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NUTRITIONAL STATUS AND INTESTINAL MICROBIOCENOSIS IN COMPLETE FASTING IN YOUNG VOLUNTEER

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Absract. Nowadays, it is becoming more and more popular among people to refuse to eat for a limited time. However, information about the impact of fasting on human health at the present time continues to be controversial. In our experiment, on the example of a young volunteer, changes in the nutritional status, metabolic profile and intestinal microbiocenosis were shown against the background of complete starvation for 15 days.

Key words: *fasting; metabolic profile; intestinal microbiota; bioimpedancemetry; young volunteer.*

СОСТОЯНИЕ НУТРИТИВНОГО СТАТУСА И МИКРОБИОЦЕНОЗА КИШЕЧНИКА ПРИ ПОЛНОМ ГОЛОДАНИИ У ДОБРОВОЛЬЦА МОЛОДОГО ВОЗРАСТА

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Резюме. В настоящее время все больше приобретает популярность среди людей отказ от приема пищи в течение ограниченного времени. Однако сведения о воздействии голодания на состояние здоровья человека в настоящее время продолжают оставаться противоречивыми. В нашем эксперименте на примере молодого добровольца были показаны изменения нутритивного статуса, метаболического профиля и микробиоценоза кишечника на фоне полного голодания в течение 15 дней.

Ключевые слова: *голодание; метаболический профиль; микробиота кишечника; биоимпедансометрия; молодой доброволец.*

INTRODUCTION

The popularity of following restrictive diets has a tendency to increase in most countries of the world [1]. In recent years, the issues of periodic fasting and its effect on the human body have been more frequently discussed at scientific medical forums [2–4]. Among the most common reasons for changing to an unconventional type of diet are usually considered the idea of health improvement and prevention of various somatic and infectious pathologies, ethical, religious, social and environmental aspects [1].

Various types of therapeutic fasting are traditionally used both in folk and Oriental medicine in the treatment of metabolic diseases, gastrointestinal and cardiovascular systems, respiratory organs and musculoskeletal system [5–7]. In classical medicine therapeutic fasting has been used since the time of Hippocrates. The founder of medicine wrote "when a patient is fed too abundantly, his disease is also fed. Sometimes it is more useful to take food away from a sick person for a while" [3].

In the USSR, the problem of therapeutic fasting was dealt with by such famous scientists as academicians P.K. Anokhin, A.A. Pokrovsky, N.A. Fedorov, L.N. Bakulev. Doctor of Medical Sciences, Professor Y.S. Nikolaev made a significant contribution to the scientific substantiation of treatment of a number of diseases by the method of unloading-diet therapy (UDT) [3]. In the XXI century, the topic of periodic fasting again came to the forefront in 2016 after the world scientific community recognised the merits of the Japanese scientist, molecular biologist Yoshinori Ohsumi. Dr Ohsumi, a professor of the Tokyo Institute of Technology, received the Nobel Award in Physiology and Medicine for his research into the poorly understood mechanisms of autophagy — regeneration processes occurring at the cellular level. In particular, Osumi discovered the genes that control this process; he was able to describe how the organism adapts to fasting, as well as the response of cells to the penetration of pathogens into the body. In autophagy, cells break down and recycle damaged organelles, in other words, they self-renew. It has been shown that failure of this regenerative process can lead to neurodegenerative diseases such as Alzheimer's disease, Parkinson's disease, Huntington's syndrome, some forms of dementia and cancer. It has also been argued that it is possible to trigger autophagy in cells by adhering to various schemes of periodic fasting [8, 9].

Fasting is a pathological process that develops due to the deficiency of nutrients that enter the internal environment of the body during the processes of cavity, membrane hydrolysis and absorption of nutrients from the intestinal lumen [10–12]. Despite the fact that the organism is deprived of the main source of nutrition, it continues to receive energy and necessary substances, as it is forced to switch to active utilisation of already existing reserves. This is confirmed by blood glucose level which is an important indicator. Certain molecular and cellular mechanisms responsible for defence functions are also switched on, which can allow the organism to survive even in conditions of complete or partial absence of food sources with minimal damage. This process provokes adaptive cellular stress responses that lead to an increased ability to cope with stress and neutralise disease processes. The body begins to actively get rid of nitrates and other harmful substances that came with food. Lack of food forces the body to activate the search for an alternative source of nutrition and forces it to spend fat and carbohydrate reserves. First of all, the body starts to spend its dead cells, followed by diseased cells, which are not suitable for maintaining normal activity. As a result, only healthy tissues remainInternal self-purification takes place. This is due to the fact that the reserve forces restore the disturbed metabolism at the molecular, cellular and tissue levels. At the same time the process of destruction of infected and malignant molecules and cells begins, after which they are replaced by new and healthy ones. At the moment of transition to fasting and it's ending, the organism feels stress. It is worth giving up food gradually. The duration of recovery should coincide with the period of fasting. The stabilisation phase occurs after the end of the recovery period [13, 14].

