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Effects of Hormonal Changes During Puberty on Cognition and Mood

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Abstract. This article explores the hormone surge during puberty and its wide-ranging effects on adolescent behavior, mood, and cognition, highlighting the importance of this area for future research. The onset of puberty leads to increased secretion of sex hormones such as estrogen and testosterone, which bring physical, emotional, and behavioral changes by activating the hypothalamic-pituitary-gonadal axis. This article provides insights into how these hormones affect adolescent brain development, particularly areas such as the prefrontal cortex and hippocampus that are responsible for higher-order thinking and memory. Hormone fluctuations not only affect adolescents' attention and processing abilities, but also lead to mood swings, increased stress sensitivity, and sex differences in externalizing behaviors (such as aggression) and emotion regulation. Girls are more prone to mood swings due to cyclical fluctuations in estrogen and progesterone, while boys exhibit risk-taking behaviors associated with testosterone. In addition, sex hormones affect adolescents' social cognition, self-esteem, and body image, leading to increased insecurity and social sensitivity. This article calls for providing adolescents with healthy coping strategies and supportive environments, and, if necessary, therapeutic interventions to help them through the challenges of this period, and points to directions for future research.

Keywords: Hormonal changes; puberty; cognition and mood.

1. Introduction

In this paper, the topic of puberty hormone surge is being addressed as well as the affections on teenage conduct. The paper highlights these problems' contributions to a particular set of developmental processes at the core of the childhood-adolescent transition and explains why they constitute an intriguing and significant field for the future. The study will go over the neuroendocrine foundations of human puberty in brief. A review highlights the social and affective aspects of gonadal hormone impacts while concentrating on the evidence for behavioral and neurobehavioral consequences of these hormones. In a broader sense, the paper will examine how these hormonal changes influence brain behavior interactions that might influence early adolescent trajectories in both positive and negative ways, and in ways that may start tiny but eventually become significant, the onset of puberty triggers the activation of the hypothalamic-pituitary-gonadal axis, leading to increase secretion of sex hormones, primarily estrogen and testosterone [1]. These hormones not only drive physical maturation but also have profound effects on behavior, emotions, and cognition, making the understanding of their impact vital for comprehending adolescent development.

Additionally, it seems that these factors are crucial for the anatomical and functional development of the teenage brain. Lastly, the paper concludes with recommendations for teenagers experiencing hormonal fluctuations. These include promoting healthy coping strategies, fostering supportive social environments, and considering therapeutic interventions when necessary. By addressing the challenges posed by unstable hormones, this paper has some experiment results and medication to suggest for teenagers who are influenced by their unstable hormones that can help adolescents navigate this tumultuous period more effectively.

2. The Introduction of Hormones

Hormones are chemicals that communicate with human organs, skin, muscles, and other tissues through the bloodstream to regulate various bodily activities. The human body receives these messages and knows what to do and when. Human health and life depend on hormones, which play a very important role in controlling the health stage and emotions. The human body contains more than 50 kinds of hormones that have been discovered thus far. People's endocrine systems are made up of hormones and the majority of the tissues that produce and release them. Hormones regulate a wide range of physiological functions, such as metabolism. Homeostasis helps continuous internal balance, including controlling body temperature, blood pressure, blood sugar, and electrolyte and fluid balance [2]. Hormones are chemical messengers that have a vast array of physiological effects and functions. physiological progress frequently entails a series of interconnection hormone reactions, only when a hormone targets a tissue's cell that has hormone receptors, which will affect that area of the body. Consider a hormone as a key and the cells that make up the target tissue, which may be a fat tissue or an organ, as locks with a specific form. The hormone will transmit a message that prompts the target site to do a certain function if it matches the receptor on the cell wall [3]. The majority of the Mormons in the human body are produced. The majority of the hormones in the human body are produced and released by specialized glands that make up the human body's endocrine system. An organ that produces hormones, digestive fluids, sweat glands, and tears, hormones are released into your bloodstream directly by endocrine glands for example hypothalamus, which allows the body's hypothalamus (an area of the brain]. to communicate with the pituitary gland, it causes the release of many hormones that regulate body pituitary gland. The pineal organ, which is located at the base of the brain, behind the bridge of the nose, and just below the hypothalamus, is a pea-sized gland called the pituitary. The anterior lobe and the posterior lobe make up its two lobes. Many of the hormones that the pituitary gland releases regulate the activity of other endocrine glands. Thyroid gland, a little gland beneath the skin that resembles a butterfly and is situated at the front of the neck. The primary function of the thyroid is to regulate the metabolic rate and pace at which the body converts the food humans eat into energy. Ovaries, an individual classified as female at birth has two ovaries, each situated beneath the fallopian tube opening sides of their uterus. The ovaries not only create the egg cells required for reproduction, but they also make hormones (Figure 1) [4].

