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THE IMPACT OF NUTRITION ON HUMAN COGNITIVE FUNCTION

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The purpose of the study was to investigate the influence of different types of populations' nutrition on neuropsychological indexes of psychological tests. The study involved 65 healthy people aged 23 to 53 years, with an average age of 35 years. All participants were divided into 3 comparable groups. The food of participants of the first group mainly contained meat and bread. The food of the second group participants mainly contained cereals, vegetable oil, sugar and potato. Vegetables, fruits, animal products and milk were the basis of the diet of the participants in the third group. The observation period lasted for 42 days. The Benton test, adopted by B.G. Khersonsky pictogram test, the Minnesota Multifaceted Personality Inventory and the Szondi tests were used for psychological testing. Neuropsychological testing was shown to have very important diagnostic aspect, since it allows to detect the subclinical cognitive deficit presence at the early stages of this disorder. The food products consumed by a person significantly determine the humans' individual typological characteristics and mental activity productivity. The influence of protein- and carbohydrate-containing foods on humans' individual-typological personality traits and mental productivity was revealed. The authors conclude that nutrition improvement additionally to complex pathogenetically confirmed therapy allows to correct effectively the formed mnestic disturbances and thus contributes to cognitive reserve preservation.

Key words: nutrition, proteins, carbohydrates, neuropsychological testing, individual-typological personality characteristics, cognitive functions, cognitive reserve.

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ВПЛИВ ХАРЧУВАННЯ НА КОГНІТИВНІ ФУНКЦІЇ ЛЮДИНИ

Метою дослідження було визначити вплив різних типів харчування населення на нейропсихологічні показники психологічних тестів. У дослідженні взяли участь 65 здорових осіб віком від 23 до 53 років. Всі учасники були розділені на 3 співставні групи. Їжа учасників 1-ї групи в основному містила м'ясо і хліб. Їжа учасників 2-ї групи в основному містила крупи, рослинне масло, цукор і картоплю. Основу раціону учасників 3-ї групи становили овочі, фрукти, продукти тваринного походження та молоко. Період спостереження тривав 42 дні. Для психологічного тестування використовували тест Бентона, адоптований Б.Г. Херсонським піктограмний тест, Міннесотський тест ММРІ та тест Сонді. Доведено важливість нейропсихологічного тестування в діагностичному аспекті, оскільки воно дозволяє виявити когнітивний дефіцит на ранніх етапах наявності цього порушення. Виявлено безперечний вплив продуктів харчування на індивідуально-типологічні особливості людини та продуктивність психічної діяльності. Показано особливості впливу на індивідуально-типологічні особливості особистості та продуктивність психічної діяльності продуктів харчування, що містять білки та вуглеводи. Автори вважають, що корекція харчування додатково до комплексної патогенетично обґрунтованої терапії дозволяє максимально ефективно коригувати сформовані мнестичні порушення та сприяє таким чином збереженню когнітивного резерву.

Ключові слова: харчування, білки, вуглеводи, нейропсихологічне тестування, індивідуально-типологічні особливості особистості, когнітивні функції, когнітивний резерв.

The study is a fragment of the research project "To investigate the chronic convulsive syndrome pathogenetic mechanisms on the model of pharmacological kindling and to study the efficacy of its complex pathogenetical correction by anticonvulsant mechanisms activation", state registration No 0122U000081.

Every human personality is formed in a certain habitat. Nutrition is an important element of the habitat; it is the basic unit of life. Henderson and Maslow placed "nutrition" at the top of their pyramids [3, 5].

Antisocial behaviour (including violence) in juvenile offenders receiving diets deficient in essential nutrients was shown to be corrected successfully by vitamins, minerals and omega-3 essential fatty acids (EFAs) administration [15]. Clinical data demonstrated omega-3 EFAs deficiency in neuroses and psychoses [4, 11]. The relationship between nutrition, serotonin metabolism and the temper of individuals were established [14].

Currently, food is considered "not only as a material substrate with nutritional, regulatory and sensory properties" but also as cognitive properties (informational and semantic) transporter [12, 14]. Nutrition undoubtedly affects brain functions and, therefore, might have a multidirectional impact on humans' intelligence, mental activity, mood and behavior.

