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DIFFERENCES IN THE ACTIVITY OF AMYLASE, PEPSINOGEN AND LIPASE IN BIOLOGICAL FLUIDS IN PREGNANT WOMEN, DEPENDING ON THE TIMING OF DELIVERY

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Abstract. ***Introduction.*** The issues of enzyme increment of digestive glands have been studied since the sixties of the last century to the present. Enzymes induce the functional activity of secretory glands and prepare the digestive tract of an infant for definitive nutrition through a period of mixed nutrition. ***The purpose of the work*** — to study the sources of enzyme supply of hematrophic, amniotrophic and lactotrophic nutrition of the fetus, the origin of enzymes of amniotic fluid, colostrum and breast milk and their participation in the autolysis of fetal and newborn nutrients. ***Materials and methods***. The material for the study was taken from non-pregnant and pregnant women. The dynamics of changes in the activity of hydrolases in biological fluids was studied. ***Results***. The participation of enzymes secreted in the mother's body in trophosystems during pregnancy and in the postnatal period has been shown. ***Conclusions***. During pregnancy, three systems are distinguished: hematrophic, amniotrophic and lactotrophic with autolytic digestion by increted enzymes.

Keywords: enzymes, incretion, recreation, pregnancy, trophosystem

РАЗЛИЧИЯ АКТИВНОСТИ АМИЛАЗЫ, ПЕПСИНОГЕНА И ЛИПАЗЫ В БИОЛОГИЧЕСКИХ ЖИДКОСТЯХ У БЕРЕМЕННЫХ ЖЕНЩИН В ЗАВИСИМОСТИ ОТ СРОКОВ РОДОРАЗРЕШЕНИЯ

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Резюме. ***Введение.*** Вопросы инкреции ферментов пищеварительных желез изучались с шестидесятых годов прошлого столетия и по настоящее время. Ферменты индуцируют функциональную активность секреторных желез и подготавливают пищеварительный тракт грудного ребенка к дефинитивному питанию через период

смешанного питания. ***Цель исследования*** — изучить источники ферментного обеспечения гематрофного, амниотрофного и лактотрофного питания плода, происхождение ферментов амниотической жидкости, молозива и грудного молока и их участие в аутолизе нутриентов плода и новорожденного. ***Материалы и методы***. Материал для исследования брался у небеременных и беременных женщин. Изучалась динамика изменения активности гидролаз в биологических жидкостях. ***Результаты.*** Показано участие инкретируемых в организме матери ферментов в трофосистемах при беременности и в постнатальный период. ***Выводы.*** Во время беременности выделяются три системы: гематрофная, амниотрофная и лактотрофная с аутолитическим пищеварением инкретируемыми энзимами.

Ключевые слова: ферменты, инкреция, рекреция, беременность, трофосистема

INTRODUCTION

The incretion of digestive glands' enzymes has been studying in the laboratory of Professor G.F. Korotko since the sixties of the last century [6–8]. A biological significance of homeostasis of hydrolases (zymogens and enzymes) in blood was resolved. The diverse role of hydrolases was revealed, including anabolic, regulatory, informational, transport and other functions of pepsinogen, amylase, lipase, alkaline phosphatase in the human body [6, 11, 15].

Experiments on animals have established the nature of the distribution of parenterally administered radiolabeled (J125) enzymes in a mother's body and fetus. Uteroplacental permeability to pepsinogen and amylase, as well as the hydrolytic activity of amniotic fluid, were also studied [3, 13, 14].

In researches on biological fluids, activity of digestive enzymes was studied in blood plasma, urine, and amniotic fluid in women during different stages of pregnancy [1, 6, 7]. After birth, such activity was studied in colostrum and breast milk until the end of breastfeeding [1, 8, 12, 15].

AIM

To study the sources of enzyme support for amniotrophic and lactotrophic nutrition of a fetus. To prove that enzymes are re-secreted in colostrum and breast milk, and that enzymes are used for autolysis of nutrients and induced to their own digestion in gastrointestinal tract of the fetus and newborn.

MATERIALS AND METHODS

Materials for the study were taken from non-pregnant (n=45) and pregnant (n=151) women — women gave birth at different weeks of pregnancy (full-term birth – 86, premature birth — 34, post-term birth — 31).

