Protein intake and body weight

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SUMMARY

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According to the World Health Organization, overweight and obesity affected 1.9 billion people worldwide in the year 2016. Changes in civilization, lifestyle and eating habits have become the main causes of obesity, which is associated with the occurrence of diseases, such as hypertension, ischemic heart disease and type 2 diabetes. Every change of diet and lifestyle should be individual. However, monitoring of energy provided with food combined with a moderate increase in protein intake may be an effective strategy for weight reduction, since protein influences metabolism and satiety. Studies on the prevention and treatment of obesity have shown that a diet with an increased protein content can affect metabolism and thus play an important role in regulating body weight, and create favorable conditions for maintaining adequate body weight after initial body weight reduction. A moderate increase in the protein supply into the diet and controlled supply of kilocalories, together with physical activity, can facilitate weight reduction.

Key words: *protein, obesity, body weight, nutrients*

STRESZCZENIE

Spożycie białka a masa ciała

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Światowa Organizacja Zdrowia podaje, że w 2016 roku nadwaga i otyłość dotyczyła 1,9 mld osób na świecie. Rozwój cywilizacji oraz idące wraz z nim zmiany w stylu życia populacji, zmiany w sposobie żywienia, stają się głównymi przyczynami wstępowania otyłości, która wiąże się z występowaniem takich chorób jak: nadciśnienie tętnicze, choroba niedokrwienna serca oraz cukrzyca typu 2. Każda zmiana diety oraz stylu życia powinna być spersonalizowana, jednak kontrola dostarczanej wraz z pokarmem energii w połączeniu z umiarkowanym zwiększeniem spożycia białka pokarmowego może stanowić skuteczną strategię redukcji masy ciała, poprzez wpływ tego składnika pokarmowego na metabolizm oraz odczuwanie sytości. Badania skupiające się na prewencji i leczeniu otyłości pozwoliły na stwierdzenie, że diety o zwiększonej zawartości białka, poprzez oddziaływanie na metabolizm, odgrywają rolę w regulacji masy ciała oraz zapewniają odpowiednie warunki do utrzymania odpowiedniej masy ciała po procesie jej redukcji. Umiarkowane zwiększenie podaży białka w diecie oraz kontrolowana podaż kilokalorii wraz z podejmowaniem aktywności fizycznej może przyczynić się do usprawnienia procesu redukcji masy ciała.

Słowa kluczowe: *białko, otyłość, masa ciała, składniki pokarmowe*

Protein is the main building block of human body tissues and biologically active compounds. It influences metabolic processes and ensures proper body condition, growth and development, as well as regeneration of damaged tissues, e.g. during wound healing [1].

The best food sources of protein are milk and its products, eggs, poultry, fish and meat of farm animals. Cheese, quark and milk contain 16-31%, 16-21% and 1-3% of protein, respectively. The best sources of meat protein are veal, mutton, beef and pork. Protein

content in poultry varies between 18 and 23%, whereas in fish it ranges from 16 to 19%. In Asian countries, the main food sources of protein are pulses, which contain 21-25% of this nutrient [1].

Current average protein intake (76 g per day per person) is lower than in the 1970s, 1980s and 1990s, when it exceeded 80 g or even 90 g. The downward trend appeared in the mid-1990s and resulted from limiting the intake of vegetable protein, which had prevailed in the diet until the mid-1970s [2].

RELATIONSHIP BETWEEN THE AMOUNT OF DIETARY PROTEIN AND BODY WEIGHT

Research into the impact of high-protein diets on body weight has shown that the diets influence mainly satiety and postprandial thermogenesis [3]. *Samaha* [4] examined the relationship between the high-protein diet and weight reduction among 132 obese people. In his study, a high-protein, low-carbohydrate diet, in which 22% of the energy came from the protein, was followed by 64 people, whereas the remaining 68 people were on a low-fat, high-carbohydrate diet, which provided 16% of energy from protein. The diets led to the reduction of body weight by 5.8 kg in the first group and by 1.9 kg in the second group.

