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EFFECTS OF DIET MODIFICATION AND THE RESULTANT BODY WEIGHT LOSS ON BODY COMPOSITION IN OBESE MENOPAUSAL WOMEN

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Key words: obese women, menopausal, diet correction, body composition

The experiment was aimed at determining effects of health-promoting nutritional education and changes in dietary habits of menopausal women and their body weight loss on the composition of their body.

Fourth-month nutrition-awareness education resulted in a reduction of dietary energy content, total protein consumption (including uptake of animal protein), total fat (including saturated fats), cholesterol, sucrose, and Na. On the other hand, an increase was recorded in the consumption of plant protein, starch, dietary fibre, vitamin B_6, PP and beta-carotene as well as mineral components – K, Ca, Mg, Zn and liquid. Those changes were accompanied by slow, but steady, reduction of body weight (from 86.7±8.5 to 80.7±8.2 kg), and a reduction of BMI (from 33.3±3.5 to 31.3±3.4), WHR (from 0.87±0.09 to 0.84±0.07), and WHtR (from 0.65±0.06 to 0.60±0.06).

A change in body composition involving not only a significant reduction in the fat proportion (from 46.6±5.9 to 41.8±4.1%) and an increase in the fatless body weight (from 51.3±5.3 to 57.2±3.6%) and water content (from 39.1±3.4 to 42.8±3.6%), but primarily a true reduction of the body fat content (from 38.7±7.9 to 33.3±6.7 kg), without any change in the fatless weight and water content were found as well.

INTRODUCTION

Numerous studies have already demonstrated that the composition of the body changes with age. Fatless body weight as well as bone mineral content and density are relatively constant until the age of about 40. Subsequently, the values of those parameters are observed to decrease both in women and in men. In addition, the rate of the fatless body weight reduction is faster in men, while women show a faster rate of a decrease in bone mineral content and density [Ito *et al*., 2001]. At the same time, body fat content, including that of the intra-abdominal fat, increases with age [Beaufrere & Morio, 2000; Ito *et al*., 2001]. Moreover, women at that age face the menopause associated with, *i.a*. a drop in the oestrogen content; in addition, their lifestyle changes as a result of a stabilised social situation and involves less physical exercising. Therefore, fat tissue accumulation becomes more of a medical than a cosmetological problem. The physician's recommendation that the woman patient lose weight results in her making various attempts towards slimming. Those most frequently tried attempts include a drastic reduction of fat and complex carbohydrate consumption, reduction of diet's caloric value without changing diet composition, a significant increase in diet's protein content, drinking popular "digestive" teas or infusions, and following different diets "prescribed" by the popular press. All those efforts are geared towards a single goal: a rapid body weight loss. The faster and the larger the loss, the shorter duration of the selected dietary behaviours. And yet, the first days – or even weeks – of the slimming diet enhance primarily the loss of water or of fatless body weight, which – in view of the lack of change in relevant metabolic pathways – does not bode well with respect to systematic and persistent loss of fat tissue.

As the author has for years been involved in healthy lifestyle promotion and nutritional education among menopausal women, resulting in, *i.a.,* body weight loss (from 4.5 to 12.5 kg during 4 months of education) due to changed dietary habits, it was deemed interesting to follow the accompanying changes in the composition of the body.

MATERIALS AND METHODS

The study involved 42 women aged 48–58 years, the BMI values of which ranged from 29.7 to 41.8.

The women volunteered to participate in a 4-month-long health-promoting nutrition-awareness course that spanned from October until the end of January. Classes (two 45-min lessons) were held once a week. The curriculum covered information on the fundamentals of alimentary tract function and the resultant dietary recommendations; the role in physiology, sources of, and demand for basic nutrients, vitamins, micro- and macroelements; the importance of water uptake for the alimentary system and for the total water budget of the body; acid-alkali equilibrium in nutrition; nutrition-based prophylaxis of heart disease, insulin-independent diabetes, and cancer (including diet-dependent cancer, with a

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particular attention to colon and breast cancer). The classes focused also on numerous other aspects of human physiology, nutrition physiology, dietetics, and correct meal arrangement and preparation.

