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CORRELATION OF PROTEIN CONTENT AND OTHER NUTRITIONS IN HUMAN DIET

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Abstract

To identify correlations between protein content and other components of the diet we evaluated the actual diet using method of analyzing frequency of food consumption (for two months) of 68 persons of different ages and genders.

The results of our studies revealed the ratio of protein and energy in the actual diets of the surveyed respondents which was a fairly stable value ranging from 3.03 ± 0.07 g/kcal in respondents aged 46 to 65 years to 3.75 ± 0.09 g/kcal in the group surveyed individuals aged 11 to 14 years.

Due to the fact that in the age group of 15 to 23 years 48 % of the respondents were found to be deficient in protein and energy below the approved standards, further correlation analysis of the content of protein and other nutrients in the diet was performed in this group. The respondents of this group were divided into 6 experimental groups according to the content of protein and energy in the diet.

Our studies revealed strong positive correlations between protein and energy content and protein and fats content in the diet with average correlation coefficients of 0.66 and 0.46, respectively, and a low correlation between protein and carbohydrates content, the correlation coefficient was 0.16.

Analysis of the structure of the actual diet revealed strong positive correlations of protein with B_6 and B_{12} vitamins of the diet and lack of correlation with vitamins A and C in all the experimental groups.

When analyzing correlations between content of protein and mineral elements of the diet we revealed strong positive correlations with an average correlation coefficient of 0.65 between protein and phosphorus and 0.36 between protein and sodium (0.36) as well as weak correlations with potassium, calcium and magnesium with correlation coefficients of 0.3, 0.25, and 0.22, respectively.

Key words: protein; energy; nutrient composition; analysis of food consumption frequency; method of actual nutrition estimation; protein and energy provision.

Introduction. Numerous studies have shown that nutrition disorders were often accompanied by various structural and functional changes in the organism as well as disorders of metabolism, homeostasis and its adaptive mechanisms.

In today's literature there is no single term that reflects the state of human nutrition. They often use such concepts as nutritional, food, trophological, protein to energy ratio, alimentary support, nutritional status, and status of nutrition which are essentially synonyms. The term "protein-energy deficiency" is used to denote nutritional status disorders [10]. Insufficient supply of protein and energy is accompanied with violation of nutritional support with the reduction of muscle mass and adipose tissue, and one of these changes can be more pronounced and differ in people of different ages.

According to the literature, a research was conducted in Europe by SENECA (Survey in Europe on Nutrition and the Elderly; a Concerted Action) dedicated to the studying of nutritional status of elderly patients [11]; this research showed that protein-energy deficiency combined with micronutrient deficiency was the main problem of elderly people in unorganized populations. Functional reorganization of the organ system, oral diseases, loss or reduction of ability to perform self-care, cognitive impairment, depression, loneliness and lack of resources are common causes of eating disorders, which in turn adversely affect the course of the diseases, life expectancy and quality of life of the elderly aged individuals [2, 3].

Numerous studies performed by domestic and foreign authors on children and adolescents established a correlation between dietary factors and morbidity in such classes of diseases as endocrine ones, eating disorders, metabolism, digestive organs, infectious and parasitic diseases etc. [1, 2, 4].

Development of protein-energy deficiency at this age has a negative effect on the completion of the genetic program of growth and development of the child, it leads to weight loss, disrupts the final formation of morphotype, sexual development and function of internal organs and causes changes in biochemical and immunological parameters which promotes early formation of chronic somatic pathology [3, 5].

Given the above, it is rather important to study a systematic approach to the study of correlations between protein and energy intake in the human diet with other food macronutrients as well as specific features of correlation of protein intake with macro-, micronutrients and vitamins in the diet.

Materials and methods. To solve this problem, an analysis of the actual diet of 68 persons of different ages and genders was done; these persons were divided into 3 age groups: 7 to 14 years, 15 to 23 years, and 24 to 65 years.

To assess the actual diet we applied a calculation method using a retrospective protocol of analyzing frequency of food consumption over a two-month period (questionnaire method using a specially prepared questionnaire filled out by the respondents themselves, it included 67 questions. It allows you to determine how frequently some product was consumed for a certain period of time, and amount of the food consumed is analyzed along with the frequency of consumption) [10]. The content of micro- and macronutrients in the diet of the surveyed individuals was calculated using a database of chemical composition of food.

The data derived were compared with the recommendations of the “Standards of physiological needs of the population of Ukraine in basic nutrients and energy” which were approved by order of the Ministry of Health of Ukraine of 2017-09-03 No. 1073.

Statistical processing of the research results was performed using “Excel” program, it included determination of the arithmetic mean (M), the mean error of the mean (m) and correlation analysis to assess reliability of the correlation coefficients. Differences were considered significant at a level of probability of error not exceeding 5 % ($p < 0.05$).

