients suffering from schizophrenia (min – max, ± SD)**

Meal	Women (n = 15)		Significance of differences	Men (n = 18)		Significance of differences
	"before"	"after"		"before"	"after"	
Glucose (mmol/l)	3.83 – 6.89 4.96±0.89	3.56 – 6.22 4.42±0.76	*	4.11 – 8.39 4.97±1.08	3.22 – 5.28 4.14±0.61	**
TG (mmol/l)	0.61 – 5.20 2.07±1.29	0.68 – 5.20 1.72±1.19	-	0.67 – 4.02 1.92±1.07	0.61 – 3.56 1.52±0.75	*
TC (mmol/l)	3.29 – 7.59 5.40±1.25	3.42 – 6.16 4.92±0.85	-	3.16 – 6.83 5.07±1.08	2.67 –5.62 4.41±0.91	*
HDL-C (mmol/l)	0.84 – 1.78 1.21±0.33	0.84 – 1.78 1.24±0.30	-	0.75 – 1.88 1.11±0.39	0.46 – 1.84 1.09±0.42	-
LDL-C (mmol/l)	1.58 – 5.30 3.29±1.01	1.58 – 4.24 3.02±0.86	-	1.58 – 4.87 3.19±0.98	1.48–4.17 2.71±0.86	**

*statistically significant difference $p \leq 0.05$; ** statistically significant difference $p \leq 0.01$

Table 9. **Impact of diet correction on selected carbohydrate-lipid metabolism indicators of other NH residents – group II (min – max, ± SD)**

Meal	Women (n = 3)***		Significance of differences	Men (n = 16)		Significance of differences
	"before"	"after"		"before"	"after"	
Glucose (mmol/l)	3.56 – 4.64 4.09±0.53	4.06 – 5.28 4.46±0.71	-	3.56 – 8.56 5.04±2.40	3.68 – 6.22 4.15±1.19	**
TG (mmol/l)	0.79 – 1.13 0.92±0.18	0.76 – 1.50 1.02±0.42	-	0.68 – 3.62 1.70±0.79	0.70 – 4.15 1.71±1.13	-
TC (mmol/l)	3.55 – 4.92 4.27±0.69	2.98 – 4.92 3.83 ±0.99	-	2.85 – 6.60 5.03±1.02	2.85 – 6.45 4.73±0.92	-
HDL-C (mmol/l)	1.19 – 1.63 1.35±0.24	1.02 – 1.20 1.10±0.09	-	0.84 – 2.36 1.17±0.37	0.66 – 1.59 1.05±0.26	-
LDL-C (mmol/l)	1.95 – 3.20 2.50±0.65	1.53 – 3.12 2.25±0.80	-	1.51 – 5.22 3.45±1.11	1.51 – 4.84 3.47±0.87	-

** statistically significant difference $p \leq 0.01$; *** due to the small size of the group, no statistical analysis was performed

Discussion

Results of this study, which involved chronically mentally ill residents of a nursing home, showed that those individuals, too, are capable of altering their nutrition habits to more appropriate ones. This is not only because the patients accepted the dietary changes which took their preferences into account, but also on the account of the fact that the meals became more attractive (due to better-quality products used, inclusion of fresh and/or dried seasoning herbs and diet diversification) and an opportunity of choosing between two versions of a dish (e.g., sweet or spicy). These effects were seen as a reduced amount of uneaten food returned to the kitchen. On the other hand, the patients' consent to a change in the source of the major nutrients (e.g., from fried battered pork to roasted or stewed poultry and fish) or inclusion of wholemeal bread, coarse groats, non-sweetened dairy products, natural yoghurt, a higher proportion of vegetables, and replacement of beverages such as coke, coffee and tea drunk daily with water seemed to be an outcome of rational nutrition education carried out in different ways. The effect of education seems to be confirmed also by the significant reduction in the glycemic load of snacks, snack consumption being a reflection of conscious nutritional decisions and choices.

Evaluation of the educational activities frequently showed a surprisingly high level of knowledge on nutrition in the patients and their understanding of how necessary a change of diet was. The education was enhanced by patients meeting at meals, particularly at supper which involved carbohydrate dishes served hot (e.g., casseroles with vegetables, *al dente* groats with vegetables, vegetable salads, etc. offered in 2–3 versions). That the supper was a preferred meal was evident by the fact that many female patients changed for supper, replaced slippers with pumps, styled their hair, etc. because – as they said – they felt as they were going to a restaurant. This served also to improve interpersonal relationships between the patients.

The diet alterations resulted in a number of beneficial changes in the patients' body functions (often individual but always personally important, improving the quality of life), reported by both the concerned individuals and the personnel and physicians. Those changes involved, *inter alia*, blood pressure being brought to a normal level, improved perception of wellbeing, better sleep quality, enhanced taste (and occasionally increased appetite), and improved defecation.

