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GROWTH AND PUBERTAL DEVELOPMENT DISORDERS IN CHILDREN: CLINICAL FEATURES AND MODERN DIAGNOSTIC APPROACHES

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Abstract. The aim of this study was to provide a comprehensive assessment of the clinical features of growth and pubertal development disorders in children and adolescents, as well as to analyze modern diagnostic approaches. The main forms of disorders considered include growth delay, delayed puberty, and precocious puberty. Growth delay was found in 2–5% of children and may be attributed to constitutional factors as well as endocrine diseases. Delayed puberty occurs in 2–3% of adolescents, predominantly in boys, and is most often constitutional in nature. Precocious puberty is diagnosed mainly in girls, accounting for up to 80% of cases, and requires early intervention to prevent complications.

The study methods included clinical evaluation of anthropometric parameters, determination of pubertal stage using Tanner's scale, hand radiography to assess bone age, hormonal assays (growth hormone, IGF-1, thyroid hormones, gonadotropins, estradiol, testosterone), and instrumental techniques such as ultrasound examination of the thyroid gland and pelvic organs, as well as magnetic resonance imaging of the brain.

The analysis confirmed that the most common disorders are growth delay and precocious puberty. These conditions are multifactorial in origin and require comprehensive diagnostic evaluation to differentiate constitutional variants from pathological forms. The practical significance of the study lies in the fact that early diagnosis and correct interpretation of clinical and laboratory data improve prognosis and quality of life in children with growth and pubertal development disorders.

Keywords: growth delay; delayed puberty; precocious puberty; hormonal disorders; diagnostics; bone age; adolescent medicine.

Introduction. Growth and pubertal development disorders in children and adolescents represent one of the key challenges in contemporary pediatric endocrinology. According to national guidelines and clinical observations, the prevalence of growth delay and pubertal disorders ranges from 2% to 5% in the general population, and is significantly higher among patients with endocrine pathology. The endocrine system plays a central role in regulating growth and pubertal maturation. Disturbances in the secretion of growth hormone, gonadotropins, thyroid hormones, and insulin may lead to growth delay, precocious puberty, or delayed puberty. Environmental factors such as nutrition, physical activity, psychosocial stress, and chronic diseases also exert a considerable influence, as demonstrated by both national and international studies.

Current clinical guidelines emphasize the importance of early diagnosis of growth and pubertal disorders, since timely intervention can prevent severe somatic and psychosocial consequences. Growth delay, in particular, may be the first manifestation of endocrine diseases such as hypopituitarism or type 1 diabetes mellitus.

International research further highlights the significance of this issue. Palmert and Dunkel demonstrated that delayed puberty requires comprehensive evaluation of hormonal profiles and bone age. Latronico and colleagues identified central precocious puberty as a distinct clinical

AMERICAN ACADEMIC PUBLISHER
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category necessitating early intervention. Rogol and co-authors emphasized the impact of nutrition and physical activity on growth and pubertal development, while Biro and colleagues described the relationship between anthropometric changes and pubertal tempo in girls.

Aim of the Study. The objective of this work is to provide a comprehensive evaluation of the clinical features of growth and pubertal development disorders in children and adolescents, based on the analysis of anthropometric parameters, hormonal profiles, and instrumental diagnostic methods, as well as to compare the obtained findings with contemporary national and international clinical guidelines.

Materials and Methods. The study included 120 children and adolescents aged 5 to 16 years (mean age 10.8 ± 2.4 years) who were observed in the Department of Endocrinology at the Andijan State Medical Institute. The cohort comprised 65 boys (54.2%) and 55 girls (45.8%). Inclusion criteria were height below –2 SDS compared with age-appropriate norms, signs of precocious puberty defined as the appearance of secondary sexual characteristics in girls before the age of 8 years and in boys before the age of 9 years, and signs of delayed puberty defined as the absence of pubertal development in girls older than 13 years and boys older than 14 years. A prerequisite for enrollment was the possibility of conducting a comprehensive endocrinological evaluation. Exclusion criteria included severe somatic diseases, congenital malformations, chronic infections, and previously diagnosed genetic syndromes such as Turner syndrome and Klinefelter syndrome, which are associated with growth and pubertal disorders.

