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AGE-SPECIFIC FEATURES OF FATTY ACID COMPOSITION OF LIPID SERUM IN RATS WITH OBESITY UNDER THE INFLUENCE OF IODINE

Introduction. *The article presents new data on the age-specific features of the fatty acid composition of the total serum lipids of white male rats with experimental alimentary obesity in the comparative effect of intragastric administration of biologically active iodine in the composition of Jodis-concentrate and inorganic iodine as a part of the Iodomarin.*

The aim of the study *– to investigate the comparative effect of biologically active iodine in the composition of Jodis-concentrate (JC) and inorganic iodine (II) as a part of Iodomarin (IM) on the fatty acid content of total serum lipids of white rats males with experimental alimentary obesity.*

Research Methods. *Experimental alimentary obesity have been investigated during 45 days on 48 Wistar white male rats of various ages. Animals were divided into 3 age groups, 16 animals in each: the group 1 – age 3 month; the group 2 – age 4 months; the group 3 – age 6.5 months. In each age group there were 4 subgroups: 1 – control, which was on the main diet at vivarium; subgroups 2, 3 and 4 – with experimental alimentary obesity. Besides it, animals of the group 4 received intragastrically intravenous iodine in the form of Iodine-concentrate and group 4 – inorganic iodine in the form of potassium iodide in Iodomarin drug. The fatty acid composition was determined by gas-liquid chromatography on a Hewlett Packard HP-6890 gas chromatograph with a flame-ionization detector equipped with a SP-2380 capillary column of 100 m in length (Supelco).*

Results and Discussion. *In serum of white rats in all age groups with EAO, an increase in the relative content of the SFA amount was noted, mainly due to stearic acid, compared with intact animals. In animals with EAO, who received Iodomarin and Jodis-concentrate results were better, comparing with animals in the subgroup 2.*

Conclusions. *Therefore, iodine has a positive effect on the fatty acid composition of lipid serum in rats with obesity.*

KEY WORDS: **blood serum; acid composition of lipid serum; Jodis-Concentrate; Iodomarin; obesity; rats.**

INTRODUCTION. Today, obesity remains an acute medical and social problem in a large part of humanity. Infringement of lipid metabolism has its pathogenetic features at different stages of postnatal development [1]. Investigation of the lipid profile of blood and tissues in ontogenesis is an urgent issue, taking into account the importance of lipid disorders for many diseases. The intensity of lipid metabolism in the body is largely determined by hormonal regulation, including the action of hormones of the thyroid gland [2, 3]. It is known that the production of the required amount of thyroxine and triiodothyronine at all stages of ontogenesis depends on the sufficient amount of exogenous iodine intake [4, 5]. Considering the endemic deficit of this microelement, it will be obvious that the synthesis of thyroid hormones will decrease and the intensity of the main metabolism, including lipid, will decrease accordingly [6].

The fat load provokes the formation of active forms of oxygen, which leads to the activation of lipid peroxide oxidation processes [7]. There is evidence that a high level of saturated fatty acids leads to an increase in proinflammatory cytokines, activates Toll-like receptors and influences the development of the oxygenase metabolism of polyene FA [8]. M. Peppa and other researchers have investigated that in half of patients with hypothyroidism, a lipid metabolism disorder is observed [2, 9, 10].

Our preliminary studies of the influence of biologically active and inorganic iodine on a number of indicators of lipid metabolism [11, 12], hormonal status [13], in white rats of different ages with obesity have proved the necessity to investigate the fatty acid composition of animal blood.

The aim of the study – to investigate the comparative effect of biologically active iodine in the composition of Jodis-concentrate (JC) and

inorganic iodine (II) as a part of Iodomarin (IM) on the fatty acid content of total serum lipids of white male rats with experimental alimentary obesity.

RESEARCH METHODS. The study was conducted on 48 Wistar white male rats of various ages who were in the appropriate sanitary-hygienic conditions of the vivarium of I. Hobrachevsky Ternopil State Medical University of the Ministry of Health of Ukraine and were on a standard feeding.