The dynamics of changes in enzyme activity (pepsinogen, amylase and lipase) in biological fluids (blood, saliva, urine and coprofiltrate, umbilical cord blood and amniotic fluid) were studied at the end of pregnancy, and colostrum and breast milk were studied in the postpartum period.

Determination of proteolytic, amylolytic and lipolytic activities was carried out in blood plasma, saliva, urine and coprofiltrate both in non-pregnant women and pregnant women at the end of pregnancy.

Determination of total proteolytic activity was carried out at pH values of 1.5–2.0 using the spectrophotometric (tyrosine) method of Kunitz–Northrop in modification. Amylolytic activity was determined using Caraway's amyloclastic method. Lipolytic activity was determined using a unified method with olive oil as a substrate [12].

Statistical processing of the obtained data was carried out in Microsoft Excel 2003, Primer of biostatistics 4.03 and SPSS 11.0 programs.

RESULTS

The process of enzyme incretion by digestive glands is reflected in indicators of enzymes' activity in blood and urine, as well as ratios between them [14, 15].

Amylolytic activity in blood plasma of pregnant women is naturally higher than in non-pregnant women, regardless of the timing of delivery (Table 1).

In case of full-term birth, the activity of amylase in urine is almost the same as the control values. In case of preterm and post-term birth, it is reduced, which indicates the retention of the enzyme in the body of pregnant women.

The activity of pepsinogen in blood plasma is more stable than activity of amylase, but excretion of pepsinogen in urine of pregnant women is 2.1 times ($p < 0.001$) higher than in urine of non-pregnant women, indicating the degree of proteolytic enzyme incretion.

Lipolytic activity of blood and urine during pregnancy is increased compared to controls, especially in women with full-term birth.

An example of the re-secreted origin of proteolytic enzymes in saliva is the detection of pepsinogen activity there (Table 2).

Table 1

Indicators of the activity of digestive enzymes in the blood and urine of control group individuals and women at the end of pregnancy with different delivery dates)

Таблица 1

Показатели активности пищеварительных ферментов в крови и моче у лиц контрольной группы и женщин в конце беременности с различными сроками родоразрешения

Показатели / Indicators	Контрольная группа / Control group (n=45)	Срочные роды / Urgent delivery (n=86)	Преждевременные роды / Premature birth (n=34)	Запоздалые роды / Delayed delivery (n=31)
Кровь / Blood				
1. Амилаза (ед/мл) / Amylase (units/ml)	13,5±0,8	25,0±1,3*	22,4±1,3**	20,1±1,4**
2. Пепсиноген (тир. ед/мл) / Pepsinogen (tyr. units/ml)	58,1±1,1	48,2±2,6**	62,3±4,2	60,3±4,4
3. Липаза (ед/мл) / Lipase (units/ml)	18,1±0,7	32,1±1,8*	37,1±1,8*	24,1±1,4
Моча / Urine				
1. Амилаза (ед/мл) / Amylase (units/ml)	64,1±1,6	67,2±2,1	36,2±1,1*	44,3±2,1**
2. Пепсиноген (тир. ед/мл) / Pepsinogen (tyr. units/ml)	4520,3±212,0	9650,1±211,5*	10422,1±231,5*	9309,3±211,5*
3. Липаза (ед/мл) / Lipase (units/ml)	20,6±0,8	41,2±1,9*	30,8±1,9**	31,1±1,7*

Note: the reliability of differences with the indicators of the control group: * — p <0,001; ** — p<0,05.
Примечание: достоверность различий с показателями контрольной группы: * — p <0,001; ** — p <0,05.

Table 2

Indicators of the activity of digestive enzymes in saliva and coprofiltrate of control group individuals and women at the end of pregnancy with different delivery dates

Таблица 2

Показатели активности пищеварительных ферментов в слюне и копрофильтрате у лиц контрольной группы и женщин в конце беременности с различными сроками родоразрешения

