

Interplay of Autonomic Nervous System, Metabolic Disorders, and Psychological Aberrations in Adolescents - A Narrative Review

Ghosh S*

Department of Health Professions Education, Bhaikaka University, India

*Corresponding author: Sarmishtha Ghosh, Department of Health Professions Education, Bhaikaka University, Karamsad, Anand, Gujarat, India, Email: essjee63@gmail.com

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Abstract

Adolescence, characterized by rapid physical, psychological, and emotional changes demonstrates significant shifts in autonomic nervous system (ANS) functioning, metabolic processes, and psychological well-being. Apart from serving as a homeostatic tool for survival, ANS controls nutrient absorption and energy expenditure. A disordered system can lead to several clinical disorders including numerous psychophysiological phenomena. ANS physiology and pathophysiology are closely related to the metabolic and psychosocial abnormalities in teenagers which eventually highlight the much needed comprehensive adolescent health care. An understanding of the complex interplay between these factors is critical to address adolescent health needs through an integrated strategy. Thus the mini review is written to throw light on the relationships among ANS physiology, metabolic diseases, and psychosocial abnormalities in teenagers and to emphasize the importance of these relationships for comprehensive adolescent health care.

Keywords: Adolescence; Metabolic Diseases; Autonomic Nervous System; Adolescent Health

Abbreviations: ANS: Autonomic Nervous System; HRV: Heart Rate Variability.

Introduction

Adolescence is a critical period characterized by rapid physical, psychological, and emotional changes. During this developmental phase, adolescents experience significant shifts in their autonomic nervous system (ANS) functioning, metabolic processes, and psychological well-being. Understanding the complex interplay between these factors is critical to comprehensively addressing adolescent health needs. The purpose of this article is to clarify the relationships among ANS physiology, metabolic diseases, and psychosocial abnormalities in teenagers and to emphasize the importance

of these relationships for comprehensive adolescent health care.

Physiology of ANS

The ANS controls several involuntary body processes, such as blood pressure, digestion, heart rate, and urine. Furthermore, the ANS regulates the stress reactions. From the moment of birth until death, the human body experiences stress for a variety of reasons, such as the shift from childhood to adolescence, work deadlines or assignment submissions, financial difficulties, or interpersonal interactions. These circumstances cause the body to go through a complicated process known as the fight-or-flight reflex. The parasympathetic and sympathetic branches of the ANS act as a mediating factor in this. Stress causes the body

to activate its Sympathetic branch, which sets in motion all physiological processes aimed at protecting the body and ensuring survival. Increases in blood pressure, heart rate, and breathing are reactionary measures that direct energy toward the muscles to prepare the body for combat or flight. The parasympathetic branch functions in the opposite way to encourage relaxation and healing to replace the energy used during the process. To conserve energy, it also reduces blood pressure, decreases the heart rate, and facilitates other body functions including digestion. The Autonomic Nervous System (ANS) is a vital component of the body's survival that functions at a level below consciousness. It serves as a weapon for fight-or-flight and rest-and-digest, and it is essential for controlling nutrient absorption and energy expenditure. When this becomes disordered, it can lead to several clinical disorders. Numerous psychophysiological phenomena may ensue. As a result, maintaining the right balance between the two branches of the ANS is crucial for the human body to remain in a state of homeostasis. The ANS is also linked to the development of normal mental states. Changes in metabolism can have an effect on insulin sensitivity and weight regulation if there are disruptions in one or both branches. Diabetes and other chronic illnesses may arise from it [1].

Changes in Adolescence

Significant physical, mental, and emotional changes occur during adolescence as a person moves from childhood to maturity. This phase of development is crucial for the autonomic nervous system (ANS), as it goes through a maturation and refinement process. This has significant knock-on effects on behaviour and health. Early childhood is characterized by sympathetic nervous system dominance, with the individual largely in a fight-or-flight state for quick action. However, the transition to adulthood is accompanied by a substantial change in ANS activity. Silveti MS, et al. reported that heart rate variability (HRV) is an important indicator of ANS activity which shows a gradual increase in parasympathetic tone and a decrease in sympathetic dominance throughout adolescence [2]. Studies also reported that the nervous system matures to be better equipped to handle stress in adult life and also promote rest and recovery [3,4].

