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Actual lipid consumption in sports training. Functional role and importance in metabolism

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Abstract

Currently, many athletes, including coaches (except nutritionists), unilaterally evaluate the lipid component, considering it mainly a source of energy. The large number of overweight (obese) people has led to the fact that the main goal of rational nutrition has become the "fight" against excessive fat consumption. However, fats (lipids) are indispensable food factors, as are, for example, proteins.

In highly developed countries, on average, no less than 40% of the daily energy requirement is covered specifically by fat consumption.

Carbohydrates are also a source of energy. They can accumulate in the body in the form of glycogen. However, the volume of glycogen stored in the body is immeasurably smaller than that of lipid reserves. Moreover, if the intake of carbohydrates is excessive, the energy from their consumption is also stored in the form of triacylglycerols, which are much more "convenient" for long-term storage and metabolism, if necessary.

About 95% of the total volume of biologically accessible energy in the triacylglycerol molecule contains residues of three long-chain fatty acids, and only 5% belongs to glycerol (glycerin) residues. Oxidation of these fatty acids with a high energy value until their transformation into CO_2 and water is accompanied by the release of energy. The oxidation of fatty acids and carbohydrates has only one final pathway: the citric acid cycle, the Krebs cycle, the tricarboxylic acid cycle.

The biological meaning of fat accumulation can be easily understood by comparison with fetal metabolism. In the intrauterine environment, reserve lipids are lacking. The fetus receives the nutrients it needs through the placenta from the mother's bloodstream. At the same time, this intake of nutrients is continuous, unlike newborns and adults, who have different diets. The fetus does not need energy reserves (reserve lipids) for long periods, as it is in a thermally regulated environment, it is well protected, thanks to the amniotic fluid and the tissues of the mother's body, from mechanical shocks. Only a short time before it is born, the body of the fetus creates its lipid stores. From the moment of birth, these lipids perform three main functions in complex: a) they are energy reserves; b) ensure thermal insulation, thanks to the subcutaneous fat layer; c) protect the child from external mechanical actions and cushion internal mechanical movements of organs and systems.

Keywords: food, proteins, fats, carbohydrates, sports training, cell receptors.

Introduction.

Diets of young, healthy individuals, including performance athletes, must meet general and special nutritional requirements. Therefore, diets must be rational, balanced, adequate, and in certain justified cases, be oriented towards a certain goal.

In the front section, we present information on dietary fat consumption.

1. In our previous publications, the essence, methodical procedures, and calculation methods in order to accurately determine the individual weight of athletes and their dynamics have been exposed quite thoroughly [8].

Simplified ways of calculating human body composition (body fractionation): the percentage of muscle, fat and bone tissue in the body were also presented.

Individual weight values, weight and height indices and body fat percentage are the essential parameters that determine the rational use of fats in the diet.

The specificity of lipid metabolism consists in the fact that they can accumulate in the form of reserves (deposits). If there is an increase in body weight, then the first cause that is analysed is the accumulation of fat reserves. This may be the consequence of excess fat as such in the diet (exogenous cause) and (or) excessive synthesis of fat from carbohydrates in food, which were not spent in energy processes.

In the case of intense, long-lasting efforts specific to people who carry out difficult professional activities, as well as, of course, performance athletes, weight loss is possible. In these cases, the appropriateness of the intake and consumption of food and/or reserve fat substrates are analysed.

In performance sports, attempts to reduce body weight are quite common, and this weight loss must necessarily occur at the expense of lipid reserves. However, the sudden decrease in body weight is accompanied by the decomposition of both reserve fats and protein structures of the body, a fact that, in any case, leads to a decrease in the capacity for physical work (see details in our previous publications) [8]. In this way, this means that rational nutrition from the point of view of fat intake is as much a current issue as those related to other nutrients of major importance.

We could imagine an ideal situation: healthy young people or performance athletes maintain a constant weight and a high work capacity for a long time. And in sports, in addition to these, the ability to endure high-intensity training efforts, to quickly recover work capacity, to register a positive dynamic of the results of the motor tests and high sports results are also necessary. In such cases, one can talk, with great probability, about the rational characteristic of the diet and regarding fat substrates. Sudden changes in body weight (increase, decrease) are always "suspicious" both from the point of view of the rational nature of nutrition and the intensity of physical efforts.