Results and their discussion. According to the results of the analysis of the actual nutrition of the respondents, the features of the protein-energy status of different age groups of the population were determined with the revelation of a number of discrepancies in the consumption of protein and energy with food. Assessment of the composition of the weighted

average diet of the surveyed persons revealed a variety of products general list of which included more than 60 items. At the same time, the qualitative characteristics of the latter also differed significantly. Thus, the ratio of protein and energy varied in products from 19.1 g per 100 kcal for beef to 0.08 g for butter; this differed 23 times.

According to the results of our research, the ratio of protein and energy in the actual diets of the surveyed respondents was quite stable and ranged from 3.03 ± 0.07 g/kcal in the respondents aged 46 to 65 years to 3.75 ± 0.09 g/kcal in the group of the surveyed individuals aged 11 to 14 years.

According to the results of our research, the ratio of protein and energy in the actual diets of the subjects was a fairly stable value (Table 1). In particular, for the age group of 15 to 18 years it was 3.21 ± 0.08 g/kcal and for the age group of 19 to 23 years it was equal to 3.36 ± 0.08 g/kcal.

Table 1 – Protein to energy ratio in the diet of the respondents of different age groups

Age	Protein to energy ratio, g/kcal
7 to 10 years	3.37 ± 0.08
11 to 14 years	3.75 ± 0.09
15 to 18 years	3.21 ± 0.08
19 to 23 years	3.36 ± 0.08
24 to 45 years	3.28 ± 0.08
46 to 65 years	3.03 ± 0.07

The results of the study do not contradict the existing concept of digestion. Assessing distribution of the population in the age aspect we found a pronounced dependence of the ratio of protein and energy in the diet on the age. Such a high stability of indicators can be interpreted by physiologically conditioned human endeavor for a certain ratio of food components.

The importance for the organism of maintaining a certain ratio of food components can be confirmed by the results of our research having been performed to assess the micro- and macronutrient status of persons with different protein and energy provision.

When considering individual diets, all subjects were divided into groups for protein and energy supply. In the age group of 7 to 14 years this distribution was as follows (Table 2).

Table 2 – Share of the respondents in the age group of 7 to 14 years with different protein and energy consumption, %

Protein consumption	Energy consumption		
	Below standard	Standard	Above standard
Above standard	10	19	2
Standard	25	22	1
Below standard	21	0	0

This distribution did not show any persons who consumed less protein than the standard values and energy more than the recommended standard in the diet; there were no individuals who consumed less protein than the recommended standard at a normal level of energy supply as well. The largest number of the subjects formed a group that differed in protein consumption within the recommended standard and energy less than normal, it was equal to 25 %. There were 22 % of the respondents who consumed protein and energy within the recommended standard, and there were 19 % of individuals supplied with excessive amount of protein at normal energy supply.

In the course of consideration of the protein-energy status of the adult population (24 to 65 years), a slightly different picture of the distribution of the subjects was revealed depending on the consumption of protein and energy in the diet (Table 3).

Table 3 – Share of the respondents in the age group of 24 to 65 years with different protein and energy consumption, %

Protein consumption	Energy consumption		
	Below standard	Standard	Above standard
Above standard	15	22	29
Standard	12	4	1
Below standard	15	2	0

This distribution did not show any individuals who consumed less protein and more energy than the recommended standards. The largest number of the surveyed individuals formed a group characterized by excessive consumption of protein and energy (29 %). Only 4 % of the respondents consumed optimal amount of protein and energy.

In the age group of 15 to 23 years this distribution was as follows. This distribution did not show any groups of persons who consumed less protein than the recommended standard with reduced energy supply as well as normal protein consumption and excessive energy intake. The largest number of the surveyed individuals formed a group that differed in the deficit of protein and energy intake from the recommended diet and this figure was about 50 %. Also, 16 % of the respondents with normal protein and low energy supply and 11 % of them with excessive protein intake and parallel low level of energy supply were found (Table 4).

Table 4 – Share of the respondents in the age group of 15 to 23 years with different protein and energy consumption, %

Protein consumption	Energy consumption		
	Below standard	Standard	Above standard
Above standard	11	8	8
Standard	16	9	0
Below standard	48	0	0

This distribution corresponded to the pattern that described the ratio of protein and energy in the human diet. In the group of persons aged 15 to 23 years the largest number of individuals was revealed; they formed a group with some deficit of protein and energy (40 %) in the actual diet as compared to the approved standards and this radically distinguished them from the other age observation groups. Deficiency of protein and energy supply can lead to some decrease in the organism's functional reserves, impaired health and mechanisms of adaptation to environmental changes in the future. Therefore, the correlation analysis for protein and micro- and macronutrient content was subsequently performed only in the respondents of this group. Thus, from the respondents aged 15 to 23 years, 6 groups of persons were formed regarding the protein-energy status; these are shown in Table 5.