Animals at the beginning of the experiment were divided into 3 age groups, 16 animals in each: the group 1 – age 3 month; the group 2 – age 4 months; the group 3 – age 6.5 months. In each age group there were 4 subgroups: 1 – control, which was on the main diet at vivarium; The subgroups 2, 3, 4 – with experimental alimentary obesity (EAO), which were formed through an inductor of a food traction – a sodium glutamic acid salt in the ratio of 0.6: 100.0 and a high calorie diet that included standard food (47 %), sweet concentrated milk (44 %), corn oil (8 %) and vegetable starch (1 %) [14]. Daily, during 45 days, animals of the group 3 received intragastrically intravenous iodine in the form of Jodisconcentrate in a dose of 0.1 ml (0.4 micrograms of iodine) per kg of body weight per day and in the group 4 – inorganic iodine in the form of potassium iodide in the Iodomarin drug at a rate of 0.4 micrograms of potassium iodide per kg of body weight of an animal a day. During 45 days of an experiment, it was control of reproduction of alimentary obesity by weighing animals, measuring nasal-anal length and calculating the body mass index (BMI) – dividing the body weight in grams by the length in square centimeters. At the end of the experiment, the animals were killed by decapitation under thiopental anesthesia. During the experiment, the requirements of the European Convention for the Protection of Vertebrate Animals used for Experimental and Other Scientific Purposes (Strasbourg, 1986), the Law of Ukraine On the Protection of Animals from Cruelty and the EU directive 2010/10/63 on the protection of animals used for scientific purposes were kept.

Blood was taken from the cavity of the heart into the test tubes and centrifuged to produce serum. Blood serum lipids were extracted with chloroform-methanol in a ratio of 2:1 by Folch method [15]. Methylation of the fatty acids was carried out with sodium methoxide at room temperature followed by acidification with sulfuric acid and continued methylation at 70 °C [16]. The fatty acid composition was determined by gas-liquid chromatography on a Hewlett Packard HP-6890 gas chromatograph with a flame-ionization detector equipped with a SP-2380 capillary column of 100 m in length (Supelco). Fatty acid methyl esters (Supelco) were used to identify chromatographic peaks and to calculate chromatograms. The obtained experimental data was processed statistically using Student's t-test according to the standard method [17].

RESULTS AND DISCUSSION. As the results of studies have shown, the qualitative composition of fatty acids of serum lipids in white rats of different age was identical. Data in Tables 1–3 shows that among the saturated fatty acids (SFA) of the blood serum lipids of white rats at the age of 3-, 4- and 6.5-months the main ones were palmitic, stearin, and among PUFA – linoleic, arachidonic, linolenic. Monounsaturated fatty acids (MUFA) in serum lipids of intact and experimental rats of all ages were

Table 1 – **Fatty acid composition of serum lipids of 3 month old white rats with experimental alimentary obesity and iodine setting (%, M±m, n=4)**

FA Code	Group of animals			
	1	2	3	4
14:0	0.7±0.1	1.2±0.1*	1.0±0.1	0.9 ±0.1
16:0	19.1±2.1	24.1±2.2*	22.3±1.6	21.0±2.5
17:0	1.6±0.1	2.0±0.2*	1.8±0.1	1.7±0.2
18:0	11.0±1.1	16.4±1.2*	14.0±1.5*	12.1±1.1$^{\#}$
18:1 ώ-9	18.1±1.7	16.7±1.8*	17.0±1.3	18.0±1.6
18:2 ώ-6	23.3±2.1	18.1±1.9*	19.2±2.0	22.1±2.0$^{\#}$
18:3 ώ-3	5.4±0.3	2.2±0.2*	2.9±0.3*$^{\#}$	4.4±0.4$^{\#}$
20:4 ώ-6	12.8±1.2	15.3±1.1*	14.3±1.6*	13.3±1.4
20:5 ώ-3	2.4±0.2	1.3±0.1*	1.6±0.1*$^{\#}$	2.1±0.2$^{\#}$
22:5 ώ-3	2.1±0.2	0.9±0.1*	1.4±0.1*$^{\#}$	1.8±0.1$^{\#}$
22:6 ώ-3	3.5±0.3	1.7±0.1*	2.2±0.1*$^{\#}$	2.6±0.2*$^{\#}$
SFA	32.4±1.0	43.9±1.2*	39.1±1.3*	35.7±1.2*$^{\#}$
PUFA ώ-6	36.1±1.0	33.4±1.0*	33.5±1.1*	35.4±1.0
PUFA ώ-3	13.4±0.5	6.1±0.4*	8.1±0.5*	10.9±0.5*$^{\#}$
ώ-6/ώ-3	2.7	5.5*	4.2*	3.2$^{\#}$