2. In point 1 above, too much attention was paid to body weight and even the conclusion was drawn that if a constant weight is maintained, then the ratio between food rations and the intensity of physical efforts, including in performance sports, is adequate.

Such categorical statements can be made based on practical rationality. In our conditions, the possibilities of applying some medico-biological tests are limited; athletes from the Republic of Moldova rarely go to centralized sports camps; feeding takes place, practically, in individual conditions; the control regarding the correlation "nutrition ↔work capacity↔sports performance" remains at the level of the sports coach/team and some episodic consultations made by doctors. Attracting nutritionists, most of the time, is not foreseen. Taking into account the concrete conditions, an attempt is made to communicate to practitioners information and knowledge that, in our opinion, could prove useful.

In this sense, checking the weight and its dynamics is a good, integral indicator of the adequacy of nutrition and physical effort. It is a fair statement, considering the other aspects of sports training: a good ability to cope with physical efforts, quick recovery, good dynamics of sports results. A constant weight, especially that weight, which is individually considered "fighting", reflects, at the very least, the lack of an excessive increase in fat reserves in the body.

It is also known that special measures are often taken, consisting of combining effort with a special diet, which leads to an increase in body weight. Such cases are combating the negative effects of weight loss, caused by reducing the percentage of adipose tissue in the body (most often, in women with hormonal disorders); anabolic periods of training, including for representatives of higher weight categories; surplus carbohydrate reserves (glycogen).

Cases of intentional weight gain, listed above, require a thorough check.

Are there situations in sports dietetics in which an attempt is made to increase body mass specifically due to the accumulation of fat reserves? In fact, such examples exist. Nevertheless, in such cases, the goal is not simply the accumulation of a surplus of fat, but an increase in body weight and (or) a redistribution of it in the body, which will ensure it advantages in a certain sport or, in some exceptional situations, in special habitat conditions. For example, long-distance and open-water swimmers have a greater chance of success if there is a subcutaneous layer of fat in their body, which has undeniable advantages: protection from the cold, improved diving ability and some improvement in the hydrodynamic profile.

In cross-country swimming, in swimming in frozen waters, a way to resist the cold is also achieved thanks to the subcutaneous tissue. We could not find the exact data on this subject. A plausible assumption is possible, starting from the principle of analogy. Aborigines and migrants adapted to the conditions of cold environments (Arctic and subarctic zone), are characterized by a uniformly distributed layer of subcutaneous adipose tissue [9].

Another example is that of athletes who perform in the super heavy weight categories (weightlifting; some wrestling events, especially professional sumo; partially throwing some weights), anabolic training is carried out without taking into account the accumulations of fat reserves. In these cases, anabolism, that is, the actual increase in lean mass (muscle and other tissues with active metabolism), occurs simultaneously with the increase in the amount of reserve fat. According to accurate body fraction data, such individuals have a maximum individual level of lean mass.

When we watch the evolution of very fat giants in sumo or weightlifting, we naturally assume that they will reach their individual level of anabolism at the lean mass criterion. And the excess of fat deposits is only an auxiliary phenomenon, which serves to reach the given level of anabolism. By the way, this is an example not of external stimulation due to anabolic steroids, but the combined influence of special diets and physical efforts. The example presented should not be considered as an exotic fact regarding some special sports in higher weight categories.

In general, in the world there is a gigantic problem of all mankind: malnutrition, protein-energy (MPE) of hundreds of millions of people. There are attempts to solve this problem with the joint effort of the respective states/regions and world organizations, humanitarian aid funds, etc. The body mass deficit of people suffering from MPE is determined according to anthropometric indices and with the help of statistical tables specially developed by WHO, OAA (see, for example:11). In such programs, a well-founded biological idea is implemented: if the deficit of body mass is eliminated, then the metabolism is normalized, the normal values of lean mass are returned, and it is no longer important if, at the same time, the amount of fat deposits has also increased. To a certain extent, the growth of reserve fat occurs in parallel with the growth of active tissue masses.

In the former USSR, in the post-war period, there were population rehabilitation programs (pioneer camps, rest homes, etc.), which aimed to strengthen the population's health by means of physical education, prophylactic and curative activities.

