# METHODOLOGICAL ASPECTS OF STUDYING THE ACTUAL NUTRITION OF ATHLETES

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Analysis of actual nutrition of athletes and its correspondence to energy expenditure seems relevant as a balanced diet produces a direct effect on physical endurance and professional performance of athletes. It is meaningful to estimate not just nutritional and energy value of the diet, but also a degree of diversity of basic groups of food products as sources of essential nutritional substances in the diet of athletes along with dietary fibers to optimize the gut microbiome diversity. Regular studies of actual nutrition conducted with certain time intervals and simultaneous assessment of biomarkers characterizing the alimentary status enable to trace their effect on professional performance, effectiveness of the training process, adequate restoration and health for every athlete and the whole team.

**Keywords:** athletes, actual nutrition, 24-hour reproduction method, frequency method, microbiome

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# МЕТОДОЛОГИЧЕСКИЕ АСПЕКТЫ ИЗУЧЕНИЯ ФАКТИЧЕСКОГО ПИТАНИЯ СПОРТСМЕНОВ

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Анализ фактического питания спортсменов и его соответствия энерготратам представляется актуальным, поскольку сбалансированный рацион непосредственно влияет на физическую выносливость и профессиональную результативность спортсменов. При этом целесообразно оценивать не только пищевую и энергетическую ценность рациона, но и степень разнообразия основных групп пищевых продуктов как источников эссенциальных пищевых веществ в питании спортсмена, а также пищевых волокон для оптимизации видового разнообразия кишечного микробиома. Проведение периодических исследований фактического питания через определенные временные интервалы с одновременной оценкой биомаркеров, характеризующих пищевой статус, позволит отслеживать их влияние на профессиональную производительность, эффективность тренировочного процесса, адекватность восстановления и состояние здоровья как каждого конкретного спортсмена, так и команды в целом.

**Ключевые слова:** спортсмены, фактическое питание, метод 24-часового воспроизведения, частотный метод, микробиом

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According to the results of studies conducted by the Federal Research Center for Nutrition, Biotechnology and Food Safety, prevalence of impaired optimal product structure, food and energy value of the diet is noted in the majority of examined athletes. The first place is occupied by non-correspondence of daily dietary calories to actual energy expenditure; percentage of fat and saturated fatty acids in the structure of dietary calories exceeds the recommended levels by 20–40%; aggregate consumption of carbohydrates is below the recommended level by 10–35%; high consumption of added sugar (18–24%) and salt is noted [1].

In some studies, a significant difference of up to 44% was recorded between the data about actual consumption obtained using questioning (survey) and registration with portion weighing. Exactness of obtained data depends on unconscious or conscious under-reporting of data regarding use or exclusion of some products and dishes out of the diet (alcoholic beverages, fast food, confectionery products); altered eating rate or customary food behavior due to a complex complete description of ingredient composition when the questionary is filled in [2, 3]. Due to positive or negative assessment of survey results, these data can be confirmed using the measurement errors. A lack of the 'golden standard' of transformation of primary data to interpret results and reliable tools, including experienced trained interviewers who can conduct large studies, restricts the possibility of comparing data of various studies, especially the ones devoted to assessment of training process effectiveness.

Recommendations related to organization of optimal nutrition for athletes commonly concern a higher need in energy to satisfy actual energy expenditures, increased quota of proteins and carbohydrates in the structure of total caloric intake to maintain and gain muscle mass and restore glycogen reserves respectively and an increased need in certain microelements (for instance, iron, calcium, sodium) and vitamins. However, specific kind of sports, scope and intensity of training, and level of intake of food products are interrelated. It means that the food intake should not be static during different phases of a training process with various levels of load. Actual nutrition is accessed and biochemical indicators and vitamin supply in athletes are examined to understand how they correspond to the level and kind of physical activity considering age- and gender-related features, type of sporting specialization and phase of sports activity. Risks of metabolic disbalances including energy exchange are detected. To reduce the risks, recommendations related to nutrition correction are developed.