Complete fasting is divided into periods of emergency adaptation, long-term stable adaptation, and decompensation. The initial period of emergency adaptation consists in activation of glycogenolysis, full use of its reserves, and stimulation of gluconeogenesis, with normal blood glucose levels during 12 to 24 h of fasting being ensured by glycogen reserves in the liver. Already after 24 hours from the beginning of fasting, glycogen stores in the liver are depleted, so the level of glucose in the blood is maintained by its formation from glycerol, glucogenic amino acids and free fatty acids during gluconeogenesis. After 24 h from the beginning of exogenous fasting, the organism starts to use proteins as energy sources and intensify the processes of gluconeogenesis. Starvation for more than 72 h leads to a decrease in the processes of amino acid utilisation, which is clinically manifested by a decrease in nitrogen excretion with urine. Glucose formation from amino acids by this time does not correspond to the energy needs using only or mainly glucose of brain cells, erythrocytes, brain matter of kidneys, other tissues and organs. With prolonged starvation, gluconeogenesis moves from the liver to the kidneys, where deamination occurs. In addition,

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there is a transformation of ketones into glucose through the acetone; the brain also begins to use ketone bodies as energy sources, but only after a certain reorganisation — by the 10th–12th day. As soon as the transition to a different energy supply of the nervous tissue occurs, the 2nd period of adaptation occurs — stable long-term adaptation to complete fasting. This period starts from the 2nd week of complete fasting and lasts until the 8th week of fasting and longer — depending on the volume of fat reserves. Glucose deficiency in the body, which occurs during prolonged fasting, is replenished by other energy substrates such as ketone bodies. The most important consequence of this neuroendocrine restructuring is the redirection of energy resources to those consumers that have exclusively or predominantly non-insulin-dependent glucose transporters inside cells (the brain, retina, gonads, adrenal glands, diaphragmatic muscle, myocardium, partly liver and kidneys). The cells where glucose transporters are exclusively insulin-dependent (connective tissue in all its types, lipocytes, bones, cartilage and ligaments, bone marrow, cells of blood and lymphoid organs, vascular walls, etc.) are on «starvation rations». The result of activation of the neuroendocrine catabolic system is the suppression of hunger, intestinal peristalsis. The supply of amino acids and lipolysis products into the blood increases due to adaptive intensification of catabolism. At full prolonged fasting only neurons of the brain and spinal cord use glucose as an energy substrate; cells of all other tissues utilise free fatty acids and ketone bodies for biological oxidation. The terminal period of decompensation occurs at a loss of 40–50% of the initial body weight, characterised by the loss of 100% of fat depots, almost 97% of visceral adipose tissue, increased protein breakdown in organs and tissues, and not only insulin-dependent, but also those whose metabolic interests were preserved for some time. Because of the mass apoptosis of cells, the nucleic acids are destroyed, and the excretion of non-urea nitrogen increases. During fasting there is a stepwise change in metabolism with characteristic stages of endocrine and metabolic changes and change of the main energy substrates [5, 6, 8, 13].

Researches confirm that changing caloric intake can have long-term positive effects on the body. Individual pilot intervention trials and several randomised studies in this direction have been carried out in experiments on sick people for therapeutic purposes [3, 5, 10, 11, 15]. Observations on healthy people in order to reveal the effect of fasting on healthy people and their physical capabilities are few and not widely studied.

AIM

To evaluate nutritional status, metabolic profile and gut microbiocenosis during complete fasting in a young human.

MATERIALS AND METHODS

The young volunteer was a young woman, 31 years old, married, with children. She is a 2nd year student of the Faculty of Paediatrics of the Federal State Budgetary Educational Institution of Higher Professional Education SPbGPMU of the Ministry of Health of the Russian Federation. The examination included determination of anthropometric and laboratory-instrumental indicators (clinical blood analysis, biochemical blood analysis, immunological status, determination of blood gas composition, gut microbiota composition by chromatography-mass spectrometry, assessment of the component body composition by bioimpedanceometry). The examination was carried out on the 1st, 4th, 9th, 15th days of complete fasting and 1 month after.