Показатели / Indicators	Контрольная группа / Control group (n=45)	Срочные роды / Urgent delivery (n=86)	Преждевременные роды / Premature birth (n=34)	Запоздалые роды / Delayed delivery (n=31)
Слюна / Saliva				
1. Амилаза (ед/мл) / Amylase (units/ml)	2385,3±264,7	4781,6±423,8*	3717,3±223,8**	4702,9±323,8*
2. Пепсиноген (тир. ед/мл) / Pepsinogen (tyr. units/ml)	1520,9±247,6	2612,9±218,1*	2443,5±218,1**	2253,7±118,1**
3. Липаза (ед/мл) / Lipase (units/ml)	64,8±7,0	124,1±11,6*	176,5±11,6*	74,5±3,4**
Копрофильтрат / Coprofiltrate				
1. Амилаза (ед/мл) / Amylase (units/ml)	19,5±0,8	44,4±3,9*	35,2±2,1*	36,2±1,8*
2. Пепсиноген (тир. ед/мл) / Pepsinogen (tyr. units/ml)	442,2±20,5	153,8±10,9*	174,7±16,2*	122,4±8,2*
3. Липаза (ед/мл) / Lipase (units/ml)	320,8±12,6	344,4±17,2	475,3±21,8**	375,3±20,8**

Note: the reliability of differences with the indicators of the control group: * — p <0,001; ** — p <0,05.
Примечание: достоверность различий с показателями контрольной группы: * — p <0,001; ** — p <0,05.

Pepsinogen secreted in stomach is released into saliva from blood, and in pregnant women it is 1.5 times (p<0.001) higher than in non-pregnant women, thereby ensuring the participation of salivary glands in secretion of the enzyme.

The excretory-re-secretory origin of the hydrolytic activity of coprofiltrates is explained by the fact of amylase, pepsinogen and lipase detection in feces [3, 6, 11].

During pregnancy, amylolytic and lipolytic activities increase, and pepsinogen activity decreases almost 3 times (p <0.001). These relationships are inversely dependent on the level of pepsinogen excretion in urine, which generally affects the pepsinogen content in blood of pregnant women.

Another trophic system is associated with fetal amniotrophic nutrition and autolytic digestion due to the absorption of amniotic fluid, which contains both nutrients and enzymes corresponding to substrates — hydrolases of maternal origin [2–4].

This is proven by the presence of amylase, pepsinogen and lipase in amniotic fluid, which has the property of accumulating enzymes used by a fetus for hydrolytic processes in gastrointestinal tract when digestion is still imperfect (Table 3).

Of particular interest are data on the activity of enzymes secreted into colostrum and breast milk of women depending on the delivery time (Table 4).

Colostrum is more active in enzymes than breast milk. General proteolytic (4 times; p <0.001) and lipolytic (3 times; p <0.001) activities differ especially from mature breast milk, while the amylolytic activity of these biological fluids differs by less than 2 times (p <0.05) with a decrease during the transition to mature breast milk. This proves the role of colostrum and breast milk enzymes in colostrum-lactotrophic nutrition.

DISCUSSION

Maternal blood plasma, being the nutrient medium of a fetus, ensures hydrolytic processes and plays a role in anabolic processes [3, 6, 12, 14, 15].

The conducted studies revealed an increase in the activity of amylase and lipase in blood serum of all women at the end of pregnancy, regardless of the time of delivery. Multidirectional changes in this fluid were observed in pepsinogen: a decrease in enzyme activity in women with full-term birth and an increase in post-term and premature birth.

The amylase excretion in urine of pregnant women with full-term birth corresponded to indicators of the control group, and in premature and post-term birth the enzyme activity decreased, which indicates the retention of amylase in the body of pregnant women [1, 3, 6]. The activity of pepsinogen and lipase in urine is increased in port-term pregnancy compared to controls, especially in full-term labour.

Amylolytic activity of saliva is caused not only by the secretion of α-amylase synthesized by the salivary glands, but also by the secreted pancreatic α-amylase. In this regard, the

Table 3

Indicators of the activity of digestive enzymes in amniotic fluid and umbilical cord blood in pregnant women, depending on the timing of delivery

Таблица 3

Показатели активности пищеварительных ферментов в амниотической жидкости и пуповинной крови у беременных в зависимости от сроков родоразрешения