At that time, the main indicator of the success of the activity was the individual increase in body weight, a fact that was requested and verified in an obligatory manner. Of course, these goals were considered fair and well-founded. Overeating, excess weight have not yet become the prerogative of all mankind. At the same time, it cannot be said that the problem of excess weight (obesity) is not an important one, including for specialists in the field of physical education and sports.

The purpose of the above is completely different: no matter, task, problem of people's nutrition, in general, and in high-performance sports, in particular, should not be brought to absurdity, should not affect the natural processes of the metabolism of all nutrition components.

There is constant information about new "trend" diets. In the context of the real existence of the problem of obesity, diets with reduced calorie content are promoted. These diets assume a lower caloric intake than the number of calories the body consumes. In other words, people put themselves in a situation of starvation, something that all international funds and organisations (WHO, OAA, UNICEF, etc.) are trying to combat.

Metabolism is not divided with the help of "impermeable barriers" into independent processes: energetic, biochemical synthesis, self-regeneration of structures, regulators, hormones, mediators, synthesis, and disposal of waste products. They all interact. Just for a better understanding, sometimes it is more convenient to focus on energy expenditure (high physical efforts); in other cases, we talk about the predominance of syntheses (growth, development, anabolic phases). In other cases, we are forced to be more interested, for example, in catabolic processes and the elimination of waste products from the body.

It sometimes happens that people overeat protein-rich foods. If food proteins have been absorbed and not eliminated naturally (diarrhoea, flatulence, etc.), those metabolic processes that allow the body to "place" and eliminate the final products of excess protein are intensified (the biochemical cycle of urea, the ornithine cycle is intensified). However, even in the case of a normal protein intake, the same synthesis of the end products of metabolism proceeds in the same way, but at a normal physiological level.

When using low-calorie diets, all metabolic processes are altered. If the energy value of the food rations is extremely low, clear symptoms of alimentary dystrophy eventually develop, down to the most abominable forms.

Do the above also refer to the problems of sports dietetics? Unfortunately, yes. Quite frequently and in many sports, a strict regulation of weight is practised in the sense of reducing it below the individually acceptable level; as a result, there is a body mass deficit and an energy insufficiency of the food rations. The most serious consequences of such restrictions are felt during the periods of growth and development of the body: sports for young people, sports for juniors. It seems that, in this sense, the most problematic sport is women's gymnastics.

Competitions between children in different wrestling genres, in which, for certain reasons, it is aimed at the athlete to succeed in a certain weight category, are gaining more and more popularity.

In competitions for juniors and seniors, many athletes have to evolve for a long time in weight categories that are not specific to them (improper).

Thus, the lipid components of food rations are as important for adequate nutrition as the other factors (proteins, carbohydrates, macro- and micronutrients).

The essential food problems of man boil down to the fact that, in this sense too, we are a special biological species. People often feed differently than their natural metabolic processes require. Freedom of action is a wonderful purely human quality, but it can just as easily confuse us about our needs.

In the case of a normal adult, who has a correct, balanced diet, the lipids that enter the body with the food are used for the biosynthesis of the necessary endogenous lipoids, the oxidation of triacylglycerols, as sources of energy, takes place. At least, 40% of the daily energy needs of man are covered specifically by the fats contained in food rations. Both biosynthesis and oxidation occur simultaneously, and a certain steady state is established for these processes. The amount of fat in the body is maintained at a constant level for a relatively long time. In the case of changes in the content and caloric value of food rations, some insignificant temporary deviations may occur.

In cases where carbohydrates, fats or proteins are consumed for a long time in quantities that exceed energy and plastic needs, the surplus calories are stored in the form of triacylglycerols. At the same time, both dietary carbohydrates and the carbon chains of fatty acids (after deamination) can serve as a source of acetyl-CoA for the biosynthesis of fatty acids and triglycerides. The surplus of fat accumulated in this way can be used to obtain energy for performing efforts of moderate intensity and very long duration, to ensure thermal regulation in freezing environments and under starvation conditions.

The meaning of the accumulation of excessive amounts of reserve fat can be better understood on the basis of examples from biology.

Many animals fall into so-called hibernation; others, such as camels, are adapted to withstand water scarcity. Migratory animals, birds and some insects must "store" large reserves of energy substrates in their bodies. In all cases listed, fat reserves are used.

