# The likelihood of developing hypoglycaemic states may be an individual risk factor in elite canoeists

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**Abstract**

**Objective of the study** aims to establish the significance of possible hypoglycemia in a complex of risk factors that have a negative impact on the functional state of the body of highly qualified athletes involved in canoeing and kayaking.

**Methods and structure of the study.** This study analyzes scientific publications proving the importance of maintaining adequate carbohydrate reserves during intense physical activity. The study monitored venous blood glucose levels in elite canoeists. 73 male rowers (age range 18-37 years) of various skill levels (18 HMS, 21 MSIC, 34 MS) were examined 40 hours after the end of the last workout. Blood samples were taken and analyzed again in 35 people. Venous blood samples were analyzed at the Consultative and Diagnostic Center of the Research Institute – Regional Clinical Hospital No. 1 named after S.V. Ochapovsky (Krasnodar). A total of 166 measurements were taken.

**Results and conclusions.** The centile levels of hematocrit were determined, and significant differences in glucose concentrations corresponding to hematocrit values above and below the 75th centile were revealed. The study of the glucose level in venous blood 40 hours after the end of the workout demonstrated that the maximum values (95th centile) were below the upper limits recommended by WHO for healthy people (5.5 mmol/l). At the same time, in 28.4% of cases, the blood glucose level was below 4.1 mmol/l, and in 52.0% of them it was below 3.9 mmol/l.

In the context of sports medicine, it is advisable to introduce the concept of "potential hypoglycemia", which can be an individual risk factor affecting not only the effectiveness of training, but also contributing to the development of various clinical signs of non-functional overexertion, including risks for the cardiovascular system. In order to prevent potential hypoglycemia syndrome in athletes, it is imperative to add blood glucose level determination to the list of indicators monitored during ongoing medical and biological monitoring.

***Keywords:*** *highly skilled canoeists and kayakers, glucose concentration, hematocrit index, centile gradations, risk factor for functional disorders of the body.*

**Introduction.** In 2014, a group of experts from the International Olympic Committee first considered the concept of “relative energy deficit in sport” (REDs) – a condition caused by the negative effects of low consumption and availability of carbohydrates [12, 16]. However, most likely, the multidisciplinary nature of the recommended REDs markers [10] will most likely lead to the fact that this syndrome will become the subject of extensive discussion and will cause the emergence of a large number of its opponents in the near future.

**Objective of the study** is to determine the degree of relevance of potential hypoglycemia in the system of risk factors for functional disorders of the body of highly skilled kayakers and canoeists.

**Methods and structure of the study.** The work summarizes the data from literary sources substantiating the need for stable maintenance of carbohydrate reserves under conditions of intense muscular activity, and also analyzes the results of monitoring the glucose index in venous blood in highly skilled kayakers and canoeists. The study involved 73 male rowers aged 18 to 37 years (18 HMS, 21 MSIC, 34 MS; 35 people were re-examined). Venous blood samples were taken in the morning on an empty stomach (40

hours after the end of the last training session). Blood tests were performed at the consultative and diagnostic center of the Research Institute-KKB No. 1 named after S.V. Ochapovsky (Krasnodar). The total number of measurements was 166.

**Results and conclusions.** According to the literature, the required level of carbohydrate reserves in the body is one of the important factors determining and limiting performance when performing high-intensity (2.5 min to 10 min) and moderate-intensity (10 min or more) exercises [2]. However, as a rule, studies devoted to this topic focus on muscle glycogen content, not blood glucose content [8, 13, 14].

Muscle glycogen and blood glucose are different components of carbohydrate metabolism. Skeletal muscles are not able to release glucose (since there is no glucose-6-phosphatase in muscles), and muscle glycogen is mainly a local source of energy for physical exercise, and not a source of energy for maintaining blood glucose concentration [11].

Recurrent non-critical hypoglycemia, i.e. a decrease in blood sugar, has its own spectrum of serious negative consequences, which is quite wide and has almost never been analyzed as a specific risk factor in the field of sports medicine. Only in some studies [3, 5] it was emphasized that a repeated decrease in blood glucose in athletes <4.1 mmol / l is a reflection of either depletion of liver glycogen reserves or intensive use of glucose by body tissues and can serve as one of the etiological factors of states of overfatigue / non-functional overstrain.

At the same time, according to the coding according to the International Statistical Classification of Diseases and Related Health Problems (E15/E16, 0/E16, 1/E16, 2/E16.9), within the framework of diseases or conditions classified as non-diabetic hypoglycemia, potential hypoglycemia is distinguished, the characteristics of which are as follows: glucose level ≤3.9 mmol/l, but ≥3 mmol/l in venous blood and/or ≤3.9 mmol/l, but>2.8 mmol/l regardless of the presence of neuroglycopenia symptoms [4]. When it occurs, a number of neuroglycopenic symptoms arise [9, 17], some of which coincide with those in two types of overtraining [1].