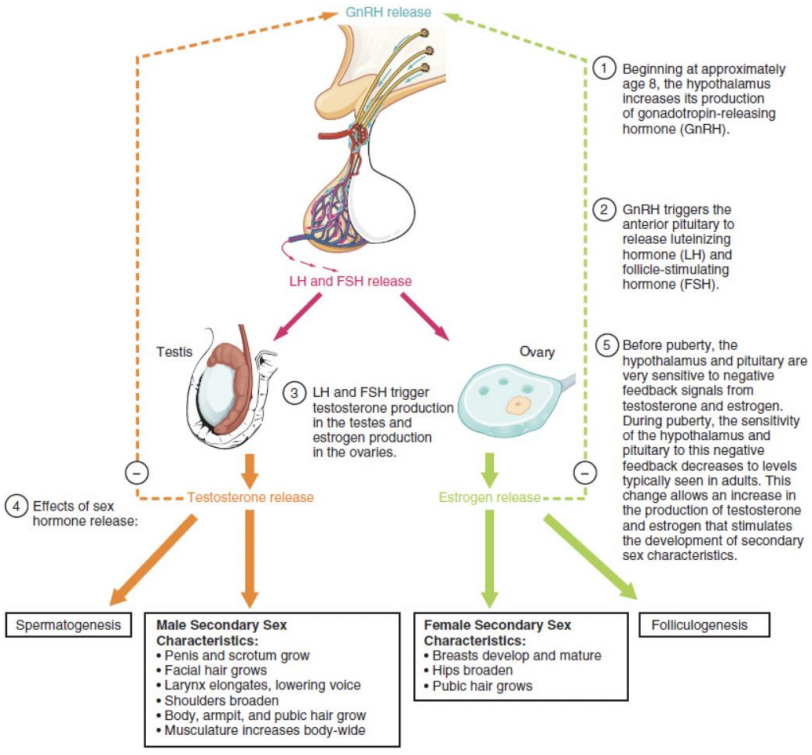

Figure 1. LH and FSH stimulate the gonads to produce sex hormones [5].