In the second week of the course, the subjects' diets were analysed in detail and modified for each women individually, the modifications involving timing, magnitude, and type of meals and adjustment of various nutrients to individual demands. It was stipulated that daily protein consumption amounted to 0.8 g/kg of body weight current, ±30% being supplied with animal protein; due to the second and third degree obesity among the women, it was recommended that fats contribute not more than 25%, but not less than 20% of the daily food energy content and that carbohydrates account for 60–65% of the daily food energy content. Diet composition was changed by substituting poultry and fish for fatty meat and meat products, low-fat cottage cheese and yoghurts for fatty dairy products (hard cheeses, spread cheeses, fatty yoghurts, *etc*.). Sweetened dairy products (*e.g*., flavoured yoghurts and spreads) were substituted with natural ones; candies and sucrose-containing products were substituted with increased amounts of coarse grits, pasta, brown rice, beans, pea, whole-flour bread, *etc*. It was made sure that the diets contained natural sources of choline, involved in mobilisation and transport of neutral fats, particularly from the liver. It was also stipulated that the diets contain higher amounts of vegetables and seasonal native fruits, particularly apples. The patients were recommended to drink more fluids in the form of clean, boiled water in place of 3–4 cups of coffee or sweetened and sparkling soft drinks. All the recommendations that involved both the principles of nutrition physiology and individual needs of each subject, were in agreement with the programme of food consumption and nutrients for the inhabitants of Poland for 2000 [Sekuła *et al*., 1991] and with nutrition standards for the inhabitants of Poland [Ziemlański *et al.,* 1995].

The question of lowering the diet's caloric value was not raised for three reasons. Firstly, the women participating in the education had already, many times and unsuccessfully, followed low-calorie diets and had formed unpleasant associations. Secondly, the diet modified as described, receiving basic nutrients from altered sources and prepared in a modified manner, almost automatically becomes lower in calories. Thirdly, lowered caloric value of a diet always induces a reduction in the basic metabolism, health-oriented recommendations with respect to nutrition being difficult to follow at reduced food rations.

METHODS

Information on diets and dietary habits of the subjects was collected twice. Having received appropriate instruction, the women recorded the timing, type, and amount of food they consumed on 3 randomly selected days (24-h periods) of the week. The written records were supplemented with information obtained from interviews with each subjects. The diets were recorded in early October; once the diet was modified and a few basic principles adopted, another set of records was obtained in early December. The food ration amount was assessed according to the "Album of photographs of food products and dishes" [Szponar *et al*., 2000]. The data were processed with a computer software Dietetyk® ver. 2.5, manufactured by JuMaR.

Composition of the body was determined twice: before and after the nutrition course, the bioimpedance technique and a Maltron device being used as recommended for a correct measurement.

Body weight was determined using a doctor surgery's scales, once a week; care was taken to observe identical conditions of weighing in each case. The Body Mass Index (BMI) was calculated from the formula: body weight (kg)/height (m)^2; the Waist/Hip Ratio (WHR) was calculated as a ratio of waist circumference to hip circumference; the Waist/Height Ratio (WHtR) was calculated as a ratio between waist circumference to height. During the nutrition course, the participants did not change their respective life styles, particularly with regard to physical exercises, which was related not only to the women being obese and lacking relevant habits, but also to the fact that the classes took place in October-January, *i.e.* months which, in the women's opinion, were not conducive even to taking a walk.

Data treatment. The data were subjected to statistical treatment (paired variables test) with the computer Statistica® software.

TABLE 1. Energy value and basic nutrients levels in daily food rations of women before and after the nutrition awareness course ($\bar{x}$ ± SD, n = 126 menus).

Components	Before education	After education
Energy (kJ)	10600±1834	9160 ± 792*
(kcal)	2650±426	2290±242*
Total protein (g)	90.4±24.1	71.6±19.1*
Animal protein	61.6±27.6	29.6±16.8**
Plant protein	28.8±6.9	42.0±8.9**
Total carbohydrates (g)	325.6±60.1	338.2±51.5
Starch	219.2±67.3	279.1±49.9**
Sucrose	118.2±19.7	38.6±7.1**
Lactose	14.2±6.7	27.8±6.3**
Dietary fibre (g)	19.7±8.1	38.6±15.2**
Total fat (g)	98.1±23.7	61.8±17.9**
Saturated fatty acids	73.1±23.3	32.6±16.3**
Unsaturated fatty acids	25.0±18.7	29.2±15.9**
Cholesterol (mg)	392.3±107.4	182.1±68.3
Vitamins :		
Beta-carotene (mg)	3.64±2.92	5.87±1.42*
E (mg)	7.2±4.8	10.9±2.1
C (mg)	62.1±48.7	82.4±41.9
B_6 (mg)	1.25±0.48	2.08±0.49**
PP (mg)	12.1±3.2	16.2±3.8**
Minerals components:		
K^+ (mg)	2700±600	4200±800*
Na^+ (mg)	2600±1100	1450±450**
Ca^{++} (mg)	480.0±370.0	760.0±210.0**
Mg^{++} (mg)	196.4±69.4	298.6±58.2**
Zn^{++} (mg)	8.1±2.9	11.4±3.9*
Liquids (mL)	970±154	1680±120**