In this context, the adaptive capabilities of grizzly bears are unique. Their hibernation period is 7 months, the body temperature decreases insignificantly: up to $\approx 32...35^0$ C. In this state, the bears lose about 6000 Kcal/day. During this time, it does not eat, does not drink, and does not stool waste products. And females give birth and nurse their little ones.

In this semi-awake state, in their body, the main source of energy is the oxidation of fats. At the same time, enough energy is formed. Glycerin turns into glucose, which is needed by the tissues that feed on carbohydrates: the brain, partially the heart, some glands of internal secretion, the kidneys. In the process of fatty acid oxidation, the so-called endogenous water is formed, sufficient to compensate for H_2O losses during breathing. Urea formed during amino acid metabolism is reabsorbed in the residual organs and reused for the synthesis of endogenous amino acids. In such a state of "hibernation", the body is a perfect autonomous "bioconverter" that consumes only reserve fats. All other functions do not change, do not deteriorate, and after this "inaction" the bear remains as strong as before hibernation.

But...the storage of fat reserves before hibernation is enormous. In a normal state, the grizzly bear consumes about 9000 kcal per day, which, compared to 1 kg of body weight, is equivalent to the number of calories expended by humans. Before hibernation, the bear eats 20 hours a day, using food rich in carbohydrates equivalent to 20000 kcal/day. Fat is synthesised from it.

Migratory birds also accumulate enormous amounts of fat in their bodies: about 40-50%, which is the only biochemical substrate for long-distance flights. Insects also migrate long distances [13].

The camel accumulates fat to ensure movement in the caravan and for the synthesis of endogenous water [14].

In our opinion, examples from biology allow a better perception of the laws of metabolism specific to humans.

Is the metabolism of the grizzly bear so different from that which provides the energy possibilities of man? Let's analyse the bioenergetic possibilities of an ordinary person: an adult man, 70 kg, % body fat = 20%. Its glycogen reserves are ≈ 400 g, mobilisable proteins ≈ 6 kg and fats ≈ 15 kg, which, expressed in calories, make up: 1600, 24000 and 135000 kcal, respectively. If such a person were to consume from 1600 to 6500 kcal per day (depending on effort), in total lack of food, the energy reserves would be sufficient for up to three months.

At the same time, most labile reserves, namely carbohydrates (glycogen of the liver, muscles), can be consumed for 24 hours. The reason for the rapid loss of carbohydrates is obvious: glucose is needed to fuel the brain, red blood cells, some liver cells and other cells. In the absence of food, these needs must be provided first. After the reserve glycogen is consumed, it is necessary to urgently mobilize a certain source and/or a glucose substitute (alternative energy substrate).

This role cannot be played by the oxidation of fatty acids, given that acetyl-coenzyme A cannot be transformed into pyruvate (precursor of endogenous glucose synthesis). When triacylglycerol breaks down, glycerin is released. This is partially processed into glucose, but in an insufficient amount to cover all needs. The last potential source of glucose is amino acids, which are formed in protein catabolism.

To preserve its motor function, the body needs to consume its structural proteins in a balanced way. That way of meeting the need for glucose must be found, which will contribute to the preservation of muscle proteins. Such an alternative source is mobilizing.

Ketone compounds become the energy source that replaces glucose. Metabolic changes in this direction occur after a certain period from the onset of starvation (fasting state), in the case of humans – approximately on the fourth day. During this time, excess acetoacetate and 3-hydroxybutyrate (ketone bodies from fatty acid molecules) are formed in the liver. The synthesis of their compounds from acetyl-CoA increases, given that in the citric acid cycle (Krebbs cycle) acetyl-CoA cannot be oxidized at the rate with which it is formed in the process of beta-oxidation of fatty acids in the liver. The citric acid cycle and beta-oxidation do not balance each other, because gluconeogenesis leads to a deficiency of oxaloacetate, which is necessary for the introduction of acetyl-CoA into the citric acid cycle. As a result, large amounts of ketone bodies are formed in the liver, which, from there, enter the blood and thus become accessible to the brain and other tissues. After ≈ 3 days of starvation, one third of the energy needs of the human brain are met by keto bodies; at the same time, the heart also uses them as a source of energy. The state in which ketone bodies serve as an important source of energy is called ketosis. The conversion of fatty acids into keto bodies in the liver and their use by the brain, heart and several other tissues significantly reduces the need for glucose. The daily glucose requirement is ≈ 40g (normal values). This means almost four times less protein, which could have been spent on synthesizing the increased amount of glucose [15].