Биологическая жидкость / Biological fluid	Ферменты / Enzymes	Срочные роды / Urgent delivery (n=86)	Преждевременные роды / Premature birth (n=34)	Запоздалые роды / Delayed delivery (n=31)
Амниотическая жидкость / Amniotic fluid	Амилаза (ед/мл) / Amylase (units/ml)	16,3±0,7	27,7±0,9*	25,8±0,9*
	Пепсиноген (тир. ед/мл) / Pepsinogen (tyr. units/ml)	5664,5±225,1	5840,8±204,3	6387,0±249,4**
	Липаза (ед/мл) / Lipase (units/ml)	228,7±18,4	201,4±15,3	234,2±16,2
Пуповинная кровь / Umbilical cord blood	Амилаза (ед/мл) / Amylase (units/ml)	35,3±1,2	10,9±0,8*	15,1±1,1*
	Пепсиноген (тир. ед/мл) / Pepsinogen (tyr. units/ml)	1041,6±88,5	1214,4±97,3**	873,0±65,4
	Липаза (ед/мл) / Lipase (units/ml)	164,9±11,2	190,4±13,4	61,2±4,5*

Note: the reliability of differences with the indicators of the control group: * — p <0,001; ** — p <0,05.
Примечание: достоверность различий с показателями у беременных женщин, родивших в срок: * — p <0,001; ** — p <0,05.

Table 4

Indicators of the activity of digestive enzymes in colostrum and breast milk in lactating women, depending on the timing of their delivery

Таблица 4

Показатели активности пищеварительных ферментов в молозиве и грудном молоке у кормящих женщин в зависимости от сроков их родоразрешения

Биологическая жидкость / Biological fluid	Ферменты / Enzymes	Срочные роды / Urgent delivery (n=86)	Преждевременные роды / Premature birth (n=34)	Запоздалые роды / Delayed delivery (n=31)
Молозиво / Colostrum	Амилаза (ед/мл) / Amylase (units/ml)	401,3±21,7	511,9±32,5**	440,9±20,3
	Пепсиноген (тир. ед/мл) / Pepsinogen (tyr. units/ml)	609,5±26,3	532,4±18,1	581,1±29,4**
	Липаза (ед/мл) / Lipase (units/ml)	634,1±28,5	523,2±25,3**	562,9±23,6**
Грудное молоко / Breast milk	Амилаза (ед/мл) / Amylase (units/ml)	215,3±19,6	267,8±14,5**	233,4±15,6
	Пепсиноген (тир. ед/мл) / Pepsinogen (tyr. units/ml)	152,9±12,1	124,2±10,2	179,1±11,6**
	Липаза (ед/мл) / Lipase (units/ml)	222,2±17,2	285,4±14,7**	230,2±12,7

Note: the reliability of differences with the indicators of the control group: * — p <0,001; ** — p <0,05.
Примечание: достоверность различий с показателями у беременных женщин, родивших в срок: * — p <0,001; ** — p <0,05.

increased amylolytic activity in pregnant women may be due to both amylases [4, 5, 7–10, 13, 14].

All pregnant women showed an increase in the amylase, pepsinogen and lipase activity in saliva, which indicates the released (secreted in saliva) origin of these enzymes.

If the salivary glands do not experience hydrostatic resistance, then in the pancreatic ducts of pregnant women this is greater than in non-pregnant women [1, 3, 6]. Accordingly, the lipolytic activity of saliva also changes, especially in premature birth, which is associated with an increased lipase activity in blood.

By the end of pregnancy, amylolytic and lipolytic activities of the coprofiltrate increased with the greatest changes in women with full-term and premature births. At the same time, there was a decrease in the pepsinogen activity in all studied groups of pregnant women compared with controls.

The amnio-placental barrier is involved in the selective accumulation of digestive enzymes in amniotic fluid, in which enzymes' content is quite significant [2, 3, 12, 15]. Umbilical cord blood is rich in proteolytic and lipolytic enzymes, especially in women with premature birth.

In the postnatal period, a child switches to a colostrum-lactotrophic type of nutrition [1, 3, 12]. In this regard, we found the highest levels of hydrolase activity in colostrum, with a subsequent decrease in its activity in breast milk on the fifth day of life. Incretion, releasing and excretion of enzymes are interrelated, maintaining the constancy of their blood content for the implementation of anabolic and regulatory processes in a fetus [13, 14, 16].

Thus, the data obtained on enzyme homeostasis in the "mother-fetus-newborn" system serve as additional material on trophic systems with their autolytic type of digestion. In the antenatal period, histotrophic, hematotrophic (transplacental) and amniotrophic nutritions are organized, and in the postnatal period, there is a lactotrophic nutrition. Enzymes induce the functional activity of the secretory glands and prepare the infant's digestive system for definitive nutrition through a period of mixed feeding.