To study the relationship between protein content and content in the diets of other macro-, micronutrients, we used correlation analysis method (the density of the quantitative traits at the linear relationship) and considered that the correlation coefficient from 0.3 to 0.5 corresponded to weak positive correlation and that from 0.5 and above was a strong positive correlation.

Table 5 – Groups of the respondents regarding protein-energy status

Group No.	Description regarding protein-energy status
Group I	reduced protein and energy intake in the diet
Group II	normal protein content in the diet with lowered energy supply
Group II	protein and energy intake within the recommended standard
Group IV	excessive protein intake with reduced energy intake
Group V	excessive protein intake with normal energy intake
Group VI	excessive protein and energy in the diet

Thus, in Group I (reduced intake of protein and energy in the diet) positive reliable correlations between protein and caloric intake ($r = 0.78$; $p < 0.05$), fats ($r = 0.6$; $p < 0.05$), and carbohydrates ($r = 0.6$; $p < 0.05$) were found. Similar correlations were found in Group II (normal protein content in the diet with low energy supply) and in Group VI (excessive protein and energy content in the diet) for observations (Table 6).

Table 6 – Correlation of protein with food macronutrients in different groups of protein and energy intake, r

Indicator	Groups of the surveyed respondents depending on the content of protein and energy component in the diet					
	I	II	III	IV	V	VI
Amount of energy	0.78	0.64	0.62	0.68	0.40	0.82
Fats	0.59	0.43	0.47	0.57	0.24	0.47
Carbohydrates	0.61	0.50	0.24	0.07	–0.19	0.60

Note: Highlighted results are reliable ones ($p < 0.05$).

In respondents of Group III (protein and energy intake within the recommended standard) amount of protein in the diet positively correlated with the amount of dietary fats ($r = 0.5$; $p < 0.05$) and caloric content of food ($r = 0.5$; $p < 0.05$). In Group V (excessive protein intake with normal energy intake) a positive relationship with the caloric content of food only ($r = 0.4$; $p < 0.05$) was found (see Table 6).

In the course of the research we found a trend in all the surveyed groups as well as a strong positive correlation of protein levels in the diet with total caloric intake, and the highest

correlation was observed in Group VI of respondents, it was equal to 0.82 (excessive protein and energy content in the diet) at that.

A study of the correlations between the protein supply of the diet and the level of vitamins in the diet of the examined group of respondents revealed specific features for each experimental group.

In Group I (reduced protein and energy intake in the diet) we found a strong positive correlation with vitamins of B_1 ($r = 0.7$; $p < 0.05$), B_6 ($r = 0.6$; $p < 0.05$) and E ($r = 0.5$; $p < 0.05$), and a weak positive correlation with vitamins of B_{12} ($r = 0.3$; $p < 0.05$) and A ($r = 0.2$; $p < 0.05$). No reliably significant correlation of protein levels with C vitamin was found (Table 7).

Table 7 – Correlation of protein with vitamins coming with food in the groups different by protein and energy intake, r

Indicator	Groups of the surveyed respondents depending on the content of protein and energy component in the diet					
	I	II	III	IV	V	VI
A vitamin	0.16	–0,11	–0.24	–0.21	–0.27	0.40
B_1 vitamin	0.71	0.66	0.23	0.07	0.41	0.73
B_6 vitamin	0.62	0.57	0.43	0.46	0.44	0.76
B_{12} vitamin	0.30	0.30	0.47	0.48	0.54	0.78
C vitamin	0.10	0.01	–0.19	–0.23	0.31	0.28
E vitamin	0.52	0.37	0.09	0.34	0.02	0.52

Note: Highlighted results are reliable ones ($p < 0.05$).

A similar relationship was found in Group VI (excessive protein and energy in the diet). In Group II of the respondents (normal protein content in the diet with low energy supply) in the diet we found a strong positive correlation of protein with B group vitamins, such as B_1 ($r = 0.7$; $p < 0.05$) and B_6 ($r = 0.6$; $p < 0.05$) and a weak positive correlation with vitamins of E ($r = 0.4$; $p < 0.05$) and B_{12} ($r = 0.3$; $p < 0.05$).

In Group III (protein and energy intake within the recommended standards) a strong positive correlation with B_{12} vitamin ($r = 0.5$; $p < 0.05$) and a weak positive correlation between protein and B_6 vitamin ($r = 0.4$; $p < 0.05$) were found. No reliable correlations

between the content of protein and C and E vitamins in the diet of Group III respondents were revealed.