All patients underwent standard clinical assessment, including medical history, anthropometric evaluation (height, body weight, body mass index), determination of pubertal stage according to Tanner's scale, and assessment of bone age by hand radiography. Laboratory investigations included measurement of growth hormone, insulin-like growth factor-1 (IGF-1), thyroid hormones (TSH and free T4), gonadotropins (LH and FSH), as well as estradiol and testosterone. When necessary, stimulation tests such as the insulin test, clomiphene test, or gonadotropin-releasing hormone test were performed to evaluate the functional activity of the hypothalamic-pituitary axis. Instrumental diagnostic methods included ultrasound examination of the thyroid gland and pelvic organs in girls, as well as magnetic resonance imaging of the brain in cases where organic pathology of the hypothalamic-pituitary region was suspected.

Statistical analysis was carried out using SPSS Statistics version 26.0. Descriptive statistics, correlation analysis, independent samples t-test, and χ^2-test for categorical variables were applied. Results were expressed as mean values with standard deviations, and differences were considered statistically significant at $p < 0.05$.

Results. A total of 120 children and adolescents aged 5 to 16 years were examined during the study. Growth delay was identified in 38 patients (31.7%), which corresponds to published data on the prevalence of short stature in the pediatric population. In most cases, growth delay was constitutional in nature; however, endocrine causes were detected in 12 children (10%), including growth hormone deficiency and hypothyroidism. These patients demonstrated reduced levels of IGF-1 and growth hormone, as well as a discrepancy between bone age and chronological age, confirmed by hand radiography (table 1).

Table 1.

Frequency of Major Growth and Pubertal Disorders in Children and Adolescents

AMERICAN ACADEMIC PUBLISHER
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ISSN NUMBER: 2692 - 5206 Volume 5. No 12. December ,2025

Disorder	Number of Cases	Percentage (%)	Characteristics	Predominant Sex
Growth delay	38	31.7	Mostly constitutional form; possible growth hormone deficiency	Both sexes
Delayed puberty	26	21.7	Predominantly constitutional form	Boys
Precocious puberty	17	14.2	82.3% of cases in girls; central form more common	Girls

Delayed puberty was diagnosed in 26 adolescents (21.7%), occurring more frequently in boys (18 cases, 69.2%). The predominant form was constitutional delay of puberty, characterized by a late onset of secondary sexual characteristics while maintaining normal growth velocity. In some patients, the delay was associated with chronic conditions such as type 1 diabetes mellitus and celiac disease. Laboratory investigations revealed reduced levels of gonadotropins (LH and FSH) and sex steroids, indicating functional immaturity of the hypothalamic–pituitary axis (table 2).

Table 2.
Main Clinical Manifestations of Growth and Pubertal Disorders

Disorder	Clinical Signs	Diagnostic Criteria	Possible Complications
Growth delay	Height below –2 SDS; discrepancy between bone age and chronological age	Hand radiography; IGF-1 measurement; growth hormone stimulation tests	Psychosocial difficulties; reduced final height
Delayed puberty	Absence of pubertal signs in girls >13 years and boys >14 years	LH, FSH, estradiol/testosterone assays; assessment of bone maturity	Infertility; decreased bone mass

AMERICAN ACADEMIC PUBLISHER
INTERNATIONAL JOURNAL OF MEDICAL SCIENCES
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Precocious puberty	Secondary sexual characteristics in girls <8 years and boys <9 years	Gonadotropin levels; pelvic ultrasound; brain MRI	Premature epiphyseal closure; reduced final height

Precocious puberty was identified in 14 girls (11.7%) and 3 boys (2.5%). Thus, girls accounted for 82.3% of all cases of precocious pubertal development. The central form was more common and was characterized by elevated levels of LH and FSH, as well as an early peak in response to gonadotropin-releasing hormone stimulation. The peripheral form was associated with ovarian and adrenal pathology, as confirmed by ultrasound examination. Clinically, precocious puberty manifested as the appearance of secondary sexual characteristics in girls younger than 8 years and boys younger than 9 years (table 3).

Table 3.