Notes: In this and other tables, the probability of differences compared to the group 1: * – $p<0.05$; the probability of the difference compared to the group 2: $^{\#}$ – $p<0.05$.

Table 2 – **Fatty acid composition of serum lipids of 4 month old white rats with experimental alimentary obesity and iodine setting (%, M±m, n=4)**

FA Code	Group of animals			
	1	2	3	4
14:0	0.8±0.1	1.3±0.1*	1.0 ±0.1	1.1±0.1
16:0	22.6±2.0	25.2±2.2*	22.2±2.5	24.6±1.7
17:0	1.8±0.1	1.9±0.2	1.8±0.1	1.7±0.1
18:0	12.4±1.4	15.8±1.2*	13.2±1.1#	15.3±1.5
18:1 ώ-9	16.2±1.1	18.5±1.8*	17.5±1.8	17.3±1.5
18:2 ώ-6	25.3±3.0	17.4±1.9*	23.4±2.3#	22.0±2.1#
18:3 ώ-3	4.1±0.3	0.7±0.1*	3.7±0.3#	1.2±0.2*#
20:4 ώ-6	11.1±1.2	16.3±1.1*	12.7±1.2#	14.6±1.4*
20:5 ώ-3	2.1±0.1	1.1±0.1*	1.7±0.1#	1.3±0.1*#
22:5 ώ-3	1.3±0.1	0.6±0.1*	0.9±0.1#	0.7±0.1*
22:6 ώ-3	2.2±0.2	1.0±0.1*	1.9±0.1#	1.2±0.1*
SFA	37.6±0.9	44.4±1.2*	38.2±1.0#	42.7±1.1*
PUFA ώ-6	35.4±1.0	33.7±0.9	35.1±0.9	36.6±1.0
PUFA ώ-3	9.7±0.4	3.4±0.3*	8.2±0.4#	4.4±0.3*
ώ-6/ώ-3	3.6	9.9*	4.3#	8.3

Table 3 – **Fatty acid composition of serum lipids of 6.5 month old white rats with experimental alimentary obesity and iodine setting (%, M±m, n=4)**

FA Code	Group of animals			
	1	2	3	4
$C_{14:0}$	1.2±0.1	1.6±0.1*	1.3 ±0.1	1.5±0.1
$C_{16:0}$	24.1±2.1	27.3±1.8	25.1±1.6	27.4±2.7
$C_{17:0}$	2.4±0.2	2.5±0.2	1.8±0.2	2.1±0.2
$C_{18:0}$	15.0±1.4	19.5±1.7*	16.7±1.4#	18.2±1.7
$C_{18:1}$ ώ-9	13.1±1.2	15.1±1.2*	14.7±1.5	14.7±1.8
$C_{18:2}$ ώ-6	26.5±2.2	19.4±1.4*	23.5±2.1#	21.0±2.3#
$C_{18:3}$ ώ-3	2.8±0.2	2.1±0.1*	2.3±0.1#	2.3±0.2*#
$C_{20:4}$ ώ-6	8.5±1.0	12.0±1.3*	10.0±1.1#	11.0±1.2*
$C_{20:5}$ ώ-3	1.7±0.1	1.2±0.1*	1.5±0.1#	1.4±0.1*
$C_{22:5}$ ώ-3	1.2±0.1	0.7±0.1*	1.0±0.1#	0.8±0.1*
$C_{22:6}$ ώ-3	1.7±0.1	1.2±0.1*	1.5±0.1#	1.4±0.1*
SFA	43±1.2	50.7*±1.2	44.5#	49.2±1.2*
PUFA ώ-6	36.3±1.2	30.4±1.1	35.1±1.2	32.0±1.1*
PUFA ώ-3	7.4±0.6	4.4±0.3*	6.8±0.5#	4.5±0.5*
ώ-6/ώ-3	4.9	9.6*	5.1#	7.1*