Statistical processing of the obtained data was performed using XL Statistica 7 (StatSoft, Russian version) and Microsoft Excel 2017 software packages.

The subject started the practice of therapeutic fasting in 2013 after a case of generalised acute arthritis of unclear aetiology. After discharge from the hospital and taking a course of sulfasalazine (for 3 months) in summer of 2013, the subject performed a course of therapeutic fasting on water for 10 days. As a result of it, her general condition significantly improved, swelling decreased, mobility improved, and subjective pain sensations in the area of large and small joints decreased. After that the subject periodically returned to the practice of spring annual fastings with the purpose of detoxification, improvement of general condition, reduction of pollen sensitisation in the spring-summer period. The present course of therapeutic fasting took place for 14 days from the end of April to the beginning of May 2022. This author's method was a compilation of different practical and theoretical materials on therapeutic fasting; the subject made additions to the fasting method based on empirical experience of past sessions [16, 17]. Before fasting, a bowel cleansing procedure was carried out, which was repeated once every two or three days in order to empty the intestine and improve its peristalsis. Drinking regime included water at will (mineral or boiled) not less than 1.5 litres per day. Every day for 14 days the subject was engaged in sports (swimming, jogging, functional training, walking at least 6 km per day). Physical activity was monitored using a fitness bracelet. Once every five days the subject received 15 g of magnesium sulphate per 150 ml of water for gallbladder emptying. «Withdrawal» from the fasting period was continued gradually over two weeks with citrus (orange, lemon, grapefruit, tangerine) juice diluted 1:1 with water. On the first day — 500 ml of pure juice, from the second to the fifth day — 1 litre of juice per day. From the fourth day the juice was not diluted. From the fifth day the subject started eating whole fruits up to 1.5 kg per day. From the eighth day the subject started eating raw and heat-treated vegetables, from the 11th day — porridge with a small amount of vegetable oil (buckwheat porridge, rice), from the 15th day — a small amount of animal protein, nuts and gradually returned to the normal diet.

RESULTS

The young volunteers height was 170 cm, the body mass was 67 kg, BMI 22.4 kg/m2, waist circumference (WC) 63 cm, hip circumference (HC) 95 cm. No pathological changes were detected in clinical and biochemical blood tests. Immunological status: hyperimmunoglobulinaemia M and E, presence of circulating immune complexes (CIC) in blood serum were noted. A decrease in the absolute and relative number of CD25+ T-cells, HLA-DR T-cells, γδ T-cells was revealed. Gas composition was characterised as respiratory acidosis, which was associated with the presence of exacerbation of seasonal pollinosis in the volunteer.

According to the results of the gut microbiocenosis study, a higher ratio of representatives of the genus *Firmicutes* over the genus *Bacteroidetes* was found.

The content of some opportunistic microorganisms was increased 2–3 times before the study, including *Actinomyces* spp., *Alcaligenes spp., Staphylococcus epidermidis* and *mutans, Streptococcus mutans* and *sanguis*, *Clostridium coccoides* and *perfringens, Rhodococcus spp. Before the beginning of fasting, the number of Bifidobacterium spp.* and *Lactobacillus* spp. was reduced by 1.5 times, *Clostridium ramosum* was reduced by 4.3 times, which probably indicated the vaginal dysbiosis.

When assessing body composition, the amount of fat mass (FM) and its fraction (FFM), lean mass (LM), active cell mass (ACM), skeletal muscle mass (SMM), total water (TW), extracellular fluid (EF) were within normal reference values. The value of active cell mass fraction (ACMF) was increased by 10%, the value of skeletal muscle mass fraction (SMMF) was increased by 6%, which was due to sufficient motor activity, good training and endurance of the subject's organism. The index of basic metabolism (BM) corresponded to 1509 kcal/day.

