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**Adipose tissue and the content of selected lipid and lipophilic compounds in the blood
plasma of adults**

Streszczenie w języku angielskim

Obesity, defined as excessive accumulation of adipose tissue, is a global health issue leading to numerous metabolic disorders, such as insulin resistance, type 2 diabetes, hypertension, and cardiovascular diseases. Visceral adipose tissue (VAT) is particularly hazardous, as it is associated with a chronic low-grade inflammatory state that promotes metabolic dysfunction and cardiovascular diseases. Elevated plasma concentrations of free fatty acids further exacerbate oxidative stress and impair insulin sensitivity. Antioxidants play a crucial role in mitigating these processes by reducing oxidative stress and lowering inflammation, which may decrease the risk of obesity-related health complications. This highlights the importance of a diet rich in polyphenols, carotenoids, and vitamins A and E.

Vitamin E comprises four tocopherols (α -, β -, γ -, δ -) and four tocotrienols (α -, β -, γ -, δ -), which are naturally present in foods, particularly in vegetable oils, certain oilseeds, and nuts. The primary forms of vitamin E found in the human diet are α - and γ -tocopherols due to their high content in available food products. However, α -tocopherol is recognized as the most biologically active form of vitamin E, exhibiting the highest concentrations in plasma and other tissues. Moreover, the α -forms of both tocopherols and tocotrienols are considered the most metabolically active. This study focuses on analyzing the bioactive role of different isoforms of vitamin E found in food and investigating the associations between plasma concentrations of selected tocopherols and tocotrienols and the metabolic health of adults with normal and excessive adipose tissue content. The criteria for metabolic health assessment included adipose tissue content, lipid profile (cholesterol and its fractions), plasma free fatty acid profile, the activity of selected lipid metabolism-related enzymes, and C-reactive protein (CRP) concentration as an inflammatory marker.

The primary aim of the study, forming the empirical basis of this work, was to assess the relationship between adipose tissue content and the concentration of body lipids such as cholesterol and its fractions, free fatty acid profiles, and the plasma levels of lipophilic compounds (α - and γ -tocochromanols) in adults.

The study, consisting of an observational study and a survey, was conducted in 2020-2024. In the first study, body composition, lipid compounds (cholesterol and its fractions, free fatty acids), CRP levels, and vitamin E concentrations were assessed in a group of 127 adults. The second study involved developing a semi-quantitative food frequency questionnaire (FFQ) for vitamin E-rich products and a dietary assessment calculator to estimate the intake of different vitamin E isoforms, followed by an evaluation of their consumption in a group of 447 adults.

The first study revealed that higher adipose tissue content was the primary determinant of lower plasma α - and γ -tocochromanol concentrations. Furthermore, lower total cholesterol and its fractions were associated with reduced vitamin E levels, with the strongest correlations observed for high-density lipoprotein (HDL) cholesterol. Inadequate vitamin E status, measured by plasma α -tocopherol concentration, was observed in 27% of participants, including 30% of individuals with excessive adipose tissue and only 12% of those with normal adipose tissue content. Tocopherols accounted for 70.8% of the total α - and γ -tocochromanols, while tocotrienols constituted 29.2%.

Excess adipose tissue beyond recommended levels was also associated with higher CRP concentrations. In contrast, α - and γ -tocochromanols exhibited significant negative correlations with CRP, supporting the potential anti-inflammatory role of vitamin E. Individuals with obesity demonstrated increased activity of $\Delta 6$ -desaturase (D6D) and stearoyl-CoA desaturases (SCD16 and SCD18). Elevated D6D activity may exacerbate chronic inflammation, while increased SCD activity affects lipid metabolism and potentially modifies vitamin E bioavailability. However, multivariate analysis did not confirm the negative correlation between vitamin E isoforms and SCD activity, necessitating further research.

Analysis of the obtained results indicated that plasma α - and γ -tocochromanol concentrations in adults with excessive adipose tissue might be insufficient relative to proposed reference values and associated with poorer metabolic health. Given that the risk of metabolic diseases increases with age and obesity and is also influenced by biologically driven changes in body composition favoring increased fat mass, maintaining plasma α -tocopherol concentrations at a health-promoting level ($>30 \mu\text{mol/L}$) could be beneficial for overall health.

In the second study, dietary tocopherol and tocotrienol intake average 11.3 mg α -tocopherol equivalents per person per day. Considering the adequate intake (AI) value established in the Polish dietary guidelines, only 57% of participants met the recommended intake level for vitamin E. The dominant dietary tocopherol forms were α - and γ -tocopherols, with almonds and sunflower seeds being the primary sources of α -tocopherol, whereas chips, crackers, nachos, and rapeseed oil were the main sources of γ -tocopherol. Among tocotrienols, the β -form was predominant, with whole-grain bread, whole-grain pasta, brown rice, and cornflakes serving as the principal dietary sources. Tocopherols accounted for 94.3% of total vitamin E intake, while tocotrienols constituted only 5.7%.

In light of the findings, excessive adipose tissue content may be associated with lower plasma levels of lipophilic compounds, including vitamin E, potentially weakening the body's antioxidant defense. Increased vitamin E intake may support metabolic health, particularly among individuals with excessive adipose tissue. Therefore, selecting appropriate dietary sources of vitamin E, which is predominantly in plant oils.