

Hypercarbohydrate Diet and Its Impact on Hormonal Imbalance in Adolescents

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Abstract: In recent years, the increased consumption of high-carbohydrate diets among adolescents, particularly sugary beverages and fast foods, has led to disturbances in hormonal balance. This article analyzes the effect of hypercarbohydrate nutrition on the endocrine system of adolescents, specifically on the secretion of key hormones such as insulin, leptin, ghrelin, and cortisol. A review of the literature indicates that excessive carbohydrate intake leads to insulin resistance, disruption of leptin signaling, and hormonal imbalance, contributing to the development of metabolic syndrome. Additionally, changes in hormone levels during adolescence have been identified as early risk factors for obesity, dyslipidemia, and type 2 diabetes. The study emphasizes the need to explore the mechanisms by which hypercarbohydrate nutrition affects the endocrine system and to promote healthy eating habits among youth.

Key words: *adolescents, carbohydrates, hypercarbohydrate diet, hormonal imbalance, insulin resistance, leptin, ghrelin, metabolic syndrome, endocrine system, obesity*

Introduction

In recent years, the prevalence of obesity among adolescents has sharply increased not only in developed countries but also in Uzbekistan [11]. According to the WHO Regional Report for Europe, 15–20% of children aged 10–17 in Central Asian countries, including Uzbekistan, exhibit signs of overweight or obesity [12]. These figures are twice as high as those reported in the previous decade, highlighting the need for comprehensive preventive measures [13].

Current research indicates that carbohydrates, particularly high glycemic index foods, can rapidly raise blood glucose and insulin levels, increasing the likelihood of endocrine imbalance [4]. Moreover, hormonal changes during adolescence, especially fluctuations in insulin, leptin, and cortisol levels, play a crucial role in the formation of metabolic syndrome [14]. Chronic elevation of cortisol, sleep disturbances, and stress-related hypercortisolemia accelerate fat accumulation, particularly abdominal obesity [15]. Therefore, assessing sleep quality, identifying stress levels, and monitoring physical activity in adolescents are considered important clinical criteria [16].

Attention should also be given to the type of carbohydrates consumed—whether fiber-rich or refined—since diets high in fiber can reduce the risk of insulin resistance [6]. Scientific studies have shown that insufficient sleep increases ghrelin levels, decreases leptin levels, and subsequently leads to excessive appetite and eating disorders [17]. Over time, this can result in insulin resistance, dyslipidemia, and components of metabolic syndrome, such as hypertension [18]. Physical inactivity during adolescence, particularly against the backdrop of increased academic workload and widespread online learning, exacerbates this issue [19]. Consequently, daily energy expenditure decreases, muscle mass declines, and fat accumulation accelerates. Long-

term consequences include reduced insulin sensitivity, elevated blood pressure, and increased risk of cardiovascular diseases [20].

The imbalance arising during adolescence, especially when combined with a high-carbohydrate diet, can disrupt energy homeostasis and alter hormone and adipokine levels (e.g., leptin, adiponectin) [8]. Observational studies in Uzbekistan have also revealed a direct association between adolescent sleep deprivation, low physical activity, irregular eating patterns (fast food, sugary drinks, late-night meals), and obesity [21]. Therefore, evaluating sleep quality and physical activity levels, as well as analyzing their interrelation, is a relevant and urgent direction in modern endocrinology [22].

Thus, studying adolescents' high-carbohydrate eating habits and their association with hormonal imbalance and the development of metabolic syndrome is scientifically relevant.

The aim of this article is to systematically analyze, based on recent literature, the effect of hypercarbohydrate nutrition on hormonal imbalance in adolescents, particularly on the levels of insulin, leptin, and ghrelin, as well as on the risk of metabolic syndrome. The results of this study may not only provide scientific novelty but also have practical significance in promoting healthy eating habits and shaping preventive strategies among adolescents.