Another researcher who conducted a study on obese persons was *Brehm* [5]. In his study, forty-two obese women were divided into two groups: 20 persons (group 1) were on a diet with reduced fat content, in which 17% of energy came from protein, and the remaining 22 persons (group 2) followed a low-carbohydrate diet, in which 23% of energy came from protein. After six months, body weight in the first group was reduced by 8.8 kg on average. Weight reduction in the second group was significantly lower –3.9 kg on average. In another study that was conducted on a group of 119 overweight persons following a high-protein, low-carbohydrate diet for six months (26% of energy came from protein), body weight was reduced by 12.9%. This is almost double the effect that was achieved by persons whose diet provided 19% of energy from protein, as this group reduced their body weight by 6.7% [6].

Two short-term studies also show a positive influence of the high content of protein in the diet on weight reduction. In a 4-week study, 13 obese men with hyperinsulinemia were divided into two groups. The first group obtained 45% of energy from protein, whereas in the second group 12% of energy came from protein. After 4 weeks, the group who consumed more protein reduced the body weight by 2.3 kg more, as compared to the other group (8.3 kg vs 6 kg) [7]. A two-week study in 21 overweight women showed that 11 women who were on a diet, in which 49% of energy came from protein, reduced their body weight by 5.5 kg, while the remaining group of 10 women, who were on a diet assuming 21% of energy from protein, reduced their weight by 3.95 kg [8].

Weigle [9] conducted a study that compared the effects of an isocaloric high-protein diet and a normal protein diet, which was not focused on weight reduction. In a group following the isoenergetic diet (30% energy from protein, 20% from fats and 50% from carbohydrates) the feeling of satiety was increased, and the body weight remained stable during the one-week diet. The same group followed then an identical diet with the same proportion of macronutrients *„ad libitum"* for six weeks. The feeling of satiety did not change, and body weight reduction by 4.9 kg was observed. In another study, a high-protein diet was compared with a control diet in order to estimate weight reduction over a period of six months. The study group consisted of obese persons on a diet, with 25% of energy from protein, 45% from carbohydrates and 30% from fats. The control group was on a diet providing 12% of energy from protein, 58% from carbohydrates and 30% from fats. Reduction of weight (8.5 kg vs 5.1 kg) and body fat (7.6 kg vs 4.3 kg) was significantly higher in the group following the high-protein diet [10].

Researchers suggest that following a high-protein diet *„ad libitum"* is more effective in reducing body weight. Persons on a non-energy-restricted diet eat less than those on an isoenergetic diet [9]. A negative energy balance, which can often be observed, is probably caused by a decrease in the amount of energy from food, which results from increased satiety and postprandial thermogenesis [11,12].

ROLE OF PROTEIN IN MAINTAINING BODY WEIGHT

Even a small increase in the amount of energy from protein in a diet can show beneficial effects. Following a high-protein diet for six months reduced the risk of returning to an earlier weight in overweight persons who had lost 5-10% of body weight during a four-week low energy diet [13]. Another study focused on body weight control, which was conducted among persons who were on a four-week low-energy diet, showed that return to the previous body weight was lower by 50% in the group whose diet provided 18% of energy from the protein, compared to the group whose diet provided 15% of energy from protein [14].

A study on overweight and obese persons showed that the *„ad libitum"* diet, in which 18% of energy came from protein, resulted in a further increase in body weight of 1 kg, three months after a four-week slimming treatment finished. For comparison, a diet

providing 15% of energy from protein, caused an increase in body weight by 2 kg [15]. In his study, *Lejeune* showed that weight gain in the group of persons on a high-protein diet, who had previously reduced their weight, was 0.8 kg compared to the control group, where the weight increased by 3 kg [13]. After one year, these values rose to 1 kg in the study group and 3.9 kg in the control group [16].

RELATIONSHIP BETWEEN THE TYPE OF DIETARY PROTEIN AND BODY WEIGHT

Mikkelsen compared the effects of low-fat diets on the body weight of 12 overweight and obese men. All diets were isoenergetic but they contained different amounts of protein: *„pork diet"* provided 29% of energy from protein, *„soy diet"* – 28%, and *„carbohydrate diet"* – 11%. The daily energy expenditure measured in the breathing chamber was greater in those on the *„pork diet"* and *„soy diet"* compared to the *„carbohydrate diet".* This result proves that the vegetable protein and animal protein have a greater thermogenic effect than carbohydrates, which may be important for the treatment of overweight and obesity [17].

A study by *Bosello* aimed at comparing the effect of soy and casein on weight reduction in obese patients. Participant to the study were divided into two groups. The source of protein in the first group was casein, and in the second group it was soy. Both diets were low in energy and contained the same amount of protein. The study resulted in similar body weight reduction in both groups [18].