During the first two days of the fasting period, the volunteer's feeling was satisfactory, she led a relatively passive lifestyle. From the 3rd to the 6th day, the volunteer noticed the weakness and decreased concentration. Physical activity during these days was quite intensive (kilocalorie consumption according to the fitness bracelet was from 500 to 900 kcal/day). On the 7th day (the middle of the fasting period) the condition and

Table 1. Monitoring of anthropometric indicators

Таблица 1. Мониторинг антропометрических показателей

День наблюдения / Observation day	Масса тела, кг / Body weight, kg	Окружность талии, см / Waist circumference, cm	Окружность бедер, см / Hip circumference, cm
1	67	73	95
2	66	72	95
3	65	70	94
4	63	69	93
5	62,5	69	93
6	62	69	93
7	61	68	93
8	61	67	93
9	61	67	93
10	61	67	93
11	60,5	67	93
12	60	67	93
13	59	67	93
14	59	67	93
15	59	67	93
After 1 month / Через 1 месяц	67	67	93

well-being of the subject sharply deteriorated, partial lethargy appeared, pallor of the skin was noted, efficiency decreased. Verbal contact with the volunteer was maintained, but she was sluggish and delayed in answering questions. She was offered hospitalisation but she refused. This condition persisted on the following day and the volunteer was forced to stay at home. On the 9th day, the subject's condition began to improve and she was able to return to an active lifestyle and sports activities. From day 12 to 15, the subject's general condition was satisfactory, and her condition was assessed as "excellent": there was vigour, a "burst of energy" and a "high spirits".

Changes in anthropometric parameters of the volunteer during the observation period are presented in Table 1.

During the whole period of fasting, the volunteer lost 9 kg, her WC decreased by 6 cm, and her HC decreased by 2 cm. The maximum decrease in body weight was observed on day 4 (–4 kg), from day 7 to day 10 body weight remained stable, from day 11 to day 14 the volunteer lost another 3 kg. Waist and hip circumference values decreased more evenly and reached maximum values on day 8 and day 4, respectively. One month after the end of fasting, body weight had recovered to baseline values, while WC and HC remained less than baseline.

According to the results of the clinical blood test, significant changes were recorded by day 15: the total number of leukocytes decreased by 20%, erythrocytes and platelets — by 14.5% ($p < 0.05$); the mean platelet volume decreased by 21% ($p < 0.05$), thrombocrit decreased by 39% ($p < 0.05$), platelet distribution index increased by 31% ($p < 0.05$). In the leucocytic formula, there was a 42% decrease in neutrophils ($p < 0.05$) and an 18% increase in lymphocytes ($p < 0.05$). All of the indices returned to baseline values, except for the values of platelet distribution index and mean platelet volume after 1 month.

Blood glucose remained stable at the level of 4–4.5 mmol/l during the whole period of observation of the volunteer. Changes in fat metabolism were characterised by a gradual increase in triglyceride levels and maintenance of this trend after 1 month (from 0.67 to 1.21 mmol/l). Low density lipoprotein (LDL) levels increased by 14.8% ($p < 0.05$) by day 15 and decreased by 11.5% ($p < 0.05$) from the baseline after 1 month. High-density lipoprotein (HDL) levels decreased by 55% ($p < 0.05$) by day 15, and recovered to the original value after 1 month. Alkaline phosphatase levels also decreased by half by the 14th day and recovered to the baseline after 1 month. Uric acid levels decreased by 23% ($p < 0.05$) but also recovered to the baseline after 1 month.

According to the results of immune status study the volunteer still had hyperimmunoglobulinaemia M and E, CIC in blood serum after 15 days. In 1 month after the end of observation on the background of hyperimmunoglobulinaemia M and E, CIC in blood serum there was a 2-fold decrease in immunoglobulin A, a 19-fold decrease in absolute and relative number of γδ T-cells.

According to the results of blood gas composition study, primary respiratory acidosis with renal compensation was registered by the 15th day: a partial pressure of carbon dioxide in blood plasma increased 1.08 times, partial pressure of oxygen in blood plasma decreased 1.2 times. There was an increase in the amount of potassium ions in the blood by 1.17 times. In 1 month after the end of fasting, the partial pressure of carbon dioxide

