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LOW BLOOD PYRUVATE LEVELS AND THEIR ASSOCIATION WITH CHRONIC FATIGUE SYNDROME AND BMI

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Abstract. *The aim of this study was to investigate the relationship between low blood pyruvate levels, Chronic Fatigue Syndrome (CFS) and body mass index. We conducted a small study involving 31 patients diagnosed with CFS and overweight or obese, distribution between male and female are 28 women and 3 men. Blood samples were collected from all participants at Alfalab Chisinau, Pyruvate in plasma (pyruvic acid) using the NaF blood the analysis was performed at MDI Limbach Berlin GmbH MVZ Labor Limbach Berlin, Germany, normal reference range of 24-95 µmol/l. Other data were collected during nutritional consultations,* at *NUTHEIA EDUCATION SRL – Nutrition and Dietetics Center, Chisinau, such as the levels of BMI were recorded using Bioimpedance Scale. Other relevant measures, such as signs and symptoms of eating and digestive disorders reported by the patient, were also recorded during the nutritional assesment. The study found that patients with CFS had lower levels of blood pyruvate furthermore, there was a correlation between blood pyruvate levels and Body mass index. These findings suggest that low blood pyruvate levels are associated with CFS and may contribute to the pathophysiology of the syndrome. This study highlights the potential of blood pyruvate levels as a biomarker for diagnosing CFS and guiding nutritional treatment strategies in overweight and obese people.*

Key words. *Pyruvate, Body mass index, chronic fatigue syndrome (CFS), poor nutrition, health.*

Introduction

Pyruvate plays a central role in cellular metabolism and is a key intersection point for various metabolic pathways such as:

a) Conversion to Acetyl-CoA: In the presence of oxygen (aerobic conditions), pyruvate is transported into the mitochondria, where it is converted into acetyl-CoA by the enzyme pyruvate dehydrogenase complex [8].

b) Energy Production: During glycolysis, a small amount of energy is produced in the form of ATP (adenosine triphosphate) and NADH (nicotinamide adenine dinucleotide) [8].

c) Glycolysis is the process by which glucose is broken down into pyruvate in the cytoplasm of cells. This pathway involves a series of enzymatic reactions that convert one molecule of glucose (a six-carbon molecule) into two molecules of pyruvate (each a three-carbon molecule) [1].

d) Lactate Fermentation: Under anaerobic conditions (lack of oxygen), pyruvate is converted into lactate by the enzyme lactate dehydrogenase. This process regenerates NAD+ from NADH, allowing glycolysis to continue producing ATP in the absence of oxygen [7].

e) Lipogenesis: Pyruvate can be converted into acetyl-CoA, which is a key building block for the synthesis of fatty acids. This process occurs when there is an excess of carbohydrates, and the body needs to store energy as fat [7].

f) Allosteric Regulation: Pyruvate and its derivatives (such as acetyl-CoA and NADH) act as allosteric regulators of various enzymes in glycolysis, the citric acid cycle, and gluconeogenesis. This helps coordinate and balance the flow of metabolites through these pathways according to the cell's energy needs [11].

Pyruvate is a three-carbon ketoacid that occurs naturally in cells. Prolonged supplementation of pyruvate, especially in combination with interval training, may induce adaptive changes in skeletal muscle metabolism and/or affect cognitive function through neuroprotective effects [10].

Deficiency of vitamin B1 which is a coenzyme a the PDH complex, causes a decrease in its activity and consecutive pyruvate accumulation. Excess pyruvate is converted to lactate. In the high concentrations, lactate induces severe neurological damage. Optimal nutrition, or healthy eating, refers to a type of diet that meets the individual needs of each person to support and maintain the body in optimal conditions. Diet therapy, or medical nutritional therapy, is a component of the clinical management of diseases and involves temporary or permanent, qualitative and/or quantitative, interventions in diet [6].

Pyruvate is a crucial metabolic intermediate that links several key metabolic pathways, including glycolysis, the citric acid cycle, gluconeogenesis, and amino acid metabolism. Its central role allows it to

contribute to energy production, biosynthesis, and the regulation of metabolic processes, making it essential for cellular function and energy homeostasis.

Body Mass Index (BMI) is a simple calculation used to assess whether a person has a healthy body weight for a given height. BMI Categories: Underweight: BMI < 18.5. Normal weight: BMI 18.5–24.9. Overweight: BMI 25–29.9. Obesity: BMI ≥ 30

BMI is a widely used indicator of body fatness, but it does not directly measure body fat. It is a useful screening tool, but it should be used in conjunction with other assessments to evaluate an individual's health status. According to the World Health Organization (WHO), a normal weight status is associated with a BMI between 18.5 and 24.9 kg/m² [12].

The relationship between health habits, overweight, and chronic fatigue syndrome (CFS) is multifaceted and intricate. One study focused on the lifestyle of patients with CFS and found that despite having healthier habits than the general population, these did not significantly affect fatigue severity or functional impairments [4].