Another study conducted in a group of 36 obese women compared the effects of two weight reduction diets. The main source of protein in one diet was red meat, whereas in the other diet it was soybeans. After sixteen weeks, body weight was reduced by 9% in both groups. A decrease in the WHR index was also observed, which was caused by the reduction of intra-abdominal fat [19].

Deibert compared effects of three different interventions: healthy lifestyle education, and introduction of a low-fat diet with increased protein content (protein source was soy) combined with physical activity or no physical activity. The interventions were made among ninety obese persons, each of whom was randomly assigned to one intervention for the period of six months. The result of the study was BMI reduction by 2-3 kg/m in all participants to the study. However, those who followed an intervention program based on the combination of a diet and physical activity, or on a diet only, reduced their body weight more significantly than those whose who were subject to healthy lifestyle education intervention [20].

Two researchers, *Anderson and Hoie,* compared the impact of soy and dairy replacements for meals on weight reduction among obese people, who were on a low-energy diet of 1200 kilocalories per day. Participants to the study were randomly assigned to two groups: the first group consumed 5 liquid soy meal replacements, whereas the other one had 2 liquid milk meal replacements. After twelve weeks, persons who consumed soy replacements reduced their body weight by 9%, compared to those who consumed milk replacements and reduced their weight by 7.9% [21].

CONSEQUENCES OF PROTEIN OVERCONSUMPTION

Many popular slimming diets (the *Dukan* protein diet, the *South Beach* diet) assume increasing protein intake and reducing carbohydrate intake to reduce the amount of calories in a diet [22]. These diets set protein intake at the level of 71-162 g per day, which significantly deviates from the recommended daily intake, which is 46 g per day for a healthy woman with a body weight of 70 kg, or 56 g per day for a healthy man [23].

Previous studies on high-protein diets reveal their impact on the functioning of kidneys and liver, and on blood lipid concentration. A study by *Samaha* [4] compared the influence of a low-carbohydrate, high-protein *Atkins* diet and a low-fat diet on the lipid profile of obese persons. Persons who followed a high-protein diet showed a higher decrease in the concentration of triglycerides in blood (a decrease of 30%) compared to the other diet (a decrease of 4%). However, the author of the study indicated that the group following a high-protein diet achieved higher weight reduction, which probably caused a greater decrease in the blood triglycerides concentration. A positive effect of high-protein diets on lipid concentration requires further research, since it has not been confirmed in other studies [24, 25].

Short-term studies show that an increased protein intake can be associated with higher renal calcium excretion and persistent negative calcium balance.

A high-protein diet, in which the main protein source is animal protein, can acidify the body and lead to an increased activity of osteoclasts responsible for bone destruction processes, and to a reduced activity of osteoblasts, which are osteogenic cells. Another negative effect of this diet is an increased loss of calcium in the urine, which contributes to the negative calcium balance. It was observed that persons who consumed 2 g of protein per kilogram of body weight showed an increased urinary calcium excretion, compared to the group consuming 0.7-1 g of protein per kilogram of body weight per day [26].

The product of protein metabolism is urea. By providing excessive amounts of protein, a high-protein diet results in a positive nitrogen balance and increased production of urea. This negatively affects kidneys and liver, which is where the protein metabolism takes place [27]. It has been proved that a diet rich in protein can cause progression of the non-alcoholic fatty liver disease [28]. A 4-year study conducted among 45 thousand men aged 40-75 showed that increased consumption of animal protein was directly related to the risk of nephrolithiasis [26]. Other studies indicated an increased risk of uric acid stones and kidney calcium stones [29].

Individuals diagnosed with 1 or 2 metabolic syndrome disorders who are on a high-protein diet are more likely to experience microalbuminuria (increased risk by 80%), whereas those with 3 disorders are at an increased risk of developing it (increased risk by 130%) [30].

In a study by *Haring et al*. [31] conducted in 1987-1989 among 11,952 adults aged 44-66 who had no diabetes or cardiovascular diseases, and had an estimated glomerular filtration rate (eGFR) ≥60 ml/minute/1.73 m^2 over the 23-year observation period, there were 2,632 cases of chronic kidney disease (CKD). It was also shown that the consumption of red and processed meat was associated with an increased risk of the CKD. In contrast, higher consumption of nuts, legumes and low-fat dairy products showed a protective effect against the development of CKD. Furthermore, consumption of red meat is associated with an increased risk of ischemic stroke; however, it has not been proved that generally high protein intake in the diet can affect the risk of *„silent"* stroke [32].