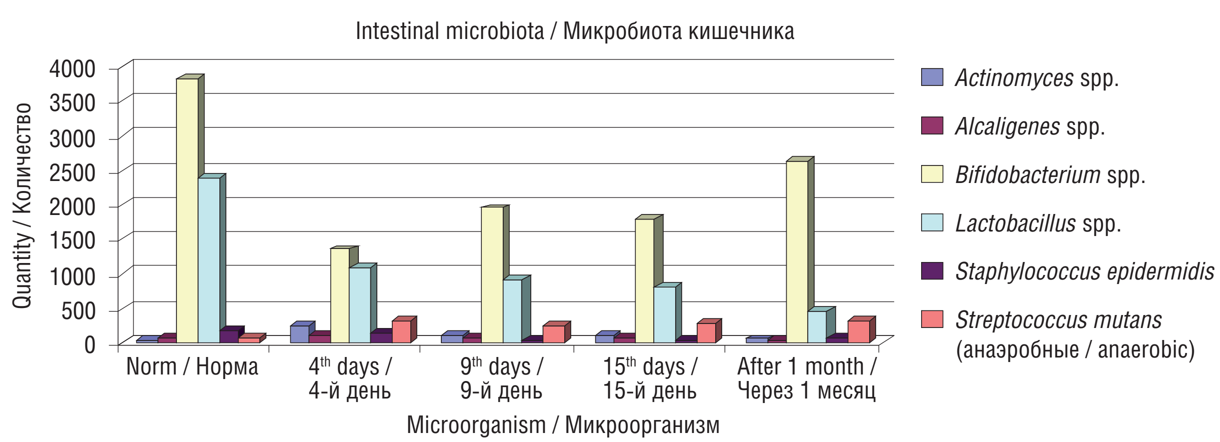

Fig. 1. Changes in the composition of the intestinal microbiota
Рис. 1. Изменение состава микробиоты кишечника

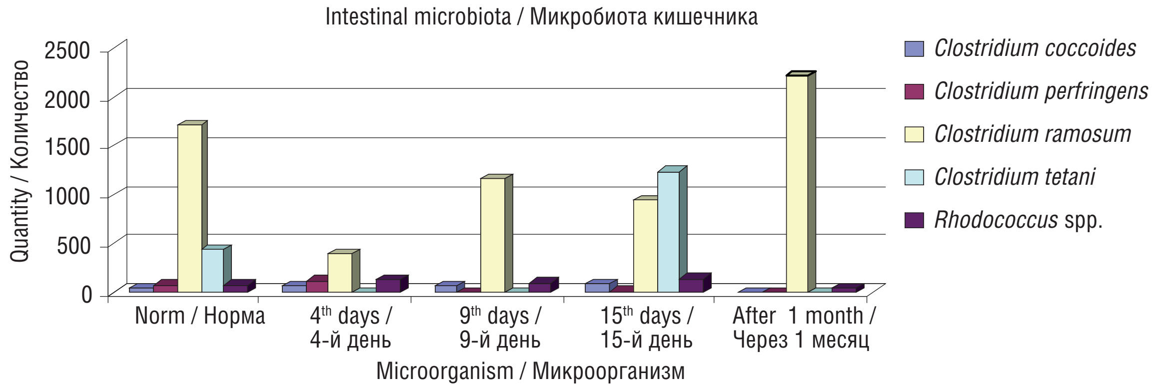

Fig. 2. Changes in the composition of the intestinal microbiota
Рис. 2. Изменение состава микробиоты кишечника

Table 2. Dynamics of indicators of nutritional status

Таблица 2. Динамика показателей состояния нутритивного статуса

День наблюдения / Observation day	ЖМ, кг / FM, kg	ДЖМ, % / FFM, %	ТМ, кг / LM, кг	АКМ, кг / ACM, кг	ДАКМ, % / ACMF, %	СММ, кг / SMM, кг	ДСММ, % / SMMF, %	ОВ, кг / BM, кг	ВЖ, кг / EF, кг
1	18,7	25,6	48,3	28,3	58,5	24,1	49,9	35,4	15
4	20,3	31,2	44,7	25,8	57,7	21,3	47,7	32,7	13,9
9	14,5	26	42,1	21,5	50,2	19,6	44	27,1	11,9
15	12	20	48	31,9	68,4	24,4	50,9	35,2	14,4
After 1 month / Через 1 месяц	18,4	25	48	29	63	24	50	36	14,5

Note: ACM — active cell mass; EF — extracellular fluid; ACMF — fraction of active cell mass; FFM — fraction of fat mass; SMMF — fraction of skeletal muscle mass; FM — fat mass; TW — total water; LM — lean mass.

Примечание: АКМ — активная клеточная масса; ВЖ — внеклеточная жидкость; ДАКМ — доля активной клеточной массы; ДЖМ — доля жировой массы; ДСММ — доля скелетно-мышечной массы; ЖМ — жировая масса; ОВ — общая вода; ТМ — тощая масса.

(45.5 mmHg) remained at the upper limit of normal, and oxygen (33.3 mmHg) was 2.5 times lower than the normal value.