Laboratory Indicators in Growth and Pubertal Disorders

Disorder	**Main Hormonal Changes**	**Additional Investigations**
Growth hormone deficiency	Decreased GH, IGF-1	Stimulation tests (insulin, clomiphene)
Hypothyroidism	Elevated TSH, decreased free T4	Thyroid ultrasound; anti-TPO antibodies
Central delayed puberty	Low LH, FSH; low estradiol/testosterone	Pituitary MRI
Central precocious puberty	Elevated LH, FSH; early peak on stimulation testing	Brain MRI
Peripheral precocious puberty	Elevated estradiol/testosterone with low LH, FSH	Ovarian/adrenal ultrasound

Thus, the findings of the study demonstrated that growth delay was the most frequent disorder among the examined children, while precocious puberty occurred more commonly in girls. Delayed puberty was observed predominantly in boys and was mainly constitutional in nature. All identified disorders were accompanied by alterations in hormonal profiles and discrepancies between bone age and chronological age, underscoring the necessity of comprehensive diagnostic evaluation using clinical, laboratory, and instrumental methods.

AMERICAN ACADEMIC PUBLISHER
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Discussion. The results of our study corroborate the findings reported in the literature, indicating that growth delay and pubertal disorders are among the most frequent reasons for referral to pediatric endocrinologists. According to Russian clinical guidelines, the prevalence of short stature in children is estimated at 2–5%. In most cases, this represents constitutional growth delay with a favorable prognosis; however, endocrine causes such as growth hormone deficiency and hypothyroidism require early detection and specific therapy. International studies also emphasize the importance of hormonal factors: Rogol and colleagues demonstrated that nutrition and physical activity exert a direct influence on growth and pubertal development.

Delayed puberty was observed in 21.7% of adolescents, more frequently in boys, which is consistent with the findings of Palmert and Dunkel, who highlighted the necessity of comprehensive evaluation of hormonal profiles and bone age in such cases. While constitutional delay was the predominant form, organic lesions of the hypothalamic–pituitary system and chronic diseases may also contribute to late pubertal onset. Abitbol and co-authors noted that timely differential diagnosis is essential to distinguish constitutional delay from hypogonadotropic hypogonadism.

Precocious puberty was identified predominantly in girls (82.3% of cases), which aligns with international data indicating that up to 80% of cases occur in females. The central form was more common, characterized by elevated LH and FSH levels and an early peak in response to gonadotropin-releasing hormone stimulation. The peripheral form was associated with ovarian and adrenal pathology, confirmed by ultrasound findings. Latronico and colleagues demonstrated that central precocious puberty requires early intervention to prevent complications such as premature epiphyseal closure and reduced final height. Kaplowitz emphasized the importance of early referral of children with signs of precocious puberty to endocrinologists for specialized evaluation.

Taken together, comparison of our findings with national and international studies indicates that growth delay is the most frequent disorder among the examined children, while precocious puberty occurs more commonly in girls. Delayed puberty was observed predominantly in boys and was mainly constitutional in nature. All forms of pubertal and growth disorders were accompanied by alterations in hormonal profiles and discrepancies between bone age and chronological age, underscoring the need for comprehensive diagnostic evaluation using clinical, laboratory, and instrumental methods.

Conclusion. The analysis demonstrated that growth and pubertal development disorders in children and adolescents are both common and clinically significant. The most frequent conditions identified were growth delay and precocious puberty, with the latter diagnosed predominantly in girls. Delayed puberty was observed more often in boys and was primarily constitutional in nature.

These disorders are multifactorial, arising from endocrine abnormalities such as growth hormone deficiency, hypothyroidism, or hypogonadism, as well as external influences including nutrition, physical activity, and chronic diseases. Importantly, growth delay and delayed puberty may represent the first manifestation of serious endocrine pathology requiring early intervention.

Comprehensive diagnostic evaluation—including anthropometric assessment, determination of bone age, hormonal studies, and instrumental methods such as ultrasound and magnetic resonance imaging—enables timely identification of pathology and differentiation from constitutional variants.

AMERICAN ACADEMIC PUBLISHER
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ISSN NUMBER: 2692 - 5206 Volume 5. No 12. December ,2025

The practical significance of this study lies in the fact that early diagnosis and accurate interpretation of clinical and laboratory findings can improve prognosis and quality of life in children with growth and pubertal development disorders. Incorporating these parameters into diagnostic and monitoring algorithms contributes to optimizing therapeutic strategies and enhancing patient outcomes.

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