In the light of current data, high protein intake has no impact on the risk of prostate cancer [33] and ovarian cancer [34].

It should also be noted that there are certain conditions which require increased protein intake, e.g. a wasting syndrome or extensive burns [1].

SUMMARY

Although a diet with increased protein content can be followed by healthy persons, extreme caution should be exercised. Increased intake of protein causes rapid excretion of calcium by kidneys, which can result in the development of osteoporosis. Supply of large amounts of animal protein in a diet can contribute to kidney stones.

REFERENCES

1. Jarosz M, Rychlik E, Stoś K, et al.: Normy żywienia dla populacji Polski. *Instytut Żywności i Żywienia,* Warszawa, 2017.
2. Laskowski W.: Wartość odżywcza diety Polaków oraz jej zmiany. – w – Wolska-Adamczyk A. (red.): Współczesne kierunki działań prozdrowotnych. *Wyd. Wyższej Szkoły Infrastruktury i Zarządzania w Warszawie,* 2015.
3. Westerterp-Plantenga MS, Luscombe-Marsh ND, Lejeune MPGM, et al.: Dietary protein, metabolism and body-weight regulation: dose response effects. *IJO*, 2006; 30: 16-23
4. Samaha FF, Iqbal N, Seshardi P, et al.: A low carbohydrate as compared with a low fat diet in severe obesity. *N Eng J Med,* 2003; 348: 2074-2081.
5. Brehm BJ, Seeley RJ, Daniels SR, et al.: A randomized trial comparing a very low carbohydrate diet and a calorie restricted low fat diet on body weight and cardiovascular risk factors in healthy women. *J Clin Endocrin Metab*, 2003; 88: 1617-1623.
6. Yancy WS Jr, Olsen MK, Guyton JR, et al.: A low-carbohydrate, ketogenic diet versus a low-fat diet to treat obesity and hyperlipidemia: a randomized, controlled trial. *Ann Int Med*, 2004; 140: 769-777.
7. Baba NH, Sawaya S, Torbay N, et al.: High protein vs high carbohydrate hypoenergetic diet for the treatment of obese hyperinsulinemic subjects. *Int J Obes*, 1999; 23: 1202-1206.
8. Worthington BS, Taylor LE.: Balanced low calorie vs high protein, low carbohydrate reducing diets. *J Am Diet Assoc,* 1974; 64: 47-51.
9. Weigle DS, Breen PA, Matthys CC, et al.: A high – protein diet reduces sustained reductions in appetite, ad libitum caloric intake, and body weight despite compensatory changes in diurnal plasma leptin and ghrelin concentrations. *Am J Clin Nutr*, 2005; 82: 41-48.
10. Due A, Toubro S, Skov A, et al.: Effect of normal-fat diets, either medium or high in protein, on body weight in overweight subject: A randomized 1-year trial. *Int J Obesity Related Metab Disord,* 2004; 28: 1283-1290
11. Astrup A.: The satiating power of protein – a key to obesity prevention? *Am J Clin Nutr*, 2005; 82: 1-2.
12. Raben A, Agerholm-Larsen L, Flint A.: Meals with similar energy densities but rich in protein, fat, carbohydrate, or alcohol have different effects on energy expenditure and substrate metabolism but not on appetite and energy intake. *Am J Clin Nutr*, 2003; 77: 91-100.
13. Lejeune MP, Kovacs EM, Westerterp-Plantenga MS.: Additional protein in taje limits weight regain after weight loss in humans. *Br J Nutr*, 2005; 93: 281-289.
14. Watford M.: Is the small intestine a gluconeogenic organ? *Nutr Rev*, 2005; 63: 356-360.
15. Westerterp-Plantenga MS, Lejeune MP, Nijs I, et al.: High protein intake sustains weight maintenance after body weight loss in humans. *Int J Obes*, 2004; 28.1: 57-64.
16. Westerterp-Plantenga MS, Rolland V, Wilson SA, et al.: Satiety related to 24h diet-induced thermogenesis during high protein/carbohydrate vs high fat dietes measured in a respiration chamber. *Eur J Clin Nutr*, 1999; 53: 495-502.
17. Mikkelsen PB, Toubro S, Astrup A.: Effect of fat reduced diets on 24h energy expenditure: comparisons between animal protein, vegetable protein and carbohydrate. *Am J Clin Nutr*, 2000; 72: 1135-1141.
18. Bosello O, Cominacini L, Zocca I, et al.: Short- and long-term effects of hypocaloric diets containing proteins of different sources on plasma lipids and apoproteins of obese subjects. *Ann Nutr Metab*, 1998; 32: 206-214.
19. Yamashita T, Sasahara T, Pomeroy SE, et al.: Arterial compliance, blood pressure, plasma leptin, and plasma lipids in women are improved with weight reduction equally with a meat based-diet and a plant-diet. *Metabolism,* 1998; 47: 1308-1314.
20. Deibert P, Konig D, Schmidt-Trucksaess A, et al.: Weight loss without losing muscle mass in pre-obese and obese subjects induced by high-soy-protein diet. *Int Obes Relat Disord,* 2004; 28: 1349-1352.
21. Anderson JW, Hoie LH.: Weight loss and lipid changes with low-energy diets : comparator study of milk-based versus soy-based liquid meal replacement interventions. *J Am Coll Nutr*, 2005; 210-216.
22. Bravata DM, Sanders L, Huang Jea: Efficacy and safety of low-carbohydrate diets: A systematic review. *JAMA*, 2003; 289: 1837-1850.
23. Bernstein AM, Trezyon L, Li Z.: Are high-protein, vegetable-based diets safe for kidney function? A review of literature. *J Am Diet Assoc*, 2007; 107: 644-650.
24. Skov AR, Toubro S, Ronn B, et al.: Randomized trial on protein vs carbohydrate in ad libitum fat reduced diet for treatment of obesity. *Int J Obes*, 1999; 23: 528-536.
25. Alford BB, Blankenship AC, Hagen RD.: The effects of variations in carbohydrate, protein, and fat content of the diet upon weight loss, blood values, and nutrient intake of adult obese women. *J Am Diet Assoc*, 1990; 90: 534-540.