represented by oleic acid in high amount. In this case, the relative quantitative content of some fatty acids of serum lipids significantly differed and depended, on the one hand, on animal age, and on the other hand, of the subgroup of animals. Thus, the total content of SFA in serum lipids at the age of 4 and 6.5 months intact white rats was in 1.21 and 1.34 times higher, respectively, and the content of the PUFA of families ώ-3 was in 1.41 and 1.85 times lower than at 3 month old intact white rats. No significant differences were found in the total content of the PUFA of the family ώ-6 serum lipids of blood of intact animals of different ages. In this case, the ratio of PUFA of families ώ-6 and ώ-3 in the serum lipids of 4 month old intact white rats was in 1.33 times, and in 6.5 month old – in 1.81 times higher than in 3 month old animals.

These physiological differences are due primarily to the higher relative serum content of PUFA at intact 3-month old white rats – ώ-3: linolenic, EPC and DHA than in age of 4 and 6.5 months and is consistent with the results of other studies on ontogenetic features of the organism [1].

Since it is known that the fatty acid composition of blood serum is close to that in tissues and organs of animals and humans, based on our results we can conclude that the age-specific features of the relative content of fatty acids of serum lipids, but indirectly and other tissues, are clinically healthy animals to a certain extent determine their varying resistance to the experimental pathological process, namely obesity. Data given in Table 1–3 shows that the serum of white rats in all age groups with EAO (subgroup 2) has an increase in the relative content

of the SFA amount, mainly due to stearic acid increased in animals at the age of 4 and 6.5 months respectively in 1.3 and 1.3 times, but in 3 month old – in 1.5 times in comparison with intact animals.

The increase of SFA in serum is likely to increase its content in cell membranes, which reduces elasticity of membranes and disrupts the function of receptors, membrane-bound enzymes and burdens the pathological process [18]. At the same time, the intensity of updating of phospholipids of cell membranes will depend, on the one hand, on the intensity of metabolism in the body due to increased iodine intake and synthesis of thyroid hormones, and on the other hand, on the rate of synthesis of membrane-bound enzymes [2].

The data presented in Table 1–3 shows that the ratio of PUFA of families ώ-6 and ώ-3 in serum lipids of 3-, 4- and 6.5-month old white rats with EAO (group 2) was higher respectively in 2.0; 2.8 and 1.9 times higher than in animals of the group 3, respectively in 1.6; 2.3 and 1.5 times; in animals of the group 4 in 1,2; 1,2 and 1,0, time higher than in intact animals of similar age. This data indicates, on the one hand, the significant and one way effect of EAO in white rats of different age groups on the metabolism of PUFA of families ώ-6 and ώ-3, and on the other hand, on the effectiveness of the use of biologically active iodine in the composition of JC and inorganic iodine as part of IM for the correction of changes in the fatty acid composition of the total lipids of serum in animals with EAO.

Generally, after using JC for experimental animals of subgroup 3 with EAO, there was a tendency to normalize the relative content of some fatty acids of total serum lipids, but for most fatty acids, this data was not reliable.