In Group V (excessive protein intake with normal energy intake) a positive correlation was found, it was strong with B_{12} vitamin ($r = 0.5$; $p < 0.05$) and weak with B_1 ($r = 0.4$; $p < 0.05$) and B6 ($r = 0.4$; $p < 0.05$) vitamins. Analysis of the structure of the actual diet revealed a positive correlation of protein with B_6 and B_{12} vitamins in all the observation groups with the highest correlation coefficient in the Group VI respondents (excessive protein and energy in the diet), which was equal to 0.78 for B_{12} vitamin, 0.76 for B_6 vitamin and 0.73 for B_1 vitamin.

The following results were obtained when studying correlations between the protein supply of the diet and macronutrients. In Group I (reduced protein and energy intake in the diet), protein content was positively correlated with food macronutrients. In particular, a strong positive correlation was associated with macronutrients such as phosphorus ($r = 0.9$; $p < 0.05$), sodium ($r = 0.6$; $p < 0.05$) and calcium ($r = 0.5$; $p < 0.05$). A weak positive correlation was observed with potassium ($r = 0.4$; $p < 0.05$) (see Table 8).

Table 8 – Correlation of protein with mineral elements coming with food in the groups different by protein and energy intake, r

Indicator	Groups of the surveyed respondents depending on the content of protein and energy component in the diet					
	I	II	III	IV	V	VI
Calcium 0.25	0.50	0.10	0.15	0.14	0.12	0.50
Potassium 0.3	0.40	0.30	0.20	0.23	0.18	0.50
Sodium 0.36	0.60	0.50	0.30	0.20	0.17	0.40
Magnesium 0.22	0.26	0.18	0.15	0.20	0.10	0.40
Phosphorus 0.65	0.90	0.80	0.75	0.25	0.27	0.90

Note: Highlighted results are reliable ones ($p < 0.05$).

In Group II (normal protein content in the diet with lowered energy supply) strong positive correlations with phosphorus ($r = 0.8$; $p < 0.05$) and sodium ($r = 0.5$; $p < 0.05$) were clearly expressed. Weak positive correlation with potassium ($r = 0.3$; $p < 0.05$) occurred.

In Group III (protein and energy intake within the recommended standards) in the diet we found a strong positive correlation with phosphorus ($r = 0.75$; $p < 0.05$) and a weak

positive correlation with sodium ($r = 0.3$; $p < 0.05$). No reliable correlation was found with other macronutrients.

In Group VI (excessive protein and energy content in the diet) we found strong positive correlations with phosphorus ($r = 0.9$; $p < 0.05$), calcium ($r = 0.5$; $p < 0.05$) and potassium ($r = 0.5$; $p < 0.05$) and weak positive correlations with magnesium ($r = 0.4$; $p < 0.05$) and sodium ($r = 0.4$; $p < 0.05$).

In all observation groups positive correlations were found between the protein and phosphorus content in the actual diet of the respondents. Thus, in Groups I, II, III and VI, they were positively strong and ranged from 0.75 to 0.9, but in Groups IV and V, the correlation coefficient was below 0.27 and was weakly positive.

The peculiarity of Groups IV and V is the lack of strong positive correlations with macronutrients in contrast to Groups I and VI where there are strong positive correlations with all macronutrients of the respondents.

Conclusion

1. Analysis of the diets of the population revealed ability of the organism to maintain a certain ratio of food components which is expressed as a relationship between protein and energy in the diet of different age groups. As a result of our studies, the ratio of protein and energy in the actual diets of the subjects was a fairly stable value in the range from 3.03 ± 0.07 g/kcal in the age group of 46 to 65 years to 3.75 ± 0.09 g/kcal in the age group of 11 to 14 years. It was also found that in the age group of 15 to 23 years about 50 % of the respondents were characterized by protein and energy provision below the recommended standards.

2. A positive reliable correlation of protein content with caloric content of food and fats content in all the observation groups and with carbohydrates in Groups I, II and VI was revealed. Also, in all the observation groups positive correlations were found between the protein content in the diet and B_6 and B_{12} vitamins, but lack of correlation with C vitamin was revealed. In group VI, a strong positive correlation was found with all the studied dietary vitamins.

Analyzing the correlations between protein content and the studied mineral elements of food we found a positive correlation in all the observation groups with varying degrees of intensity, so in Groups I and VI there was a high correlation, and in Groups IV and V the correlation was positive but low. The peculiarity of Groups IV and V was the presence of weak positive correlations with all the studied mineral elements in contrast to Groups I and VI in which strong positive correlations were found. Among all the studied mineral elements, the

highest correlation coefficient was observed between protein and phosphorus of the diet in Groups I, II, III and VI where it ranged from 0.75 to 0.9, and sodium where it ranged from 0.30 to 0.60, respectively.

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