CONCLUSION

1. Amylolytic activity of blood serum, urine and saliva in pregnant women is naturally higher than in non-pregnant women, regardless of the time of delivery.

2. The activity of pepsinogen and lipase in blood, urine and saliva during pregnancy is increased compared to the controls, especially in women with full-term delivery.

3. In coprofiltrate, an increase in amylase and lipase activity was observed, but a decrease in pepsinogen was observed in all pregnant women studied by the end of pregnancy.

4. Amniotic fluid and umbilical cord blood are rich in proteolytic and lipolytic enzymes with the greatest changes in women with premature and post-term birththe the.

5. Hydrolytic activity of colostrum is significantly higher than that of breast milk on the fifth day of life

6. Enzymes participate in autolytic digestion and induce the infant's own digestion in the body.

ADDITIONAL INFORMATION

Author contribution. Thereby, all authors made a substantial contribution to the conception of the study, acquisition, analysis, interpretation of data for the work, drafting and revising the article, final approval of the version to be published and agree to be accountable for all aspects of the study.

Competing interests. The authors declare that they have no competing interests.

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Consent for publication. Written consent was obtained from the patient for publication of relevant medical information within the manuscript.

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Вклад авторов. Все авторы внесли существенный вклад в разработку концепции, проведение исследования и подготовку статьи, прочли и одобрили финальную версию перед публикацией.

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REFERENCES

1. Arshavskiy I.A., Nemets M.P. O smene tipov pitaniya i pishchevareniya v ontogeneze. [About changing types of nutrition and digestion in ontogenesis]. Uspekhi fiziologicheskikh nauk. 2006;1:129–109. (in Russian).
2. Ivanov D.O., Avrel'kina E.V., Aleksandrovich Yu.S., Aleshina E.I. Rukovodstvo po perinatologii. [Perinatology Manual]. T. 1. 6-e izd. Sankt-Peterburg: Inform-Navigator Publ.; 2019. (in Russian).
3. Kamakin N.F. Puti gomeostatirovaniya v krovi inkretiruemykh pishchevaritel'nymi zhelezami gidrolaz, ikh anabolicheskaya i regulyatornaya rol'. [Ways of homeostatization of hydrolases secreted by digestive glands in the blood, their anabolic and regulatory role]. Avtoref. dis. … dokt. med. nauk. Tomsk; 1985. (in Russian).
4. Kolodkina E.V. Gomeostaz pishchevaritel'nykh fermentov i aktivnost' transaminaz, ikh soderzhanie v likvore u detey (kliniko-fiziologicheskoe issledovanie). [Homeostasis of digestive enzymes and transaminase activity, their content in the children's cerebrospinal fluid (clinical and physiological study)]. Avtoref. dis. … kand. med. nauk. Arkhangel'sk; 2000. (in Russian).
5. Komarov L.G., Alekseeva O.P. Salivalogiya. [Salivalogy]. Nizhniy Novgorod: NGMA Publ.; 2016. (in Russian).
6. Korot'ko G.F. Rekretsiya fermentov i gormonov ekzokrinnymi zhelezami. [Recretion of enzymes and hormones by exocrine glands]. Uspekhi fiziologicheskikh nauk. 2018; 34(2):32–21. (in Russian).
7. Korot'ko G.F. Sekretsiya slyunnykh zhelez i elementy salivadiagnostiki. [Salivary gland secretion and salivadiagnostics elements]. Moskva: Akademiya Estestvoznaniya Publ.; 2015. (in Russian).
8. Korot'ko G.F., Kadirov Sh.K. Rol' slyunnykh zhelez v obespechenii otnositel'nogo postoyanstva gidroliticheskoy aktivnosti krovi. [The role of the salivary glands in ensuring the relative constancy of the hydrolytic activity of the blood]. Fiziologicheskiy zhurnal im. I.M. Sechenova. 2014; 80(8):117–108. (in Russian).
9. Lytaev S.A., Chudakov A.Yu., Skrebtsova N.V., Gayvoronskaya V.V. Meditsinskaya sub"ektologiya v pediatrii: uchebno-metodicheskoe posobie. [Medical subjectology in pediatrics: an educational and methodological guide]. Sankt-Peterburg: Meditsinskiy institut Akademii sotsial'nykh tekhnologiy; 2019. (in Russian).
10. Timofeeva N.M. Metabolicheskoye pishchevoye programmirovaniye fermentnykh sistem tonkoy kishki potomstva. [Metabolic food programming of the enzyme systems of the small intestine of offspring]. Russian Journal of Physiology. 2012; 86(11):1531–1538. (in Russian).
11. Timofeeva N.M. Ranneye metabolicheskoye/pishchevoye programmirovaniye fermentnykh sistem pishchevaritel'nykh i nepishchevaritel'nykh organov. [Early metabolic/nutritional programming of enzyme systems of digestive and non-digestive organs]. Gastroenterologiya Sankt-Peterburga. 2014;1:38–40. (in Russian).
12. Ugolev A.M. Teoriya adekvatnogo pitaniya i trofologiya. [The theory of adequate nutrition and trophology]. Sankt-Peterburg: Nauka Publ.; 1991. (in Russian).
13. Hofman L.F. Human Saliva as a Diagnostic Specimen. Am. Soc. Nutr. Sciences. 2017; 131(2):1625–1621.
14. Kaufman E., Lamster I.B. The Diagnostic Applications of Saliva — A Review. Crit. Rev. Oral. Biol. Med. 2016; 13(2):212–197.
15. King J.C. Physiology of pregnancy and nutrient metabolism. Am. J. Clin. Nutr. 2018; 71(5):1225–1218.
16. Lytaev S.A. Modern Neurophysiological Research of the Human Brain in Clinic and Psychophysiology. Lecture Notes in Computer Science. 2021; 12940:231–241.