Particular attention should be paid to hypoglycemia in the pathogenesis of cardiovascular risks [6]. According to the results of the study by O. Rana et al. [15], during hypoglycemia in both type 1 diabetes patients and healthy individuals, coronary blood flow reserve decreases, which may serve as one explanation for the discovered link between hypoglycemia and an increased risk of cardiovascular death. It has also been established that at low plasma glucose concentrations, electrocardiograms (ECGs) show prolongation and increase in QT interval dispersion, which are proarrhythmic factors.

This is clearly seen in the analysis of ECGs recorded during spontaneous nocturnal hypoglycemia, when the unreplaced carbohydrate content leads to an even more pronounced decrease in blood glucose levels, especially against the background of additional risk factors (alcohol, quinine-containing foods and drinks, and a number of pharmacological drugs). In such cases, even emergency conditions may occur, which may explain some cases of sudden cardiac death in athletes at night in the absence of cardiac pathology.

When analyzing the results of our own observations, the following tasks were solved:

- to develop centile gradations of the hematocrit index in a selected group of athletes and to establish the relationship between the glucose concentration in venous blood and the hematocrit index (a similar approach is required when analyzing all parameters of the biochemical composition of blood);

- in the presence of a significant positive relationship between these parameters, to develop ap-

*Table 1. Centile gradations of the hematocrit index and the reliability of differences in the glucose content in venous blood with a hematocrit index above and below 47%*

| Indicator | Number of measurements | Centile gradations | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | P5 | P10 | P25 | P50 | P75 | P90 | P95 |
| Hematocrit, % | 116 | 41,00 | 42,00 | 43,00 | 45,00 | 47,00 | 48,00 | 49,25 |
| | | Reliability of differences | | | | | | |
| | | Hematocrit level 47% and above (M±m) | | Hematocrit value below 47% (M±m) | Critical value of t-test | | The obtained value of the t-criterion | |
| Glucose, mmol/l | 88 | 4,75±0,14 | | 4,31±0,04 | 2,026 | | 2,97 | |

*Note: the reliability of differences was determined by the t-criterion value corresponding to a smaller number of measurements.*

proximate centile gradations of the current glucose concentration in venous blood, having previously excluded the values corresponding to the 75th centile and above;

- to establish the number of measurements with venous blood glucose values below 4.1 mmol/l of blood and ≤3.9 mmol/l (the latter corresponds to potential hypoglycemia [4, 7].

The results of the studies showed that the correlation coefficient between the concentration of glucose in venous blood and the hematocrit index is below significant, but at the same time reliable differences were established between the values of glucose concentration corresponding to the hematocrit index above and below the 75th centile (Table 1).

The estimated centile gradations of the current glucose concentration in venous blood after excluding the values corresponding to the hematocrit value equal to and exceeding the P75 centile are given in Table 2.

*Table 2. Calculated parameters and estimated centile gradations of glucose content in venous blood with a hematocrit value below P75*

| Indicator | Meaning |
|---|---|
| Coefficient of variation, % | 9,53 |
| Average value, mmol/l | 4,31 |
| Standard deviation mmol/l | 0,41 |
| Mean Error of the Mean, mmol/l | 0,04 |
| Number of measurements | 88 |
| P5 | 3,65 |
| P10 | 3,80 |
| P25 | 4,05 |
| P50 | 4,35 |
| P75 | 4,60 |
| P90 | 4,72 |
| P95 | 4,92 |

Analysis of venous blood glucose levels 40 hours after the last workout showed that its upper values (P95 centile) in highly skilled canoeists were below the upper values recommended by WHO for healthy individuals (5.5 mmol/l). At the same time, in 28.4% of measurements, the blood glucose level was below 4.1 mmol/l, and in 52.0% of them it was below 3.9 mmol/l. In addition, in three athletes, blood glucose levels were repeatedly recorded in the range of 3.88 and 4.04 mmol/l over two years.

It should be noted that we are talking about venous blood samples, in which the glucose level is higher than in capillary blood, and under the influence of psychological stress (fear of having blood taken), the blood glucose concentration may increase.

**Conclusions.** In relation to sports medicine, it is quite reasonable to introduce the concept of "potential hypoglycemia", which can be one of the individual risk factors not only for a decrease in the effectiveness of the training process, but also for the occurrence of a number of clinical manifestations of non-functional overstrain, including cardiovascular risks. In order to eliminate the syndrome of potential hypoglycemia in athletes, it is necessary to include in the list of parameters recorded as part of current medical and biological control, the determination of blood glucose levels.

A promising direction for further scientific research in this regard is daily monitoring of blood glucose levels and testing as part of staged examinations of glycated hemoglobin levels.

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