The beneficial overall changes in the schizophrenia patients were similar to those observed in the remaining individuals. On the other hand, those changes associated with diet modification-related effects on the selected carbohydrate-lipid metabolism indicators were larger and frequently significant. This is important because disorders in the carbohydrate-lipid metabolism and their consequences in the form of type II diabetes, dyslipidemia and cardiovascular diseases are more than twice as frequent in schizophrenia patients than in the general population [18]. In light of recent studies, schizophrenia and cardiovascular diseases are suggested to have the same genetic origins [19]. Moreover, numerous studies demonstrated some of the medication used in schizophrenia and bipolar disorder to promote the development of disorders in the carbohydrate-lipid metabolism and to increase the risk of type II diabetes. This is particularly the case with the second-generation antipsychotics, particularly clozapine and olanzapine [20]. For example, it has been suggested that clozapine and olanzapine inhibit glucose transport to cells [21] and glucose metabolism [22], thus contributing to insulin resistance and its consequences. In this context, noteworthy was the significant reduction of the blood glucose concentrations to the reference level in all the patients (15 females and 18 males in group I and 16 males in group II), induced by the diet modification. This showed the patients to have followed the nutrition recommendations, which resulted in a desirable outcome regardless of the mental condition and used medication.

The observed decrease in glucose concentration resulted from, *inter alia*, reduced uptake of simple sugars, processed complex carbohydrates, which are digested rapidly and release more glucose, and an increased consumption of complex carbohydrates from wholemeal cereals, brown rice, pulses, wholemeal bread, and vegetables. The underlying physiological mechanism involved regulation of glucose removal from the blood, the efficiency of the mechanism correlating positively with a type, source and amount of dietary carbohydrates and the associated Glucose Tolerance Factor (GTF) [23]. Prolonged digestion of those carbohydrates and slow absorption of the released glucose, at a higher uptake of different dietary fibre fractions, resulted in an overall glycemic improvement [24]. The glycemic improvement must have stemmed also from the reduced overall uptake of lipids, including saturated fatty acids. The latter, by affecting the cell membrane structure and insulin receptor activity, facilitate the onset of glucose metabolism disorders [25] and are responsible for insulin resistance generation [26]. For this reason, the discussed effect could have been also produced by an improved cell insulin sensitivity.

The low glycemic load types and sources of carbohydrates, coupled with consumption of 5 meals a day served every 2.5–3 hours, helped to maintain the appropriate blood glucose concentration, which could both affect the appetite center activity and enhance patients' perception of wellbeing. The possibility of affecting the activity of hunger and satiation centers in this way seem to be important, particularly in schizophrenia patients who often show an increased appetite. This leads to body weight gain, additionally stimulated by antipsychotics [27] with a concomitant lack of response to an increase in the concentration of leptin [28], which controls the appetite and energy expenditures.

On the other hand, the literature survey does not allow to form an unequivocal opinion on the effects of caffeine reduction (in view of, *inter alia*, undesirable caffeine interactions with antipsychotics such as clozapine, olanzapine, haloperidol, and quetiapine) to the amount contained in 1–2 cups of coffee a day. On the one hand, caffeine acts by A1 adenosine receptor-dependent inhibition of muscle glucose uptake and insulin resistance increase associated with increased adrenaline concentration. On the other hand, coffee contains, e.g., antioxidants and other compounds involved in glucose metabolism which alleviate adverse caffeine effects [29].

A reduction in the blood glucose concentration has been demonstrated to bring about a reduction in the lipogenic insulin secretion [2], insulin being known to be involved in triacylglycerol biosynthesis stimulation [30]. A higher insulin concentration resulting from the diet composition not only boosts the pentose cycle and supplies materials for fatty acid synthesis but also stimulates esterification of fatty acids by facilitating glucose penetration into adipocytes and activating glycerol-3-phosphate acetyltransferase. That such a mechanism was indeed active is inferred from the significant reduction in triacylglycerols in 78% of the female patients and all the male patients in group I and in 60% of the male patients in group II.

Effects of diet modification were also visible in changes of other lipid indicators. In group I, 78% of the female patients and all the males showed a reduction in total and LDL cholesterol, the reduction in males being significant. The saturated lipid uptake has been known for a long time to correlate positively with increasing blood lipid indicators [31]. Hence, the reduced total (and saturated) lipid consumption not only contributed to normalization of glucose concentration but also resulted in the reduction of total cholesterol. In this group, the reduction was primarily due to a decline in LDL cholesterol. Noteworthy in this case is the absence of a typical reduction in the HDL cholesterol concentration; on the contrary, the contribution of HDL cholesterol to the total cholesterol pool increased in about 60% of females and 62% of males in group I. On the other hand, group II showed reduction of total cholesterol in 82% of all the patients, however, in 75% of them the reduction was associated primarily with a decline in the HDL cholesterol concentration, reduced LDL cholesterol being observed in as few as 37.5%.