Cognitive disorders (CD) are one of the biggest problems in medicine, since the cognitive imbalance itself leads to a complete loss of working capacity which transforms into dementia [6, 8]. In case of CD one could diagnose certain brain functions affecting - memory, attention, speech, praxis, social adaptation etc. [9]. Cardiovascular and neurodegenerative disorders together with psychoemotional overload, stress, depression, loneliness, hearing deficit, diabetes, hypertension, old age, female gender etc. are the main causes of CD [10].

Currently, timely CB diagnosis using various neuropsychological testing scales is the most urgent task of neurology [13]. Scales for cognitive impairments identification are used not only for their screening but also for these impairments dynamics determination [6]. The earliest cognitive imbalance detection and its therapy earlier initiation including possible food intake correction ensures patients' cognitive reserve effective preservation.

Thus, it seems to be reasonable to check the nutrition influence on human personality individual-typological features. We believe it interesting to study the influence of Ukrainian population nutritional indexes on indexes characterizing mental activity.

The purpose of the study was to investigate the influence of different types of populations' nutrition on neuropsychological indexes of psychological tests.

Materials and methods. 65 people survey aged form 23 till 53 years (36 men and 29 women) was performed on the basis of Odessa Municipal Hospital N1. The participants were healthy which was proved by blood and urine biochemical analysis, routine ECG and lungs X-rays investigation. Digestive system was checked by usual biochemical and functional probes. The average age of participants was equal to 35.3±4.7 years. All volunteers provided written informed consent before the beginning of the study which allowed to use their test results for scientific purposes.

The data of the State Statistics Committee of Ukraine concerning the bread, meat, milk, cereals, vegetable oil, sugar, potatoes, vegetables, fruits, cattle and milk population's consumption during the period from 2010 to 2020 were used as indexes characterizing the nutrition of the population [1].

The products were sorted out into food groups using the Codex food classification system which is intended primarily to classify foods into groups to establish group maximum residue limits for commodities with similar characteristics and residue potential [7]. The categories used were the following: meat, bread and bakery products, cereals, vegetable oil, sugar, potato, vegetables, fruits, animal products and milk.

To achieve the aim of the study all participants were blindly divided into 3 comparable groups. The food of participants of the first group (n=21) mainly contained meat and bread. The food of the second group participants (n=22) mainly contained cereals, vegetable oil, sugar and potato. Vegetables, fruits, animal products and milk were the basis of the diet of the participants in the third group (n=22).

Participants voluntarily agreed not to eat anything else. The observation period lasted for 42 days.

To determine the nutrition impact on personal individual-typological features expression, the following psychological testing methods were used: the Benton test, adopted by B.G. Khersonsky pictogram test, the Minnesota Multifaceted Personality Inventory (MMPI) and the Szondi tests [2]. Each used scale brief description is given inside the corresponding tables.

The multiple linear regression and correlation methods were used to determine the nutrition impact on psychological test scores. The levels of statistical significance were accepted within the range between $p<0.05$ and $p<0.1$. The data obtained statistical processing was performed using the "Statistica 7.0" package.

Results of the study and their discussion. Bread consumption had a statistically proved negative influence on MMPI test index "Displacement of factors causing anxiety – hysteria" ($r=-0.31$) and positively on indexes of both adopted by B.G. Khersonsky pictogram test "Metaphorical images" and the Sondhi's test "Paranoid tendencies" ($p<0.05$ in all cases; Table 1).

Meat consumption had a significant negative influence on the Benton's test "Inorganic errors" score ($r=-0.31$).

All the used MMPI test indexes – "Lie scale", "Anxiety fixation and organic behaviour" and "Anxiety denial and hypomanic tendencies" were improved by meat consumption ($p<0.05$ in all cases).

Adopted by B.G. Khersonsky pictogram test scale "Image of a person" together with all the used Sondhi's test scores (except of "Sadism Foreground" scale) were affected in case of meat consumption ($p<0.05$ in all cases).

Cereals and potatoes consumption revealed negative impact on MMPI test scaled "Male and female character traits expression" (regression coefficients equal to -4.50 and -0.06, correspondently) whereas both vegetable oil and sugar positively influenced on this index (regression coefficients equal to 6.18 and 1.72, correspondently; Table 2 A).