Subsequent research revealed that altered baroreflex sensitivity and elevated stress reactivity were among the pathophysiological symptoms brought on by increased sympathetic activity and decreased parasympathetic tone [5]. It has also been noted that individual variations have an additional impact on the ANS's development during adolescence. The rate and course of this maturation can be influenced by both genetic and environmental influences. Adolescents who are subjected to prolonged stress, for

example, may have delayed or disrupted ANS development, which could make them more susceptible to behavioural and health issues [6]. These ANS abnormalities can affect teenagers' general well-being by causing a range of health issues, such as gastrointestinal, sleep, and cardiovascular ailments [7].

Metabolic Illnesses

Significant metabolic alterations, such as adjustments to lipid profiles, insulin sensitivity, and glucose metabolism, are another hallmark of adolescence. During this time, metabolic control is influenced by changes in nutrition and physical activity, pubertal growth spurts, and hormonal swings. Adolescents who exhibit insulin resistance, a defining feature of the metabolic syndrome, are more likely to become obese, develop type 2 diabetes and experience cardiovascular problems [8]. In addition, disorders of lipid metabolism, characterized by elevated levels of triglycerides and low-density lipoprotein cholesterol, further increase the risk of atherosclerosis and metabolic dysregulation in this population [9].

Psychological Aberrations

As ANS activities shift chronologically with development, significant implications are indicated on adolescent health and behaviour. Adolescents demonstrate enhanced risk-taking and emotional reactivity, an indicator of heightened arousal associated with a dominant sympathetic system during early adolescence. Studies have shown associations between lower HRV, indicative of lower parasympathetic activity, and increased risk-taking tendencies in adolescents [10]. Psychological stressors can impact the brain and trigger ANS imbalances that will exacerbate metabolic and emotional difficulties. An imbalanced ANS, with prolonged sympathetic activity and insufficient parasympathetic engagement, has been linked to internalizing symptoms like anxiety and depression in adolescents [11]. Adolescents often experience delayed sleep onset and irregular sleep patterns, which may be partially explained by the ongoing maturation of the ANS. This indicates that the developing ANS also plays a role in sleep regulation, which eventually affects the health of the individual [5]. Research studies have generated pieces of evidence that support the assertion that adult mental disorders begin in adolescence. It has been found that almost half of all adult mental health disorders begin in the teenage years. This may be linked to the developmental neurobiology of the brain during adolescent years and implicates attention to mental health issues [12,13] An integrated approach to adolescent health care:

An Integrated Strategy for the Treatment of Teenage Health Research indicates that about 50% of adult mental health illnesses have their genesis in adolescence. This suggests

that attention to mental health issues is related to the neurobiology of the developing teenage brain [12,13].

To effectively design treatments that enhance the health and well-being of adolescents, it is imperative to acknowledge the interconnectedness of ANS physiology, metabolic abnormalities, and psychological aberrations. Adolescents have complicated demands that call for a multidisciplinary strategy that incorporates lifestyle, psychological, and medical interventions. Biofeedback techniques and mindfulness-based stress reduction are two interventions that target the control of the autonomic nervous system (ANS) and may help decrease physiological stress reactions and enhance overall autonomic balance. In a similar vein, dietary, physical activity, and good sleep hygiene adjustments are crucial for the management of metabolic diseases and the promotion of metabolic health in teenagers [8]. Furthermore, adolescents with psychological issues can benefit from psychotherapy interventions such as cognitive-behavioural therapy and interpersonal therapy, which can help them become more resilient [14]. The pathophysiology of several mental diseases has been linked to dysregulated ANS activity and metabolic abnormalities, highlighting the significance of targeting these physiological aspects in psychological therapies [15].

Conclusion

Understanding the interconnectedness of these factors is critical to promoting the holistic health of adolescents and addressing the complex array of physiological and psychological issues they face. By adopting an integrated approach that addresses ANS dysregulation, metabolic disturbances, and psychological aberrations, healthcare providers can optimize outcomes and support adolescents as they navigate this transformative phase of development.

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