26. Eisenstein J, Roberts SB, Dallal G, et al.: High protein weight loss diets: are they safe and do they work? A review of the experimental and epidemiologic data. *Nutr Rev*, 2002; 60: 189-200.
27. Apfelbaum WSP, Vague P, Ziegler O, et al.: Long-term maintenance of weight loss after a very-low-calorie diet: a randomized blinded trial of the efficacy and tolerability of sibutramine. *Am J Med*, 1999; 106: 179-184.
28. Kim CH, Kallman JB, Bai C, et al.: Nutritional assessments of patients with non-alcoholic fatty liver disease. *Obes Surg*, 2010; 20: 154-160.
29. Hess B, Ackermann D, Essig M, et al.: Renal mass and serum calcitriol in male idiopathic calcium renal stone formers: role of protein intake. *J Clin Endocrionol Metab*, 1995; 80: 1916-1921.
30. Hoehner CM, Greenlund KJ, Rith-Najarian S, et al.: Association of the insulin resistance syndrome and microalbuminuria among nondiabetic native Americans. The Inter-Tribal Heart Project. *J Am Soc Nephrol*, 2002; 13: 1626-1634.
31. Haring B, Selvin E, Liang M, et al.: Dietary Protein Sources and Risk for Incident Chronic Kidney Disease: Results From the Atherosclerosis Risk in Communities (ARIC) Study. *J Ren Nutr*. 2017; 27(4):233-242.
32. Haring B, Misialek JR, Rebholz CM, et al.: Association of Dietary Protein Consumption With Incident Silent Cerebral Infarcts and Stroke: The Atherosclerosis Risk in Communities (ARIC) Study. *Stroke*. 2015; 46(12):3443-50.
33. Mao Y, Tie Y, Du J.: Association between dietary protein intake and prostate cancer risk: evidence from a meta-analysis. *World J Surg Oncol*. 2018; 16(1):152.
34. Pang Y, Wang W.: Dietary protein intake and risk of ovarian cancer: evidence from a meta-analysis of observational studies. *Biosci Rep*. 2018;38(6): pii: BSR20181857.

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