*,** difference significant at p=0.05 and p=0.01

RESULTS

As analysed before modification, the mean energy content of a daily food ration was clearly higher than that recommended by nutritional standards [Ziemlański *et al*., 1995]. It was associated with an excessive intake of animal proteins, sucrose, total fats (including saturated fats) and cholesterol (Table 1) and was reflected in distribution of energy contributed by individual nutrients (Table 2). The modified diets were found to be lower in energy content and fat contribution to it, the contribution of complex carbohydrates being increased. The uptake of vitamins, mineral components, and fluids changed for the better as well. The change in the dietary energy content and in proportions of basic nutrients resulted from altered amount, type, and source of nutrients consumed. A statistically significant increase in the consumption of grain and dairy products, potatoes, vitamin C and beta-carotene-containing fruits and vegetables, and pulses was recorded. On the other hand, the intake of eggs, meat, meat products, sugar and candies was reduced significantly (Table 3).

TABLE 2. Per cent contribution of protein, carbohydrates, and lipids to the total energy content of daily food rations of women before and after the nutrition awareness course (n = 126 menus).

Index	Before education	*After education*
Protein	14.3	13.1
Carbohydrates	51.6	61.9
Fat	34.0	24.8
Saturated	25.4	13.0
Unsaturated	8.6	11.8

TABLE 3. Consumption of the selected groups of products by women before and after the nutrition awareness course ($\bar{x}$ ± SD, n=126 menus).

Component	Before education	After education
Cereals (g) [1)]	186.2±98.8	302.5±57.1**
Dairy products (g) [2)]	195.1±112.3	610.9±78.2**
Eggs (g)	24.9±21.0	20.0±5.2*
Meat and sausages (g) [3)]	256.0±163.0	70.0±27.3**
Butter and cream (g) [4)]	40.3±27.5	11.1±5.0**
Other fats (g)	32.0±35.0	38.2±6.8
Potatoes (g)	68.0±42.0	150.0±42.0**
Vitamin C–containing fruit and vegetables (g)	128.0±115.0	320.0±98.0**
Beta-carotene–rich fruit and vegetables (g)	65.0±72.9	168.0±35.3*
Other fruit and vegetables (g)	96.0±71.5	650.0±50.0**
Pulses (g)	0.8±1.3	25.5±7.0**
Sugar and sweets (g) [5)]	110.7±39.0	20.0±4.5**

[1)] converted to flour; [2)] converted to milk; [3)] converted to meat with bones; [4)] converted to butter; [5)] converted to sugar; **,* – difference significant at p=0.05 and p=0.01

TABLE 4. Changes in body weight, BMI, WHR and WHtR of obese women exposed to 4-month-long health-enhancing nutrition awareness course ($\bar{x}$ ± SD, n=42).

Index	Before education	After education
Body weight loss (kg)	86.7±8.5	80.7±8.2**
BMI	33.3±3.5	31.3±3.4**
WHR	0.87±0.09	0.84±0.07**
WHtR	0.65±0.06	0.60±0.06**

*,** difference significant at p=0.05 and p=0.01

The reduction in body weight of the course participants, steady but varying in intensity between the women, was reflected in the changes of their BMI and WHR (Table 4).

Changes were also observed in body composition. A significant reduction in fat per cent was recorded, accompanied by a significant increase in per cent fatless body weight and water content (Table 5). The absolute values showed a significant decrease in the body fat content, accompanied by small changes in the fatless body weight and water (Table 5).

DISCUSSION

The data on effects of a 4-month health-promoting nutrition-oriented education among obese women showed that the education resulted in a number of nutritionally advantageous changes which have already been described in the author's earlier publications [Friedrich, 1997, 1998, 2005].

Generally, the overall effect involved a reduction in the diet's caloric content and correct partitioning of energy uptake between the major nutrients as well as an increased consumption of vegetables, fruits, and non-processed complex carbohydrates, which was reflected in an increased uptake of vitamins, minerals, and dietary fibre. Consumption of liquids increased significantly as well.

Reduction in the energetic content of the diet and the change in its composition, arrived at as a result of the education, lied at the roots of a slow, albeit constant body weight reduction of the women subjects, which was positively correlated with a reduction of their BMI, WHR, and WHtR.