We have described metabolism during starvation in more detail for the following reasons:

a) By presenting such a dramatic state as an example, the interaction, the integration of carbohydrate, protein and fat metabolism is more clearly manifested. As it was found, metabolism can proceed in such a way that, to a maximum extent, the most important structures of the body are saved: the structural proteins. Energy production is possible due to enormous reserves, called triacylglycerols.

b) The notion of starvation is somewhat uncertain. The night break, in which the body is not provided with nutrients, represents a fasting period lasting 12 hours, like any interval between meals. If in the intervals between meals the person performed physical efforts, which led to the depletion of labile reserves of carbohydrates (glycogen), then from the point of view of biochemistry, he is in a state of fasting. This means that it is necessary to put into operation a means of energy production at the expense of reserve and labile lipids.

c) In the ontogeny of man, there is only one period of life when he is not hungry at all. Necessary products and substances, intermediates of metabolism are delivered constantly and in the required quantity and proportions! It is the intrauterine period. The life of the fetus can be represented metaphorically in the following way: the most accurate calculations have been made regarding everything it needs; food formulas were "prepared", the technical means of introducing them into the circulatory system were put into operation; delivery takes place constantly - the fetus is constantly under the action of an ideal "perfusion". The above description is a little idealized, because, with the appearance of motor activity, the fetus intensifies, due to its own movements, the placental vascularization, respectively, receives higher shares of nutrients [16].

In the final stages of intrauterine development, lipid reserves accumulate in the body, which the newborn will need later, under the conditions of a periodic food intake.

d) To some extent, the state of fasting can also be considered the exhaustion of accessible, labile sources of energy during all physical efforts. If a certain bioenergy substrate is exhausted, then an effort of adequate power can no longer be performed: a break is required, the restoration of substrates, a repeated effort. Naturally, one would like to restore the substrates spent during the effort. This fact is impossible, however. The speeds of the recovery processes do not allow extemporaneously to replace the endogenous substrates with nutritious ingredients from the food consumed orally.

In this context, a better situation can be seen in terms of the bioenergetic assurance of very long efforts, performed with moderate power: runs or similar efforts > ≈ 4...5 hours. During such efforts, the main substrates of bioenergetics are fatty acids. In addition, their reserves, as we mentioned above, are inexhaustible, but only up to a certain level of physical intensity of effort.

This group of physical efforts (in terms of power, duration) includes: the 100 km run; 100 miles (=160 km); triathlon and "super triathlon" (swimming - 5 km, cycling - 250 km, running - 50 km), as well as other events similar in duration and intensity: cross-country skiing, cycling, swimming.

The question arises whether the nutritional elements from the substrates can and should be used to achieve such efforts. There is no such necessity: the fat substrates of bioenergetics, anyway, are not exhausted (see the data presented above). This does not mean, however, that a distant "stimulation" is not necessary with ingredients that limit such efforts indirectly, not at the level of substrates: fluid limits, electrolytes, glucose, alkaline reserve concentration.

Humanity achieved the same objectives, empirically, when it was necessary to cover extremely high energy expenses: difficult and long professional activities; life and work in cold climates etc. For example, the mowing season (from dawn to dusk) is, from a bioenergetic point of view, reminiscent of competitions that take place over several days. In addition to regular food, farm workers received fat or very fatty food ad libitum. Without such additions, covering energy costs would have been impossible. Despite this fact, after mowing, the workers remained weak, underweight. This means that their food ration was not balanced and that, as energy substrates, proteins were used!

Conclusions:

In food hygiene, energy expenditure is divided into five categories, depending on the duration and volume of work performed. The fifth category of difficulty is accepted only for men.

It is about the fact that, most likely, high-energy expenditure is accompanied by the catabolism of structural proteins. In other words, there is a limit to the power and daily volume of human metabolism.

At the same time, long-term competitions in extreme sports are enjoying increasing popularity: 24-hour races; extreme endurance races, which last several days; ultra-swimming marathons; ski competitions; maritime competitions etc.

It is certainly necessary to establish acceptable limits for testing human capabilities under extreme conditions. Bioenergetic assurance must be of such nature that it does not affect the body's structural proteins.

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