Table 1

Significant regression coefficients outlining the meat and bread consumption impact on psychological indexes

N	The indexes used		Consumption	
			bread	meat
Benton's test				
1		Inorganic errors	-	-0.30
MMPI test				
2	(L)	Lie Scale - indicates how sincere the subject was during the testing	-	0.28
3	(3)	Displacement of anxiety triggers - hysteria	-0.31	-
4	(7)	Anxiety Fixation and Organic Behaviour (Anxiety, Psychasthenia)	-	0.22
5	(9)	Anxiety denial and hypomanic tendencies	-	0.35
Pictogram test by B.G. Khersonsky				
6	(M)	Metaphorical images	0.28	-
7	(I_CH)	Images of a person	-	-0.34
Sondhi's test				
8	(H2)	Sexual undifferentiation	-	-0.23
9	(S1)	Sadism foreground	-	0.27
10	(S2)	Sadism background	-	-0.23
11	(P1)	Paranoid tendencies	0.23	-0.26

Notes: $p<0.05$ – in all cases of linear regression and correlation methods calculated indexes (here and in subsequent tables)

Carbohydrate-rich sugar and potatoes consumption was clearly associated with both “Sexual undifferentiation” ($r=0.81$) and “Epileptoid tendencies” ($r=1.66$) of the Sondhi’s test ($p<0.05$).

One could see the predominantly positive influence of vegetable, fruit and milk consumption on the Benton's test “Inorganic errors” scale with the only one exception - the animal products eating ($p<0.05$; Table 2 B).

Table 2

Significant regression coefficients outlining the cereals, vegetable oil, sugar and potatoes (part A) and the vegetable, fruit, animal products and milk (part B) consumption impact on psychological indexes

N	The indexes used. Part A		Products			
			Cereals	Vegetable oil	Sugar	Potato
MMPI test						
1	(5)	Male and female character traits expression	-4.50	6.18	1.72	-0.06
Sondhi's test						
2	(H1)	Sexual undifferentiation	-	-	-	0.81
3	(E2)	Epileptoid tendencies (anger, jealousy, etc.)	-	-	1.66	-
	The indexes used. Part B		Products			
			Vegetables	Fruits	Animal products	Milk
Benton's test						
4		Inorganic errors	2.59	6.94	-1.20	9.29
MMPI test						
5	(5)	Expression of masculine and feminine character traits	-1.50	-0.19	- 5.09	6.06
6	(0)	Social contacts	2.02	5.62	0.41	-6.87
Sondhi's test						
7	(S2)	Sadism background	-1.76	-	-1.28	5.71
8	(K1)	Catatonic tendencies (withdrawn, resentful, etc.)	-1.25	-2.31	-1.27	4.09

Both milk and animal products consumption positively correlated with the MMPI test scales “Expression of masculine and feminine character traits” and “Social contacts”, with the regression coefficients equal to 6.06 and 0.41, correspondently ($p<0.05$).

Vegetables and animal products eating had negative correlation with the Sondhi’s test “Sadism background” index (-1.76 and -1.28, correspondently, $p<0.05$). These products together with fruits affected the “Catatonic tendencies” scale of the Sondhi’s test ($p<0.05$). Milk consumption accidently and unexpectedly corresponded to both Sondhi’s test “Sadism background” and “Catatonic tendencies” scales improvement (5.71 and 4.09, correspondently, $p<0.05$).

Thus, the observations conducted and the results obtained showed a significant influence of food products consumption on human psychological activity expression and cognitive processes features. We ant to stress that neuropsychological testing reveals important diagnostic aspect, since it allows to detect the cognitive deficit presence at the early stages of this disorder. To discuss the data obtained we suppose it reasonable to focus on the following.

The first line of discussion we dedicated to meat consumption which significantly positively determined the MMPI test indexes “Lie scale”, “Anxiety fixation and organic behaviour”, “Anxiety denial and hypomaniacal tendencies” together with the Sondhi’s test scale “Sadism background”. Meat consumption therefore resulted in the above-mentioned individual-psychological personality traits expression increase. We believe that protein ingestion contributes to the above mentioned individual-typological humans’ features formation.

Meanwhile, meat ingestion had a significant negative effect on the Benton's test indexes “Inorganic errors”, on the MMPI test index “Displacement of factors causing anxiety”, on the index of adopted by B.G. Khersonsky pictogram test scale “Image of a person” and on the Sondhi's test indexes “Sexual undifferentiation” and “Sadism background”. Consequently, protein intake increase prevents the above mentioned humans’ individual-typological features formation and improves therefore the mental activity efficiency.