TABLE 5. Effects of health-promoting nutritional education and changed dietary habits on composition of the body ($\bar{x}$ ± SD, n=42).

Index	Before education	After education	Difference
Fat content (%)	46.6±5.9	41.8±4.1**	
Fat content (kg)	38.7±7.9	33.3±6.7**	-5.4±0.8 = 90%
Fatless body weight content (%)	51.3±5.3	57.2±3.6**	
Fatless body weight content (kg)	45.7±4.8	45.2±3.8	-0.5±0.18 = 8.3%
Water content (%)	39.1±3.4	42.8±3.6*	
Water content (kg)	33.9±3.3	33.8±2.7	-0.1±0.06 = 1.7%

*,** difference significant at p=0.05 and p=0.01

That, in turn, was indicative not only of a decrease in the total amount of fat in the subjects' bodies, but also of an improved hormonal and metabolic status. As demonstrated by Krotkiewski *et al*. [1983] in their study on obese women and men, insulin release changes in proportion to changes in BMI, insulin removal from circulation by the liver being negatively correlated with WHR. The indices listed are also positively correlated with the extent of glycaemia. As reported by Lopatyński *et al*. [2003], BMI and WHtR showed the strongest correlation with glycaemia after exposure to glucose. In the experiment described, WHtR was the index that changed most (by about 7%), followed by BMI (a 6% change), and WHR (an about 3.5% change).

The body weight loss rate, particularly during the first two months of education, was associated with implementation of recommendations and their individual effects on the women subjects [Friedrich, 1997]. During the two subsequent months, the weight loss was associated with observance of the recommendations by the subjects, but apparently also with normalisation of metabolic pathways, induced by the correct diet. This effect is indicated by the significant decrease of WHR and WHtR in all the women.

The change in waist size and its ratio to hip circumference or height, particularly pronounced in menopausal women, was not related to body weight loss. As shown by Broda [2001], who studied women of different age groups (including menopausal subjects), physical exercises enhancing body weight reduction result in the loss of subcutaneous fat tissue, particularly that located on the legs and in the vicinity of armpits, and decrease the amount of hip fat, which – coupled with a lack of such changes in the waist – affects the WHR value.

With respect to the body composition determined prior to the modification of the diet, the fat content – important for the physiological assessment of a potential for metabolic disorders – was in 83% of the women much higher than that suggested by their BMI values. The body fat weight, even in those women whose BMI ranged within 29.7–30.0 (27% of all the subjects), was found to vary from 32.5 to 36.2 kg, which corresponded to 31.7 to 43.7% of the body fat tissue.

The fatless body weight, a good reference for the assessment of physiological and biochemical indicators of the body functions and providing information on the total content of muscle tissue, was found to amount, on average, to slightly more than half the body weight of the women. In 23% of the subjects, the fatless body weight was still lower and ranged within 44–49%.

This was accompanied by a water per cent concentration in the body lower than the recommended 46–65%. As few as 11% of the women showed body water content to be close to the lower limit of the recommended range. Water deficiency in the remaining women was observed to vary from 4.2 to 15.5% (6.9%), relative to the lower limit of the recommended range. The high variability of the body water content in the women examined could have been related to, *i.a*. wide differences in the fat tissue content between the women.

The changes in dietary habits, occurring during the 4 months of nutrition-oriented education, were found to affect the body composition in a significant manner. The most desired effect, in addition to the maximum body weight loss, was the loss of fat tissue, the per cent content of which in the body did decrease significantly. The absolute loss of fat tissue, averaging 5.4±0.68 kg, accounted for 90% of the average body weight loss. Referring to the results of the author's earlier studies, it should be added that the diet modification applied results in a higher (by the factor of 2.5) loss of visceral fat tissue, compared to the subcutaneous component [Friedrich, 2005]. The effect is enhanced primarily by the observed normalisation of blood concentrations of lipopoietic insulin and cortisol [Friedrich, 2005], responsible for the accumulation and location of the deposited fat tissue [Tessari, 2000]. The effect is rendered still more valuable due to the fact that, as shown by Słonka [1998], uncontrolled dieting may stimulate deposition of energetic substrates, whereby the body weight loss observed is associated primarily with the loss of the fatless body weight and water [Poskitt, 1995].