The diet correction effect in both groups could have been related to specific outcomes of consuming unsaturated acids in the form of olive and rapeseed oils, fat fish and different consumption levels of vegetables, including those containing vitamin C. Group I patients preferentially reached for snacks in the form of fruits and vegetables which replaced sandwiches served prior to the diet modification. It should be borne in mind, however, that group II patients were more frequently treated with levomepromazine, which brings about vitamin C deficiency [32].

Many other factors contributed to the reduction of total cholesterol in the patients; noteworthy was the significantly increased uptake of dietary fibre. It enhances the removal of bile acids and their salts from the intestine, directs cholesterol to the bile acid pool, and reduces the amount of cholesterol available for incorporation into lipoproteins [33]. Effects of increased consumption of dietary fibre (particularly its soluble fractions) [34] were additionally augmented by the increased vitamin C uptake. Both components jointly control the activity of HMGCoA reductase, a key enzyme in cholesterol synthesis pathway [35].

Reduction of the blood total cholesterol concentration could have been also enhanced by the decline in animal protein intake, accompanied by an increased uptake of folates and vitamin B_6. Those vitamins are important for protein metabolism, particularly in metabolism of methionine. When their uptake is not correlated with dietary protein consumption, methionine is not metabolized properly and homocysteine is produced. Excess homocysteine adversely affects, e.g., the vascular endothelium and may be responsible for an increased total cholesterol concentration in the blood [36].

The overall health-promoting dietary effects on the cholesterol concentration were also enhanced by increased consumption of dietary choline sources. Beneficial effects of choline are observed in the nervous system as well as in lipid transformations in the body, on account of choline being involved in lipid and cholesterol transport and metabolism.

Diet modifications involving, *inter alia*, reduction in simple sugar and animal protein consumption along with an increased uptake of probiotics and dietary fibre, would have to produce beneficial effects in intestinal microbiota composition and colon function. These effects might have been at the root of normalized defecation (including timing and frequency) reported by the respondents. As shown by literature data, the intestinal microbiota – in addition to its effects on carbohydrate-lipid metabolism [37] – may be also involved in the slow but consistent body weight reduction observed in patients [38].

When assessing overall effects of the modified diet composition on the studied metabolism, it should be added that – in addition to the effects of macrocomponents – important were also changes associated with increased uptake of vitamins, minerals and other biologically active components. This concerns primarily the, already mentioned, increased uptake of vitamin C and its antioxidant function, vitamin B_6 – active in glucose metabolism, and the usually deficient vitamin D, the concentration of which is correlated with, *inter alia*, HDL cholesterol [39]. The increased (by about 200% in relation to the initial level) vitamin D uptake following fish oil supplementation could have been involved in the HDL – cholesterol content increase observed in the study. Moreover, the significantly increased uptake of calcium could have contributed to changes in lipid transformations observed in the patients. Calcium deficiency has been demonstrated to stimulate calcitriol release, which increases cellular calcium ion absorption, lipogenesis rate and adipose tissue accumulation [40].

The mechanisms of dietary component effects on carbohydrate-lipid metabolism described above are, however, related not only to the presence of those components in the diet but also to their contents. The differences observed in responses to diet modification could have resulted from individual differences in how the patients followed dietary recommendations. It seems that schizophrenia patients, aware of metabolic disorders associated with their condition, which are augmented by the antipsychotics they were treated with, were more disciplined in following the recommendations. It also seems that applied polypharmacology could have been involved in the effects of diet modification on the studied parameters. Unfortunately, the available literature contains no relevant references.

On the other hand, a poorer result of the diet modification on the studied parameters in group I females seems to be a gender-specific effect, a known metabolism disorder risk factor in schizophrenia [41], rather than to the female patients being less willing to follow the dietary recommendations. It was the female patients who – when they were losing weight – were the most motivated to follow the recommendations (e.g., to give up sweets and caffeinated sweet beverages; to limit their coffee consumption to 1 cup a day; to eat the prescribed amounts of vegetables and fruits). As shown by data the author obtained in numerous studies, weight loss awareness is of paramount importance for women. Neither the actual body weight nor the age or the illness (the mental illness in this case) change the women's willingness to lose weight [3, 5, 42, 43].

Conclusions

Analysis of the obtained results allowed to conclude that:

(1) Chronically mentally ill patients are capable of following, with full acceptance and cooperation, rules of correct nutrition;
(2) Changes in nutritional habits are reflected in numerous body functions being improved, including improvements in carbohydrate-lipid metabolism indicators;
(3) Effects of changes in nutritional habits were so strong that beneficial, frequently statistically significant changes in concentrations of glucose, triacylglycerols, total cholesterols and its fractions HDL and LDL, were observed also in antipsychotics-treated schizophrenia patients.

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