Meanwhile, actual nutrition is of primary importance. However, as collection of data is important and due to possible errors arising during interpretation of results, the assessment is not always conducted or the results yield little information. A complex study of frequency values and consumed number of basic groups of food products and alimentary status along with their dynamics control help detecting individual requirements and trace their changes depending on the scope and intensity of training sessions during the training and contest period [4].

Research purpose: determine basic methodological aspects of examining actual nutrition in athletes and people with a high level of physical activity.

## MATERIALS AND METHODS

84 athletes were examined, including 25 basketball players, male students of the Academy of Physical Culture (20.9 ± 1.8 years) in spring, 24 male athletes playing for Amor hockey club (average age of 26.4 ± 7.4 years) in summer (August) and 25 females (22.4 ± 3.7 years) from the ice hockey team with pucks in spring (March) at the Novogorsk training center, athletes from national archery teams of the Republic of Buryatia ($n$ = 10) in summer (August) at Enkhaluk sports camp (Republic of Buryatia, Kabansky district, Novy Enkhaluk village).

Actual nutrition of athletes was studied using two methods: 24-hour reproduction method and frequency method.

During the frequency method, a special questionnaire was used, which allows to estimate anthropometric characteristics, level of physical activity (considering working days and weekends), rate of consuming some groups of products for a certain period of time. Analysis of Human Nutritional Status computer program (version 1.2.4 of Research Institute of Nutrition of the Russian Academy of Medical Sciences of 2004) assesses caloric intake, composition of average daily diet, rate and number of separate products, and graphically displays the level of consumption of certain groups of products as compared with the recommended values during the preceding month. The primary questioning lasts at least 45 minutes.

The 24-hour reproduction method establishes the amount of actually consumed food products and dishes by surveying of the interviewed person who enumerates what was eaten prior to the survey by memory. In the end of the survey, they obtain data about the time of food intake, place of food making and taking, composition and amount of the dish and product, and ways of its preparation. The obtained data are included into a special questionnaire or directly to the program. The most reliable data are obtained in the presence of three questions related to nutrition: two working days and one day-off before that.

When analyzing the results of examination of actual nutrition, it should be estimated as follows:

- Correspondence of the diet energy value to energy expenditure of athletes;
- Contribution of proteins, fats and carbohydrates to the total caloric intake expressed as percentage;
- Specific consumption of proteins, fats and carbohydrates in g/kg of body mass of an athlete per day;
- Correspondence of dietary micro- and macronutrients to the recommended levels and needs of athletes;
- Dietary regimen (amount and time of food intake) and distribution of food and energy value by food intake during a day or training sessions.

Arrival of every critically important nutrient as part of foods for particular nutritional uses and nutritional supplements is evaluated separately considering liquid to dissolve instant mixtures (water, milk with various mass fraction of fat, other fluid), number of consumed meals per intake and number of intakes per day.

Adequate consumption of basic nutrients is estimated in accordance with methodical recommendations MP 2.3.1.0253–21 'Standards of Physiological Needs in Energy and Nutrients for Various Groups of the Russian Federation'.

## RESEARCH RESULTS

It is known that the type of actual nutrition (regimen, scope, chemical composition) can be influenced by the level of physical activity depending on sporting tasks, seasonality, individual food preferences, religious beliefs, etc.

When the examination results of basketball players were compared, it has been established that daily caloric intake calculated on the basis of the frequency method insignificantly exceeds the one obtained using the 24-hour

reproduction method. Meanwhile, consumption of proteins and carbohydrates was also higher with no differences in the fat content (fig. 1 and 2).

Moreover, a tendency to a more moderate consumption of nutrients and energy on a weekday was detected using the 24-hour reproduction method. Thus, caloric intake was 2,880 ± 1,015 kcal/day due to a lower consumption of carbohydrates and fats with an increased amount of protein.

Analysis of the results obtained while examining actual nutrition among athletes during training at Enhalo camp displayed a similar tendency: energy value and content of basic nutrients obtained using the frequency method were higher. In this case, a more significant difference was observed because actual nutrition was assessed using the method of food consumption frequency analysis during a month that preceded visits to the training camp. It means that athletes were relatively free to choose among dishes and products available at home, in the dining area and at food trade companies. During the training session, when the diet was assessed using the 24-hour reproduction method, all athletes were eating at the camp dining area, and only some of them had non-perishable products (confectionery, including chocolate, chips, etc.) at their disposal. In other words, during the training session, the possibility to diversify the diet is objectively limited.