Changes in dietary habits elicited also a significant response from the per cent fatless body weight, which is an obvious effect when viewed in the light of the reduced body fat content. More important, however, is the fact that the absolute fatless body weight was maintained at an almost unchanged level. It was only in about 7% of the subjects (3 women) that the body weight loss observed was associated with a decrease in the fatless body weight and water content. The absolute fatless body weight in 30% of the women observing correct dietary habits for 4 months was observed to increase. And yet, a reduction in the fatless body weight is one of frequent effects accompanying inappropriate dieting aimed at slimming down [Poskitt, 1995]. Because the women participating in the experiment did not change their lifestyle, particularly with respect to physical exercise, the cause of the effect cannot be sought in the influence of physical exercise on the magnitude of muscle mass. It seems that improved sensitivity of insulin receptors, associated with diet modification, and insulin effect on amino acid and protein metabolism [Tessari, 2000] may be listed as one of the causes, the latter effect in the liver not diminishing even at a reduced muscle weight [Beaufrere & Morio, 2000].

The significant increase in the body water content, observed during the experiment, seems interesting from a physiological angle. Water, owing to its special physical and chemical properties as well as due to its accounting for most of the body weight, is regarded as one of major body components. Assays performed after 4 months of education showed the body water content to have increased, on average, from 39.1 to 42.8%; however, the water content still failed to reach 46%, the lower end of the recommended range. What makes the effect obtained still more interesting is that, considering the mean fat weight loss of 5.4 kg (which includes about 10% of water), the expected water loss should have amounted to an average of about 0.5 L.

One of the causes could involve a decrease, observed in earlier studies [Friedrich, 2005], in the concentration of cortisol which inhibits vasopressin release, which in turn enhances kidney function (filtration and water excretion) [Bass *et al*., 1984]. The effect observed could have been related to the increased potassium uptake. As shown by the recently published data, increased potassium consumption and absorption in kidney canaliculi is accompanied, on the one hand, by a reduced sodium absorption, regarded as a cause of blood pressure normalisation [Morris *et al*., 2006], observed during the experiment. On the other hand, the increased potassium uptake is accompanied by a reduced calcium excretion. As an intracellular ion, potassium is active in maintaining osmotic equilibrium and in water absorption by the cells, particularly the muscle ones, thus improving the muscle hydration.

Assessment of all the changes in the women's body composition allows concluding that the diet modification, primarily aimed at improving dietary habits and health, was advantageous not only for the body weight reduction, but also for the composition of the body. While allowing the women to lose fat tissue, it helped them to retain – or even to increase – the fatless body weight and body water content. The effects observed were conducive to increasing the subjects' fitness and well-being, despite the body weight reduction and the changes in dietary habits and menus the women had to introduce and adhere to.

CONCLUSIONS

Analysis of the results obtained allows concluding that the health-promoting education in nutrition, targeting obese menopausal women, significantly improved their dietary habits, which resulted – in addition to advantageous changes in body functions and self-perception – in:

1. a slow, albeit persistent, body weight loss, accompanied by a significant reduction in BMI, WHR, and WHtR;
2. a change in the composition of the body involving not only a significant reduction in the fat proportion and an increase in the fatless body weight and water content, but primarily a true reduction of the body fat content, without any change in the fatless weight and water content.

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WPŁYW KOREKTY DIETY I WYNIKAJĄCEJ STĄD UTRATY MASY CIAŁA NA JEGO SKŁAD U OTYŁYCH KOBIET W OKRESIE MENOPAUZALNYM

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W przeprowadzonym doświadczeniu badano wpływ prozdrowotnej edukacji żywieniowej i zmian nawyków żywieniowych na skład ciała kobiet w okresie menopauzy.

Stwierdzono, że czteromiesięczna edukacja żywieniowa spowodowała obniżenie wartości energetycznej diety, obniżenie spożycia białka ogółem, w tym białka zwierzęcego, tłuszczów ogółem w tym tłuszczów nasyconych, cholesterolu i sacharozy. Wzrosło natomiast spożycie białka roślinnego, skrobi, błonnika pokarmowego, witamin B_6, PP i beta–karotenu oraz składników mineralnych Ca, Mg, Zn i płynów (tab. 1). Zmianom tym towarzyszyła powolna ale systematyczną redukcja masy ciała oraz obniżanie się wartości wskaźników BMI, WHR i WHtR (tab. 4) oraz zmiany składu ciała polegające nie tylko na istotnym obniżeniu odsetka tłuszczu i wzroście odsetka beztłuszczowej masy ciała i wody, ale na rzeczywistym obniżeniu zawartości tłuszczu w ciele, przy braku zmian zawartości masy beztłuszczowej i wody (tab. 5).