This meat influence explained by the fact that meat contains all the substances necessary for human nutrition. It’s a significant source of essential amino acids, fats, mineral and extractive substances which are presented in an optimal quantitative and qualitative ratio and are easily assimilated by the body. The biological value of meat proteins is much higher than that of milk casein. In terms of digestion rate by proteolytic enzymes, meat proteins occupy the second place (after fish and milk proteins). The vitamins mainly of B group - thiamine (vitamin B_1) found in various types of meat approximately in amount of 0.1–0.2 mg per 100 g of product – are also present in the muscle tissue of meat.

Important to stress that extractive substances which give meat a specific taste and smell are of significant importance for meat nutritional value. The total content of nitrogenous and nitrogen-free extractive substances including anserine, carnosine, creatine, choline, purine bases, free amino acids, uric acid, ammonium salts, ammonia, free nucleotides (ATP and ADP) varies within 1.8–2.2 %. Carnosine and anserine are well-known to stimulate the digestive glands secretion for appetite stimulation and better meat digestion. Choline increases intestinal peristalsis.

Consequently, the nutritional value of meat and its unique quality characteristics contribute to biochemical reactions acceleration, support the main physiological homeostatic reactions which usually positively determined the individual typological characteristics of a person.

The second position - bread is the next alimentary factor after meat which significantly determines the individual mental activity expression. Our data showed that bread consumption significantly increased the formation of “Metaphorical images” scale adopted by B.G. Khersonsky pictogram test and the “Paranoid tendencies” scale of the Sondhi’s test and prevented the MMPI scale “Displacement of anxiety triggers” formation which totally worsened the individual's mental activity expression.

The noted influence of bread and bakery products, in our opinion, is explained by carbohydrates predominance in their composition. A special place is occupied by indigestible carbohydrates (cellulose and hemicelluloses), which are almost not broken down but increase intestinal peristalsis. Our similar conclusions also correspond to the results [3].

Thirdly, vegetable and fruit utilization had a significant positive influence on the “Inorganic errors” (Benton's test) and the “Social contact” (MMPI test) scores. A similar diet at the same time resulted negatively on “Expression of masculine and feminine character traits” (MMPI test) and “Catatonic tendencies” (Sondhi’s test) indexes. Milk and animal products consumption contributed to the development of opposite effects.

It can be assumed that carbohydrates consumption, from one side, improves the Benton's test “Inorganic errors” indexes together with MMPI test “Social contacts” indexes, and, from the other side, prevents the formation of MMPI’s “Expression of masculine and feminine character traits” and Sondhi’s test “Catatonic tendencies” indexes. The mentioned earlier outlined the general positive and negative social and psychological individuals’ features that could be relevant in humans’ mnestic functions.

Such a positive fresh fruits and vegetables importance for humans’ higher mental functions is due to the presence of carbohydrates, organic acids, tannins, nitrogenous and mineral substances, as well as vitamins. Fruits and vegetables are known to improve appetite, increase the other nutrients digestibility. Some fruits and vegetables (raspberries, blackcurrants, grapes, blueberries, strawberries, pomegranate, carrots, etc.) have therapeutic importance as they contain tannins, colouring and pectin substances,

vitamins, phytoncides and others that perform physiological protective role inside the human body. It should be added that many fruits contain antibiotics and radiation-protective substances capable to bind and extract the radioactive elements from the body. Our conclusions in this item are similar to the opinion of [12].

Summarizing we suppose worth noting that food qualitative composition significantly influences the nature of the main humans' homeostatic reactions, the expression of its adaptive reactions and compensatory mechanisms as well as the mental activity productivity and mnestic processes manifestation.

Conclusions

1. Neuropsychological testing has very important diagnostic aspect, since it allows to detect the cognitive deficit presence at the early stages of this disorder.

2. The food products consumed by a person significantly determine the humans' individual typological characteristics and mental activity productivity.

3. The influence of protein- and carbohydrate-containing foods on humans' individual-typological personality traits and mental productivity was revealed.

4. Correction of nutrition additionally to complex pathogenetically confirmed therapy allows to correct effectively the formed mnestic disturbances and thus contributes to cognitive reserve preservation.

Prospects for further research aimed at prospective attempts to correct humans' social dysfunction, typological personality traits and memory disorders using a special diet containing certain food components.

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