Contribution of proteins, fats and carbohydrates to the total caloric intake studied using the both methods, was 14%, 42% and 44% and 11%, 42% and 47% respectively. In this case, percentage of fat in the caloric intake coincides and significantly exceeds the recommended upper level, which, obviously reflects the really existing fat content of athletes' diet (table 1).

During assessment of food consumption frequency by a woman's ice hockey team of the Russian Federation it has been established that not enough dairy products were consumed. Contribution of the group of food products to energy value, proteins, fats and carbohydrates was 9.6 ± 6.7 kcal/day, 15.3 ± 10.2 kcal/day, 12.2 ± 9.1 kcal/day and 4.2 ± 3.4 kcal/day respectively. Frequency of meat and fish consumption was sufficient and extremely low respectively. It has been established that fruits and vegetables were consumed below recommended levels. Meanwhile, consumption of confectionary products (candies, cakes, chocolate) was high and constituted 2.2 ± 1.3 meals/day, respectively. Bakery goods provided to 11.3 ± 4.9% of total energy value and 30.1 ± 19.5% of total amount of carbohydrates, whereas confectionary products constituted 14.8 ± 8.9% and 18.5 ± 8.8% hereof respectively. It should be noted that high caloric intake of confectionary products is ensured due to increased content of fat, including margarine transfat, which is a risk factor of atherosclerosis and cardiovascular diseases.

The nutrition profile of male hockey players and frequency of consumption of basic groups of products mainly corresponded to generally accepted recommendations. They had more bread and cereals (0.4 to 7.1), vegetables (1.7 to 8) and fruits (0.7 to 9.6 meals per day) as compared with female hockey players. They consumed confectionary products (to 5.1 meals per day) and added sugar more frequently than women; and this could result in sharp fluctuations of blood glucose and associated fatigue. Consumption frequency of dairy products (0 ÷ 4.3 meals per day) was almost the same as the one in women and was lower than the recommended one.

The basic sources of fat were meat, sausages and eggs. Consumption of fish was very low as well: 0 to 0.8 meals per day. Male hockey players had relatively high consumption of vegetables and fruits (3–5 meals per day) with no achievement of recommended values, though; as a result, dietary fibers constituted to 30% of normal values as compared with a rather low medium level (7.2% of the recommended one) in female team players. The difference in the frequency of consumption of certain groups of food products could be correlated with their seasonal availability (table 2).

According to the presented data (table 2), marked differences in the level of consumption of several basic groups of products are found among hockey players of both genders. The women had deficiency of sources of complex and simple carbohydrates, playing an important role in provision of easily accessible energy for highly intense sports activity and maintenance of optimal endurance. Their inadequate intake can result in a decreased effectiveness of a