Physiological Significance of Nutrition During Adolescence

Adolescence is a period of fundamental restructuring of the body: rapid physical growth, increased muscle and bone mass, active development of endocrine glands and hormonal systems, and final formation of certain brain regions. During this period, the body's demand for energy and structural materials multiplies several times. If dietary intake does not meet these needs or if the eating pattern is disrupted, growth may slow, physical performance may decrease, and the risk of chronic diseases and metabolic disorders may increase. In this regard, diet quality and regularity during adolescence are not only factors affecting appearance but are also critical for overall health and uninterrupted development. [2]. Proper nutrition between ages 10 and 18 is essential for the growing body. During this time, the body's response to environmental factors undergoes fundamental changes: sexual maturation begins, the growth rate significantly increases between ages 10–13, endocrine glands become more active between ages 13–16, and certain brain regions develop [3]. Currently, many children and adolescents consume diets predominantly based on carbohydrate- and fat-rich foods, with insufficient animal protein, vitamins, and micronutrients. This situation underscores the importance of rational nutrition for adolescents: insufficient protein, calcium, and iron intake can slow bone growth, disrupt muscle formation, weaken immunity, and increase the risk of metabolic diseases. During puberty, energy and structural material demands increase sharply, making the quality and regimen of adolescents' nutrition particularly critical [2].

Effects of High-Carbohydrate Diet on the Endocrine System

Adipose tissue is not only a storage site for energy but also produces adipokines—hormone-like substances—such as leptin. In conditions of overweight and obesity, leptin levels significantly increase; however, due to leptin resistance, this hormone cannot fully perform its functions, resulting in reduced efficacy in regulating appetite and energy balance. Leptin synthesis is influenced by insulin, estrogens, and, to a certain extent, glucocorticoids. In high-carbohydrate diets, elevated insulin levels may further complicate leptin synthesis and related signaling. Leptin acts on neurons located in the hypothalamus, hippocampus, and brainstem to regulate food intake, thermogenesis, and energy expenditure. However, in leptin resistance, signaling pathways are disrupted: the hormone is produced in large amounts but fails to deliver accurate signals to the brain. These mechanisms may reduce the effectiveness of leptin signaling in high-carbohydrate diets [7].

Research has shown that 38.7% of children with obesity exhibit insulin resistance, indicating a high-risk profile. Among these mechanisms, disruption of endocrine hormones plays a central role. A study of adolescent girls with hypomenstrual syndrome demonstrated that those with strong insulin resistance had elevated erythropoietic leptin levels, decreased reproductive hormones—particularly estrogen and progesterone—and an increased LH/FSH ratio. These findings highlight the link between carbohydrate metabolism and sex hormones, which may be amplified in high-carbohydrate diets.

During obesity, the sensitivity of hypothalamic centers that control food intake is reduced. Signaling pathways for leptin and insulin are particularly impaired. Leptin, a hormone secreted by adipose tissue, normally ensures satiety via the hypothalamus. In obesity, despite elevated leptin levels, the body does not respond appropriately—a condition known as leptin resistance [10].

Association Between Hormonal Imbalance and Risk of Metabolic Syndrome

Elevated leptin levels, insulin resistance, and overweight are common in adolescents, with a correlation observed between leptin and HOMA-IR ($\rho = 0.65$) and between the L/BMI ratio and the Caro index ($\rho = 0.8$). This demonstrates a strong association between leptin resistance, impaired insulin signaling, and the development of metabolic syndrome. In overweight and obese adolescents, leptin levels are directly associated with fasting insulin, HOMA-IR, triglycerides, and low HDL cholesterol, suggesting that leptin may serve as a predictive marker for metabolic syndrome.

Disruption of endocrine hormones—including insulin, cortisol, and thyroid hormones—plays a crucial role in the initiation of metabolic syndrome. Dysregulated hormonal signaling can impair energy balance, lipid and carbohydrate metabolism, and appetite regulation [1].

During adolescence, especially in cases of obesity, significant hormonal disturbances are observed: elevated insulin, increased leptin and other adipokines, reduced tissue sensitivity to hormones, and enhanced inflammatory processes—all of which create a substrate for metabolic syndrome [5]. Daily diets in many children and adolescents rely heavily on carbohydrate- and fat-rich foods, while animal proteins, vitamins, and micronutrients are insufficient. This imbalance can slow bone growth, impair muscle development, reduce immune function, and increase the risk of metabolic diseases [9]. Overweight and obesity during adolescence lay the foundation for severe endocrine, metabolic, and reproductive disorders. Early detection, proper prevention, and a comprehensive approach can safeguard both current and future reproductive health. Therefore, this problem should be approached not only from the perspective of nutrition or physical activity but also within the context of deep hormonal and physiological mechanisms [23].

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