3. Hormonal Changes during Puberty

Sex hormones cause a sexually immature youngster to become a sexually mature adult during puberty. A growth sugar, the development of secondary sexual features, the maturation of sexual organs, and psychological changes are indicative of this stage. The hypothalamic-pituitary unit starts to operate like an adult at this moment. The pituitary releases additional gonadotropins, follicle-stimulating hormones, and luteinizing hormones, likewise in a pulsatile pattern, in response to the hypothalamus's increased secretion of gonadotropin-releasing hormones. Male secondary sexual traits, like greater muscular mass, body hair, and a deeper voice, develop in boys when their testosterone levels rise. Elevated estrogen levels in girls encourage the development of secondary sexual characteristics in women, such as the breasts and the menstrual cycle [6]. For females, the main hormones causing alterations are progesterone and estrogen. Physical changes contain one of the earliest indications of puberty in girls is breast development. Menstruation will be the menarche, or the start of the menstrual cycle, usually happens between the ages of 8 to 16. Widening of the hips and the accumulation of fat in the thighs and breasts are examples of body formation. Boys typically grow taller than girls, but they go through a growth spurt later. Increased muscular mass, particularly in the upper body, is known as muscle growth. the development of body hair on the face, chest, underarms, and pubic hair will increase the capacity to ejaculate as well as the start of sperm production. There will also be variations in health status during puberty, the way a person experiences puberty can be greatly influenced by their health [7]. Puberty can impact health status in the nutritional status of undernutrition, where people who are malnourished frequently experience delayed puberty onset. Reduced body fat can interfere with the production of hormones, delaying menarche in girls and slowing down development in boys. Overnutrition can happen on the opposite side of negative effects, obesity can have more varied effects on guys, it can hasten the onset of puberty in girls and cause early menarche. Chronic illness, because chronic illnesses affect hormone balance and lower the body's energy availability, such as cystic fibrosis, diabetes, or kidney diseases, might cause delays in puberty. Some mental health includes the onset and course of puberty can be influenced by stress, depression, or anxiety. For girls, persistent stress might cause irregular menstrual cycles or postpone puberty. Endocrine disorders growth hormone insufficiency and hypothyroidism are two conditions that can lead to delayed puberty [8]. Some of the effects on cognition and behavior conduct of children during puberty comprise testosterone, especially in boys, which is associated with increased impulsivity and risk-taking behaviors. hormonal changes can cause more daring or risky behaviors since the prefrontal cortex, the area of the brain responsible for judgment and decision making is still developing. peer pressure and social comparison of children frequently comparing themselves to classmates as they grow more self-aware, especially when emotional and physical development occurs at varying rates. Feelings of jealousy, insecurity, or worry about social integration may result from this. Changes in relationships and interests in hormones also influence sexual development, which can result in a renewed interest in romantic relationships as well as an increased emphasis on social standing, attractiveness, and outward looks [9].

4. Brain Development during Puberty

Even adult's brains are constantly changing and adjusting to different changes. Puberty is a dynamic transitional stage that gets us ready for adulthood. The same hormones, such as estrogen and testosterone, influence the body and brain during puberty, which also affects the human body throughout life. These hormones influence the shape and growth of neurons in the brain even before birth. They permanently change the maturation of the brain by reorganizing its structure during puberty. For example, changes in neuronal growth or death alter the size of brain areas. Pubertal hormones are essential for the development of important brain regions such as the amygdala, pituitary gland, and hypothalamus in both healthy humans and animals. Inadequate development throughout puberty can lead to chronic health problems, such as metabolic or sleep difficulties. Lower testosterone levels and a smaller amygdala are symptoms of Klinefelter syndrome, a genetic illness caused by an extra chromosome. These conditions can exacerbate emotional and social problems like

anxiety and trouble expressing emotions. The quantity of connections between neurons, which influences the intricacy of brain circuits, is another way that the structure of the brain varies. For example, the hippocampus contains many receptors for the hormone estrogen, which strengthens neural connections and may help with learning and memory throughout adolescence. Furthermore, myelination—a process that insulates neurons and improves communication between brain regions—is dependent on sex hormones and is a crucial aspect of brain maturation [10]. During puberty, social interactions and environmental circumstances play a major role in shaping brain development. positive interactions can promote healthy growth, whereas bad encounters may have long-term harmful effects. Adolescents also undergo cognitive growth, which includes enhanced capacity for abstract thought and problem-solving (Table 1) [11].

Table 1. Summary of the effects of different hormones on brain structure and function [12].