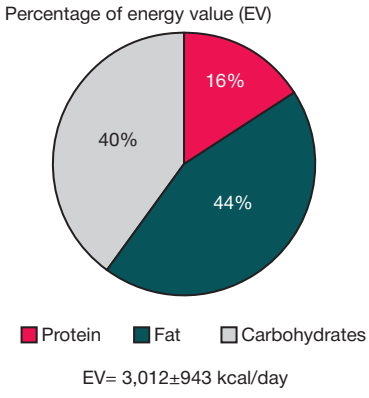


**Fig. 1.** The structure of diet energy value obtained using the food consumption frequency method

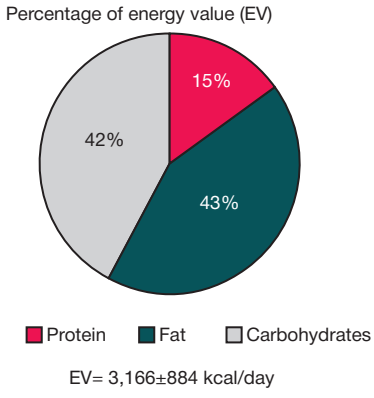


**Fig. 2.** The structure of diet energy value obtained using the 24-hour reproduction method

**Table 1.** Comparison of results of studying the actual nutrition of athletes obtained using two methods

| Values | Moscow State Academy of Physical Culture | | Enkhaluk camp | |
|---|---|---|---|---|
| | Frequency method | 24-hour reproduction method | Frequency method | 24-hour reproduction method |
| Energy value, kcal/day | 3,166 ± 884 | 3,012 ± 943 | 2,902 ± 1,198 | 2,516 ± 593 |
| Protein, g/day | 136 ± 41 | 111 ± 38 | 104 ± 46 | 70 ± 17 |
| Fat, g/day | 146 ± 69 | 144 ± 64 | 134 ± 61 | 118 ± 42 |
| Carbohydrates, g/day | 375 ± 108 | 317 ± 110 | 314 ± 147 | 29 8± 56 |

**Table 2.** Frequency of consumption of basic groups of food products by ice hockey players (men, women)

| Group of products | Actual nutrition, meals per day | | Recommended frequency, meals per day |
|---|---|---|---|
| | Men (*n* = 24) | Women (n = 25) | |
| Cereals and bakery | 2.9 ± 1.5* | 1.1 ± 0.4 | 5–8 |
| Milk and dairy products | 1.7 ± 1.81 | 1.6 ± 1,7 | 2–3 |
| Meat and meat products | 2.1 ± 0.9* | 1.5 ± 0,9 | 1–2 |
| Fish and fish products | 0.1 ± 0.4 | 0.2 ± 0,3 | 1–2 |
| Confectionery | 2.8 ± 1.2* | 2.2 ± 1,3 | 0–1 |
| Vegetables | 5.4 ± 2.0* | 1.6 ± 0.7 | 5–8 |
| Fruits | 2.8 ± 2 | 2.3 ± 1.2 | |

*$p < 0.05$

training process, premature fatigue and functional overstress. Moreover, deficiency of intake of dietary fibers that ensure normal functioning of the gastrointestinal tract and support gut microbiome diversity is found against the background of structurally unbalanced diet energy value. It is known that change in its composition caused by deficiency of fiber and complex carbohydrates is accompanied by decreased physical performance, endurance, immunological reactivity of an athlete's body and increased susceptibility to infectious agents [5, 6]. Unlike women, male hockey players eat many fruits and vegetables. The detected differences can be associated with gender-related dietary behaviour and seasonality of nutrition, including affordability of more plant products.

The results significantly ($p < 0.05$) differ among athletes depending on their gender and the season when the actual nutrition is examined. It points to feasibility of monitoring of frequency and amount of consumed basic groups of products during at least two periods: fall-winter and spring-summer.

It would be interesting to examine how the peculiarities of eating behavior, including conscious self-restriction, and interrelation between consumption of meat and milk with the alimentary status in particular, can influence health of athletes.

Results of examination of two athletes engaged in different kinds of sports are provided as an example.

1. Male, Master of Sports, aged 21, involved in rowing for 5 years, had no medical contraindications to cow's milk and replaced it with vegetable beverages based on cereals and nuts; he also refused from meat. Though Hb count was satisfactory, blood chemistry analysis displayed deficiency of serum iron (7.9 mcM/l with 10.6–28.3 mcM/l being normal values), which meant iron deficiency. Considering the detected disturbances in the nutritional pattern and abovementioned data about the alimentary status, the athlete was recommended to optimize the diet to replenish iron supplies and improve endurance [7].
2. Male, Candidate Master of Sports, basketball player aged 22.3, abruptly refused from animal derived products except for fish (to 300 g per day) during the observance of Christian fasting. His diet was rich in potato pies, peanuts (to 300 g per day), plant-based milk substitute (200–400 ml) resulting in disturbed structure of diet energy value (abrupt increase of fat proportion to 45%), protein content corresponded to 16% (recommended levels), whereas carbohydrate content was rather low (39% of caloric intake respectively).