Another study examined how unhealthy behaviors relate to chronic health outcomes, revealing complex interactions where some behaviors correlate with expected health outcomes while others do not [3]. The impact of obesity on individuals with CFS was also investigated, showing that overweight and obese individuals with CFS experience poorer functioning than their non-obese counterparts [2].

Additionally, a study on metabolic syndrome highlighted that overweight is a significant risk factor, suggesting that maintaining a healthy weight through regular exercise and stress management can help mitigate related health issues [5].

Finally, the link between physical activity, inflammation, and fatigue in middle-aged and older adults indicated that reducing inflammation through weight loss and exercise can decrease fatigue and improve physical activity levels [9].

Material and methods

In this case study, we assessed 31 individuals. Participants were selected from the group of patients evaluated at NUTHEIA EDUCATION SRL in Chisinau, based on inclusion criteria such as a diagnosis of chronic fatigue syndrome, a BMI higher than 24.9 kg/m²,

and the presence of eating and digestive disorders, including bloating and constipation symptoms.

Table.1 Representation of age, sex, and value of pyruvate in the blood for the 31 participants in the study

Nr crt	AGE	VALUE PYRUVATE µmol/l	SEX Fem/Masc
1.	44	7,16	F
2.	27	6,44	F
3.	34	5,32	F
4.	45	8,59	F
5.	34	6,01	F
6.	50	7,05	F
7.	33	6,26	F
8.	41	8,86	F
9.	46	17,16	F
10.	55	9,16	F
11.	41	9,72	F
12.	34	5,30	F
13.	25	3,58	F
14.	32	11,85	F
15.	40	3,61	F
16.	43	9,65	F
17.	49	9,79	F
18.	34	9,86	F
19.	43	13	M
20.	36	5,63	F
21.	33	4,26	F
22.	38	5,98	F
23.	29	10,03	F
24.	28	4,14	M
25.	27	7,22	F
26.	33	6,15	F
27.	35	15,17	F
28.	38	14,34	M
29.	32	12,37	F
30.	42	4,89	F
31.	40	7,63	F

Results and discussion

This distribution shows that the majority of participants fall within the 30-44 age range. All 31 participants in this study with chronic fatigue syndrome in the dataset have pyruvate values outside the normal range of 24-95 micromol/L.There are no individuals within the normal range.

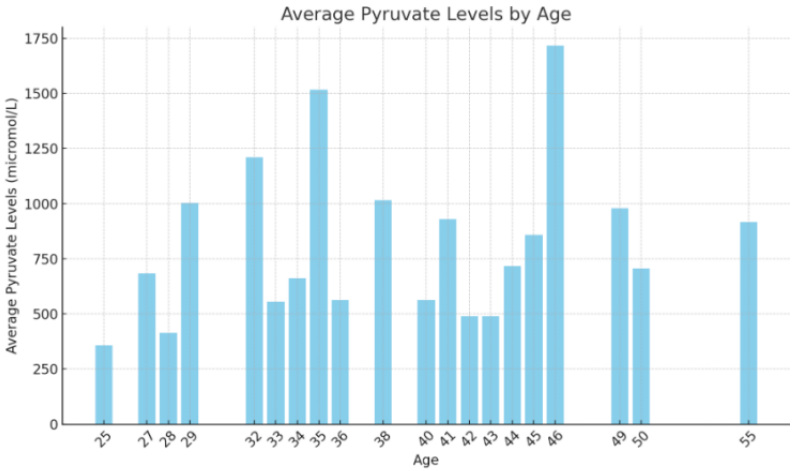

Fig.1 Distribution by age and value of pyruvate levels

All 31 individuals with a BMI higher than 24.5 kg/m² and suffering from eating and digestive disorders exhibited lower levels of pyruvate in their blood samples. This suggests that overweight and obese individuals may experience alterations in this metabolic pathway, possibly due to deficiencies in vitamins such as B1 (thiamine), B2 (riboflavin), B3 (niacin), and B5 (pantothenic acid). These deficiencies can impact the Krebs cycle and pyruvate metabolism, as inadequate nutrient intake reduces the availability of substrates necessary for pyruvate synthesis. Conditions like lactic acidosis or other mitochondrial dysfunctions can also influence pyruvate levels in the blood. Future research should focus on the gut microbiota, which produces various metabolites involved in host metabolism. Dysbiosis can change the production of these metabolites, potentially affecting the host's metabolic pathways, including those involving pyruvate levels.

Fig.2 Correlation between age and pyruvate values, scatter plot diagram where the X-axis represents age and the Y-axis represents pyruvate values

The correlation coefficient between age and pyruvate values is approximately 0.18. This indicates a weak positive correlation, suggesting that as age increases, there is a slight tendency for pyruvate values to increase, but the relationship is not strong.

Conclusions

These findings suggest that low blood pyruvate levels are associated with CFS and may contribute to the pathophysiology of the syndrome. This study highlights the potential of blood pyruvate levels as a biomarker for diagnosing CFS and guiding nutritional treatment strategies in overweight and obese people.

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