Gas chromatographic analysis of fatty acid composition of blood serum lipids of white rats males with EAO, who were prescribed IM, showed significant positive changes. Thus, in the blood serum of 3-, 4-, and 6.5-month old white rats of group 4, the lower relative stearic acid content was noted relatively in 1.37; 1.21 and 1.21 times and higher content of linoleic acid respectively in 1.21; 1.35 and 1.28 times; linoleic – in 2.0; 5.28 and 1.69 times; EPA – in 1.61; 1.55 and 1.25 times; DHA – in 1.53; 1.9 and 2.57 times, than in animals of the group 2 (control) with EAO. The ratio of PUFA of families ώ-6 and ώ-3 in the serum lipids in this group of 1-, 6-, and 12-month old animals decreased respectively in 1.72, 2.30 and 1.88 times, compared with the control group and did not have a significant difference compared to intact animals. Thus, judging from our results, the nature of differences in the fatty acid composition of the total serum lipids of 3-, 4-, and 6,5 month old white rats has physiological features in intact animals, which to a certain extent determines the dynamics of such changes in animals with EAO and with their correction JC and IM.

CONCLUSIONS. 1. Differences in fatty acid composition of total serum lipids of 3-, 4- and 6.5-month old white rats have physiological features in intact animals which to a certain extent determines the dynamics of such changes in animals with EAO.

2. The total content of serum lipids SFA in 4- and 6.5 month old intact white rats was in 1.2 and 1.3 times respectively ($p<0.05$) higher, and the content of the PUFA of families ώ-3 in 1.4 and in 1.9 times ($p<0.05$) less than in 3 month old intact white rats.

3. In the serum of white rats of all age groups with EAO, an increase in the relative content of the SFA amount was noted, mainly due to stearic acid, which increased in 1.6 and 12 month old animals, respectively in 1.3 and 1.3 times ($p<0,05$), and in 1month old – in 1.5 time ($p<0.05$), in comparison with intact animals.

4. The ratio of PUFA of families ώ-6 and ώ-3 in serum lipids of 1-, 6- and 12 month old white rats with EAO was higher in 2.0, respectively; 2.8 and 1.9 times ($p<0.05$), in animals with EAO, which received intramuscularly IM in 1.55; 2.3 and 1.49 ($p<0.05$) times; in animals with EAO, which were injected intragastric JC in 1.2 times; in 1.2 and 1.0 ($p<0.5$) time than in intact animals of similar age groups.

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ТЕРНОПІЛЬСЬКИЙ НАЦІОНАЛЬНИЙ ТЕХНІЧНИЙ УНІВЕРСИТЕТ ІМЕНІ ІВАНА ПУЛЮЯ

ВІКОВІ ОСОБЛИВОСТІ ЖИРНОКИСЛОТНОГО СКЛАДУ ЛІПІДІВ СИРОВАТКИ КРОВІ ЩУРІВ З ОЖИРІННЯМ ПРИ ВПЛИВІ ЙОДУ

Резюме

Вступ. *У статті наведено нові дані про вікові особливості складу жирних кислот загального вмісту ліпідів сироватки крові білих щурів-самців з експериментальним аліментарним ожирінням у порівняльному ефекті внутрішньошлункового введення біологічно активного йоду в складі йодіс-концентрату і неорганічного йоду в складі йодомарину.*

Мета дослідження *– вивчити порівняльний ефект біологічно активного йоду в складі йодіс-концентрату і неорганічного йоду в складі йодомарину на вміст жирних кислот загального вмісту ліпідів сироватки крові білих щурів-самців з експериментальним аліментарним ожирінням.*

Методи дослідження. *Експериментальне аліментарне ожиріння моделювали протягом 45 днів на 48 білих щурах-самцях лінії Вістар різних вікових груп. Тварин поділили на 3 вікові групи по 16 щурів у кожній: 1-ша – віком 3 місяці; 2-га – 4 місяці; 3-тя – 6,5 місяця. У кожній віковій групі було 4 підгрупи: 1-ша – контрольна, тварини якої перебували на основному раціоні віварію; 2-га, 3-тя і 4-та – щури з експериментальним аліментарним ожирінням. Крім того, тваринам 3-ї групи внутрішньошлунково вводили біологічно активний йод у складі йодіс-концентрату, а щурам 4-ї групи – неорганічний йод у формі калію йодиду в складі йодомарину. Жирнокислотний склад визначали методом газорідинної хроматографії на газовому хроматографі Hewlett Packard HP-6890 з полум'яно-іонізаційним детектором, обладнаному капілярною колонкою SP-2380, довжиною 100 м (Supelco).*