## DISCUSSION OF RESULTS

24-hour reproduction method allows to estimate the dietary regimen, food and energy value of products and dishes included into separate meals, their contribution to daily energy value, correspondence to purposes and objectives of the training process. In athletes engaged in various kinds of sport, prevalence of Relative Energy Deficiency in Sport (RED-s) amounts to 22–58%. This results in hormonal and metabolic dysfunctions and reduces professional performance. Thus, the method estimating energy balance within a day remains pressing, as it assesses the energy value of products during every meal and energy expenditure of the body, including physical load, resulting in a deeper understanding of changes in real time and identification of energy deficiency markers [8].

According to data obtained during our and other published studies, combination of two or more methods assessing actual nutrition can increase exactness of the results. Thus, the combined method of collecting data about actual nutrition can ensure a more effective technology of qualitative assessment of consumption of nutrients and energy by athletes. Using software on devices with the image function increases the accuracy of recorded data [9–11]. Results of systematic review show that preservation of the image of consumed products improves self-reporting and reveals unaccounted products and errors while determining the portion size, which can be forgotten when only traditional methods of assessment are used. Clarifying the issues about the portion size, additional use of sauces, bread, added sugar, frequency and daily dose of foods for particular nutritional uses and nutritional supplements, via general chats in messengers due to rapid feedback from a nutritional specialist, improved motivation, enhancing confidence within the 'sportsman and interviewer' couple can be an effective tool to monitor nutrition and influence the feeding behavior [12, 13].

The next stage includes diet personalization in accordance with the individual metabolic and genetic profile of an athlete. Based on the examination results, individual recommendations about diet correction are developed for every athlete, all team members or a group of those examined along with the coaching staff and physician; education is provided in the form of a cycle of lectures and seminars discussing the obtained results and ways to optimize the diets including the use of specialized food products and dietary supplements. It improves the metabolic status of athletes and ensures optimal conditions to improve sports skills.

Studies of drinking regimen and water-salt balance of athletes as a key factor limiting professional success in sport constitutes another section that examined actual nutrition. It is established that over half of athletes have a training session or go to a contest being hypohydrated or with an improperly organized drinking regimen during a training session. It results in reduced functional capabilities and health disturbance in the form of a thermal collapse or hypovolemic shock.

Prior to inclusion of foods for particular nutritional uses and nutritional supplements into the diet, it is important to estimate the content of not just basic, but also of biologically

active nutrients in an athlete's diet. Only having studied actual nutrition and values of nutritional status and having compared them with recommendations (i. e., following determination of available deficits or excessive arrival of nutrients), it's possible to develop a plan of inclusion of specialized food products and nutritional supplements for athletes.

It is recommended to study actual nutrition both in the beginning, and during key moments of the training sessions, and during an injury, after operations accompanied by a long-term decrease in vital capacity during restoration, development of acute diseases or exacerbation of existing ones.

Exact assessment of athletes' health and performance requires an integrative and dynamic approach to analysis of alimentary status biomarkers. Individual requirements in nutrients and energy significantly depend on specific features of various kinds of sports, phases of the training cycle and alimentary preferences of athletes. Regular monitoring of actual nutrition, administration of foods for particular nutritional uses and nutritional supplements, medicines and values of the alimentary status will enable detection of individual disturbances and trace changes along with the increase of a training volume. Assessment of alimentary status using an objective study of biomarker concentration eliminates systemic errors related to subjective assessment of nutrition.

## CONCLUSIONS

In our opinion, to examine actual nutrition in a large group of athletes it's better to use the frequency method, whereas an individual examination can be done in a more effective way using the 24-hour reproduction method two working days and one day off before that. While interpreting the result, it is important to take into account seasonality of nutrition, religious restrictions and certain gender-related features of product selection. To ensure better comprehension of the results of actual nutrition monitoring, including drinking regimen, level of energy expenditure during training sessions and contests, and their effect on athletes, assessment of biomarkers should include various and well confirmed markers of production, health and restoration. As many standards used to estimate biomarkers are suitable for populations in general, but not for athletes, repeated measurements allow every doctor in sports medicine, coach and athlete to set personalized reference values. An athlete can trace dynamics of these individual 'normal' values which can vary every day and every week and correlation with reduced performance, occurrence of the overtraining syndrome or risk of an injury.

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