Dynamics of changes in the number of representatives of gut microbiocenosis is presented in Figures 1 and 2.

On the background of fasting and in 1 month after the tendency to predominance of microorganisms of *Firmicutes* genus over *Bacteroidetes* genus remained. The number of *Actinomyces* spp., *Alcaligenes* spp., *Staphylococcus epidermidis* and *mutans, Streptococcus mutans* and *sanguis* decreased by the 14th day in 1,9–5 times. After 1 month it continued to decrease and reached normal values for the given sex and age of the subject. The number of *Clostridium coccoides* and *Perfringens, Rhodococcus* spp. normalised by the 14th day, and after 1 month they were not in blood samples.

The number of *Bifidobacterium* spp. increased 1.3 times after 15 days and 1.9 times after 1 month, but they did not reach the boundaries of normal reference values.

The amount of *Lactobacillus* spp., *Clostridium ramosum* on the background of fasting and in 1 month after its termination remained reduced by 50 and 25% respectively.

Changes in nutritional status according to the results of bioimpedanceometry are presented in Table 2.

On the 4th day the amount of FM increased by 1.5 kg, FFM — by 5%. The value of LM decreased by 3.6 kg, SMM — by 3 kg. The BM value decreased by 115 kcal/day. On day 9, the amount of FM decreased by 4 kg, but the FFM of the total body fat mass value recovered to the baseline value. The LM value decreased by another 2.5 kg, ACMF by 7 kg, SMM and TW by 2 and 3 kg, respectively. By day 15, the amount of FM had reached its minimum value, FFM decreased by 2.5%. The indices of LM, ACMF, SMM and TW were restored to the baseline values.

In 1 month after the end of follow-up, all investigated indices, including fat mass and its proportion, recovered to the initial ones. BM increased by 130 kcal/day and corresponded to 1624 kcal/day.

CONCLUSIONS

1. Reduction of human body weight is accompanied by loss of fat mass, reduction of active cell mass due to acceleration of basic metabolism and increased breakdown of proteins.

2. Prolonged fasting affects to a greater extent the change in the platelet link of homeostasis, which persists for a month after restoration of the dietary regime.

3. Changes in the metabolic profile during fasting are expressed in the violation of lipid metabolism in the form of an increase in triglycerides, LDL, and a decrease in HDL.

4. Starvation does not lead to significant changes in the state of cellular immunity and depends on the initial immunological reactivity of the organism.

5. During fasting, acidosis develops due to lack of carbohydrates, which, in turn, contributes to the mobilisation of fat from the depot.

6. Changes in the intestinal microbiota against the background of fasting are expressed by an increase in the number of bifidobacteria and a decrease in lactobacilli. After the cessation of fasting, this trend persists for a month. Fasting has a favourable effect on some representatives of opportunistic flora of microbiota (*Staphylococcus, Clostridium, Rhodococcus, Actinomyces, Alcaligenes*), which reduces the risk of development of diseases caused by them in the future.