Результати й обговорення. *У сироватці крові білих щурів усіх вікових груп з експериментальним аліментарним ожирінням спостерігали збільшення відносного вмісту насичених жирних кислот, головним чином за рахунок стеаринової кислоти, порівняно з інтактними тваринами. У щурів з експериментальним аліментарним ожирінням, які отримали йодомарин та йодіс-концентрат, результати були кращими відносно тварин 2-ї підгрупи.*

Висновок. *Йод позитивно впливає на склад жирних кислот загального вмісту ліпідів сироватки крові білих щурів-самців з експериментальним аліментарним ожирінням.*

КЛЮЧОВІ СЛОВА: **сироватка крові; жирні кислоти; йодіс-концентрат; йодомарин; ожиріння; щури.**

Н. Г. Копчак, О. С. Покотило
ТЕРНОПОЛЬСКИЙ НАЦИОНАЛЬНЫЙ ТЕХНИЧЕСКИЙ УНИВЕРСИТЕТ ИМЕНИ ИВАНА ПУЛЮЯ

ВОЗРАСТНЫЕ ОСОБЕННОСТИ ЖИРНОКИСЛОТНОГО СОСТАВА ЛИПИДОВ СЫВОРОТКИ КРОВИ КРЫС С ОЖИРЕНИЕМ ПРИ ВОЗДЕЙСТВИИ ЙОДА

Резюме

Вступление. *В статье представлены новые данные о возрастных особенностях состава жирных кислот общего содержания липидов сыворотки крови белых крыс-самцов с экспериментальным алиментарным ожирением в сравнительном эффекте внутрижелудочного введения биологически активного йода в составе йодис-концентрата и неорганического йода в составе йодомарина.*

Цель исследования – *изучить сравнительный эффект биологически активного йода в составе йодис-концентрата и неорганического йода в составе йодомарина на содержание жирных кислот общего содержания липидов сыворотки крови белых крыс-самцов с экспериментальным алиментарным ожирением.*

Методы исследования. *Экспериментальное алиментарное ожирение моделировали в течение 45 дней на 48 белых крысах-самцах линии Вистар разных возрастных групп. Животных разделили на 3 возрастные группы по 16 крыс в каждой: 1-я – в возрасте 3 месяца; 2-я – 4 месяца; 3-я – 6,5 месяца. В каждой возрастной группе было 4 подгруппы: 1-я – контрольная, животные которой находились на основном рационе вивария; 2-я, 3-я и 4-я – крысы с экспериментальным алиментарным ожирением. Кроме того, животным 3-й группы внутрижелудочно вводили биологически активный йод в составе йодис-концентрата, а крысам 4-й группы – неорганический йод в форме калия йодида в составе йодомарина. Жирнокислотный состав определяли методом газожидкостной хроматографии на газовом хроматографе Hewlett Packard HP-6890 с пламенно-ионизационным детектором, оборудованном капиллярной колонкой SP-2380, длиной 100 м (Supelco).*

Результаты и обсуждение. *В сыворотке крови белых крыс всех возрастных групп с экспериментальным алиментарным ожирением наблюдали увеличение относительного содержания насыщенных жирных кислот, главным образом за счет стеариновой кислоты, по сравнению с интактными животными. У крыс с экспериментальным алиментарным ожирением, которые получили йодомарин и йодис-концентрат, результаты были лучше относительно животных 2-й подгруппы.*

Вывод. *Йод положительно влияет на состав жирных кислот общего содержания липидов сыворотки крови белых крыс-самцов с экспериментальным алиментарным ожирением.*

КЛЮЧЕВЫЕ СЛОВА: **сыворотка крови; жирные кислоты; йодис-концентрат; йодомарин; ожирение; крысы.**

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