ЛИТЕРАТУРА

1. Аршавский И.А., Немец М.П. О смене типов питания и пищеварения в онтогенезе. Успехи физиологических наук. 2006;1:129–109.
2. Иванов Д.О., Аврелькина Е.В., Александрович Ю.С., Алешина Е.И. Руководство по перинатологии. Т. 1. 6-е изд. СПб.: Информ-Навигатор; 2019.
3. Камакин Н.Ф. Пути гомеостатирования в крови инкретируемых пищеварительными железами гидролаз, их анаболическая и регуляторная роль. Автореф. дис. … докт. мед. наук. Томск; 1985.
4. Колодкина Е.В. Гомеостаз пищеварительных ферментов и активность трансаминаз, их содержание в ликворе у детей (клинико-физиологическое исследование). Автореф. дис. … канд. мед. наук. Архангельск; 2000.
5. Комаров Л.Г., Алексеева О.П. Саливалогия. Нижний Новгород: НГМА; 2016.
6. Коротько Г.Ф. Рекреция ферментов и гормонов экзокринными железами. Успехи физиологических наук. 2018;34(2):32–21.
7. Коротько Г.Ф. Секреция слюнных желез и элементы саливадиагностики. М.: Академия Естествознания;2015.
8. Коротько Г.Ф., Кадиров Ш.К. Роль слюнных желез в обеспечении относительного постоянства гидролитической активности крови. Физиологический журнал им. И.М. Сеченова. 2014;80(8):117–108.
9. Лытаев С.А., Чудаков А.Ю., Скребцова Н.В., Гайворонская В.В. Медицинская субъектология в педиатрии: учебно-методическое пособие. СПб.: Медицинский институт Академии социальных технологий; 2019.
10. Тимофеева Н.М. Метаболическое пищевое программирование ферментных систем тонкой кишки потомства. Российский физиологический журнал. 2012;86(11):1531–1538.
11. Тимофеева Н.М. Раннее метаболическое/пищевое программирование ферментных систем пищеварительных и непищеварительных органов. Гастроэнтерология Санкт-Петербурга. 2014;1:38–40.
12. Уголев А.М. Теория адекватного питания и трофология. СПб.: Наука; 1991.
13. Hofman L.F. Human Saliva as a Diagnostic Specimen. Am. Soc. Nutr. Sciences. 2017;131(2):1625–1621.
14. Kaufman E., Lamster I.B. The Diagnostic Applications of Saliva — A Review. Crit. Rev. Oral. Biol. Med. 2016;13(2):212–197.
15. King J.C. Physiology of pregnancy and nutrient metabolism. Am J Clin Nutr. 2018;71(5):1225–1218.
16. Lytaev S.A. Modern Neurophysiological Research of the Human Brain in Clinic and Psychophysiology. Lecture Notes in Computer Science. 2021;12940:231–241.