REFERENCES

1. Naletov A.V. Ogranichitel'nyye tipy pitaniya v detskom vozraste — vred ili pol'za? [Restrictive types of nutrition in childhood — harm or benefit?] Health, Food & Biotechnology. 2022; 4(1): 16–23. https://doi.org/10.36107/hfb.2022.i1.s128. (in Russian).
2. Bolotova N.V., Aver'yanov A.P., Dronova Ye.G. i dr. Nemedikamentoznaya korrektsiya neyroendokrinnykh narusheniy u devochek pubertatnogo vozrasta s ozhireniyem [Non-drug correction of neuroendocrine disorders in obese girls of puberty]. Akusherstvo i ginekologiya. 2012; 7: 92–7. (in Russian).
3. Khoroshinina L.P., Ayli I., Lopatiyeva S.O. i dr. Otdalennyye posledstviya dlitel'nogo golodaniya organizma na etape yego vnutriutrobnogo razvitiya: obzor eksperimental'nykh issledovaniy [Long-term effects of prolonged starvation of the organism at the stage of its intrauterine development: a review of experimental studies]. Voprosy diyetologii. 2021; 11(2): 35–41. (in Russian).
4. Khavkin A.I., Novikova V.P., Yevdokimova N.V. Pitaniye kak sposob kontrolya khronicheskogo vospaleniya nizkoy intensivnosti cherez korrektsiyu kishechnoy mikrobioty [Nutrition as a way to control chronic low-intensity inflammation through the correction of the intestinal microbiota]. Voprosy detskoy diyetologii. 2022; 20(1): 32–41. (in Russian).
5. Ibragimov Sh.U., Shamsiyev Sh.Zh. Periodicheskoye golodaniye [Intermittent fasting]. Pol'za i vliyaniye na mozg (obzor literatury). Voprosy nauki i obrazovaniya. 2019; 28 (77): 132–40. (in Russian).
6. Yevseyev A.B. K voprosu o vliyanii interval'noy diyety na organizm cheloveka [To the question of the influence of the interval diet on the human body]. Byulleten' nauki i praktiki. 2021; 7(9): 410–16. https://doi.org/10.33619/2414–2948/70/38. (in Russian).
7. Pal'tsyn A.A., Sviridkina N.B. Interval'noye golodaniye [Intermittent fasting]. Patologicheskaya fiziologiya i eksperimental'naya terapiya. 2021; 65(4): 116–20. DOI: 10.25557/0031-2991.2021.04.116-120. (in Russian).
8. Antoni R., Robertson T.M., Robertson M.D., Johnston J.D. A pilot feasibility study exploring the effects of a moderate time-restricted feeding intervention on energy intake, adiposity and metabolic physiology in free-living human subjects. Journal of Nutritional Science. 2018; 7: e22. DOI: https://doi.org/:10.1017/jns.2018.13.
9. Akulova K.Yu., Mozgunov A.I., Stupin A.V., Goloshubova M.A. Vliyaniye preryvistogo golodaniya na sportsmenov [Impact of intermittent fasting on athletes]. Kul'tura fizicheskaya i zdorov'ye. 2020; 74 (2): 78–80. (in Russian).
10. Berkovskaya M.A., Gurova O.Yu., Khaykina I.A., Fadeyev V.V. Pitaniye, ogranichennoye po vremeni, kak novaya strategiya terapii ozhireniya i komorbidnykh sostoyaniy [Time-limited nutrition as a new strategy for the treatment of obesity and comorbid conditions]. Problemy Endokrinologii. 2022; 68(4): 78–91. https://doi.org/10.14341/probl13078. (in Russian).
11. Tinsley G.M., Moore M.L., Graybeal A.J. et al. Time-restricted feeding plus resistance training in active females: a randomized trial. Am J Clin Nutr. 2019; 110(3): 628–40. DOI: https://doi.org/10.1093/ajcn/nqz126.
12. Sutton E.F., Beyl R., Early K.S. et al. Early Time-Restricted Feeding Improves Insulin Sensitivity, Blood Pressure, and Oxidative Stress Even without Weight Loss in Men with Prediabetes. Cell Metab. 2018; 27(6): 1212–21.e3. DOI: https://doi.org/:10.1016/j.cmet.2018.04.010.
13. Moguchaya Ye.V., Rotar' O.P., Konradi A.O. Golodaniye v nachale zhizni — vozmozhnoye vliyaniye na

dal'neysheye zdorov'ye [Fasting early in life is a possible impact on later health]. Klinicheskiy sluchay. Arterial'naya gipertenziya.. 2015; 21(6): 639–45. DOI: 10.18705/1607-419X-2015-21-6-639-645. (in Russian).
14. Pereverzev V.A., Sikorskiy A.V., Blazhko A.S. i dr. K voprosu o novykh istochnikakh postupleniya endogennoy glyukozy v krov' pri golodanii [On the issue of new sources of endogenous glucose in the blood during starvation]. Vestnik Smolenskoy gosudarstvennoy meditsinskoy akademii. 2019; 18 (4): 44–51. (in Russian).
15. Khoroshinina L.P., Shabrov A.V., Buynov L.G. Golodaniye v detstve i ozhireniye u lyudey starshikh vozrastnykh grupp [Childhood starvation and obesity in older people]. Pediatr. 2017; 8(6): 56–61. DOI: 10.17816/PED8656-61. (in Russian).
16. Choi I.Y., Lee C., Longo V.D. Nutrition and fasting mimicking diets in the prevention and treatment of autoimmune diseases and immunosenescence, Molecular and Cellular Endocrinology. 2017; 455 (1): 4–12. DOI: 10.1016/j.mce.2017.01.042.
17. Han K., Singh K., Rodman M.J. Fasting-induced FOXO4 blunts human CD4+ T helper cell responsiveness. Nature Metabolism. 2021; 3(3): 318–26. DOI: 10.1038/s42255-021-00356-0.