Brain Structure	Brain Function	Model	Hormone(s)	Effect
Hypothalamus	Hormone secretion; regulation of temperature, appetite, emotions, and sexual behavior	Animal (rat)	Testosterone, progesterone, and estradiol	↑ New cell growth
Pituitary	Hormone secretion; regulation of hormone production in other endocrine glands	Human (healthy adolescent)	Testosterone and estradiol	↑ Grey matter volume
Amygdala	Emotion processing; fear, aggression, sexual behaviors, and reward learning	Animal (rat/hamster)	Testosterone	↑ New cell growth
		Human (healthy adolescent)	Testosterone and DHEA	↑ Grey matter volume
		Human (Klinefelter syndrome)	Testosterone	↓ Grey matter volume
Hippocampus	Learning and memory	Animal (rat)	Estrogen	↑ Synaptic density
Myelin	Insulates axons; increases speed and efficiency of signal transmission in neurons	Animal (rat)	Sex steroids	↑ Myelination
		Human (healthy adolescent)	Testosterone and estradiol	↑ Myelination

4.1. Suggestions for Decreasing Extreme Emotions in Ages 8-16

Some ways to prevent children experiencing puberty from expressing extreme emotions are to listen to upbeat or their favorite songs, spend time with a good listening friend, go for a walk with a dog, get a hug from parents, and receive their understanding. Spend time with family and friends and watch a movie. Parents should be good listeners to hear about what's going on in their lives and allow them to share opinions so they can try different things to see what works best. Parents should also be role model to show their children what's right and wrong. Parents should solve the problems their kids have together, by fostering problems, solving skills also demonstrating appreciation for their opinions in making decisions that impact their lives. and gives them hope about life and motivation to keep going to manage their emotions by using coping strategies. Try to give children some space or time alone during this period so they may reflect on their newfound feelings and experiences. Additionally, collaborating to develop coping mechanisms is essential for adolescents, as it helps them deal with and control emotional ups and downs independently [13].

4.2. Experimental Validation

The study compared the prediction performance of physical puberty age with the linear model of pubertal timing, revealing a difference in prediction accuracy in previously unseen data. The physical puberty age model had a significantly lower prediction error in both males and females. The study also investigated the association between each puberty age gap measure and different dimensions of mental health problems. The hormonal puberty age gap was not significantly associated with any mental health problems in either gender. The physical puberty age gap was positively associated with all dimensions in males and females.

Frederiksen et al.'s study on sex-specific estrogen levels and reference intervals from infancy to late adulthood, published in the Journal of Clinical Endocrinology & Metabolism, found that lower estradiol and estrone levels in TS5 compared to TS4 are likely due to sampling error. The study's results suggest that LC-MS/MS can provide valuable insights into the relationship between estrogen levels and the development of TS5. The study's findings highlight the importance of accurate sex-specific estrogen levels.

5. Conclusion

This paper explores the hormonal sugar during puberty and its impact on teenage behaviors, lighting the importance of understanding these changes for future research. The neuroendocrine foundations of human puberty are discussed, along with the social and emotional aspects of gonadal hormone impacts. The paper highlights how hormonal changes influence brain behavior interactions, shaping early adolescent trajectories in both positive and negative ways. Puberty triggers the activation of the hypothalamic-pituitary-gonadal axis, leading to increased secretion of sex hormones, primarily estrogen and testosterone. These hormones drive physical maturation but also profoundly impact behavior, emotions, and cognition. Understanding these hormonal effects is crucial for comprehending adolescent development and the anatomical and functional development of the teenage brain. Cognitive development during puberty is marked by changes in brain areas responsible for higher-order thinking, such as the prefrontal cortex. Hormonal fluctuations, particularly in estrogen and testosterone, influence memory processes through interactions with the hippocampus, a key area for learning and memory. Adolescents may experience fluctuations in attention and processing spending due to changing hormone levels, leading to difficulties in sustaining focus. Mood regulation is also affected by hormonal changes, with rising sex hormones influencing neurotransmitter systems such as serotonin and dopamine, resulting in heightened emotional sensitivity, mood swings, and vulnerability to stress. Gender differences in mood are evident, with girls more prone to emotional volatility due to cyclical estrogen and progesterone, and boys more likely to exhibit externalized behaviors like aggression linked to testosterone sugars. Social and psychological impacts include the influence of hormones on adolescents' social cognition, self-esteem, and body image. Hormonal changes can contribute to feelings of insecurity and heightened social sensitivity, while testosterone sugars in boys have been linked to increased risk-taking behaviors.

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