ЛИТЕРАТУРА

1. Налетов А.В. Ограничительные типы питания в детском возрасте — вред или польза? Health, Food & Biotechnology. 2022; 4(1): 16–23. https://doi.org/10.36107/hfb.2022.i1.s128.
2. Болотова Н.В., Аверьянов А.П., Дронова Е.Г. и др. Немедикаментозная коррекция нейроэндокринных нарушений у девочек пубертатного возраста с ожирением. Акушерство и гинекология. 2012; 7: 92–7.
3. Хорошинина Л.П., Айли И., Лопатиева С.О. и др. Отдаленные последствия длительного голодания организма на этапе его внутриутробного развития: обзор экспериментальных исследований. Вопросы диетологии. 2021; 11(2): 35–41.
4. Хавкин А.И., Новикова В.П., Евдокимова Н.В. Питание как способ контроля хронического воспаления низкой интенсивности через коррекцию кишечной микробиоты. Вопросы детской диетологии. 2022; 20(1): 32–41.
5. Ибрагимов Ш.У., Шамсиев Ш.Ж. Периодическое голодание. Польза и влияние на мозг (обзор литературы). Вопросы науки и образования. 2019; 28 (77): 132–40.
6. Евсеев А.Б. К вопросу о влиянии интервальной диеты на организм человека. Бюллетень науки и практики. 2021; 7(9): 410–16. https://doi.org/10.33619/2414-2948/70/38.
7. Пальцын А.А., Свиридкина Н.Б. Интервальное голодание. Патологическая физиология и экспериментальная терапия. 2021; 65(4): 116–20. DOI: 10.25557/0031-2991.2021.04.116-120.
8. Antoni R., Robertson T.M., Robertson M.D., Johnston J.D. A pilot feasibility study exploring the effects of a moderate time-restricted feeding intervention on energy intake, adiposity and metabolic physiology in free-living human subjects. Journal of Nutritional Science. 2018; 7: e22. DOI: https://doi.org/:10.1017/jns.2018.13.
9. Акулова К.Ю., Мозгунов А.И., Ступин А.В., Голошубова М.А. Влияние прерывистого голодания на спортсменов. Культура физическая и здоровье. 2020; 74 (2): 78–80.
10. Берковская М.А., Гурова О.Ю., Хайкина И.А., Фадеев В.В. Питание, ограниченное по времени, как новая стратегия терапии ожирения и коморбидных состояний. Проблемы эндокринологии. 2022; 68(4): 78–91. https://doi.org/10.14341/probl13078.
11. Tinsley G.M., Moore M.L., Graybeal A.J. et al. Time-restricted feeding plus resistance training in active females: a randomized trial. Am J Clin Nutr. 2019; 110(3): 628–40. DOI: https://doi.org/10.1093/ajcn/nqz126.
12. Sutton E.F., Beyl R., Early K.S. et al. Early Time-Restricted Feeding Improves Insulin Sensitivity, Blood Pressure, and Oxidative Stress Even without Weight Loss in Men with Prediabetes. Cell Metab. 2018; 27(6): 1212–21. e3. DOI: https://doi.org/:10.1016/j.cmet.2018.04.010.
13. Могучая Е.В., Ротарь О.П., Конради А.О. Голодание в начале жизни — возможное влияние на дальнейшее здоровье. Клинический случай. Артериальная гипертензия. 2015; 21(6): 639–45. DOI: 10.18705/1607-419X-2015-21-6-639-645.
14. Переверзев В.А., Сикорский А.В., Блажко А.С. и др. К вопросу о новых источниках поступления эндогенной глюкозы в кровь при голодании. Вестник Смоленской государственной медицинской академии. 2019; 18 (4): 44–51.
15. Хорошинина Л.П., Шабров А.В., Буйнов Л.Г. Голодание в детстве и ожирение у людей старших возрастных групп. Педиатр. 2017; 8(6): 56–61. DOI: 10.17816/PED8656-61.
16. Choi I.Y., Lee C., Longo V.D. Nutrition and fasting mimicking diets in the prevention and treatment of autoimmune diseases and immunosenescence, Molecular and Cellular Endocrinology. 2017; 455 (1): 4–12. DOI: 10.1016/j.mce.2017.01.042.
17. Han K., Singh K., Rodman M.J. Fasting-induced FOXO4 blunts human CD4+ T helper cell responsiveness. Nature Metabolism. 2021; 3(3): 318–26. DOI: 10.1038/s42255-021-00356-0.