

Patterns of Growth

The Human Growth Foundation is a non-profit volunteer organization. Its mission is to help children and adults with disorders related to growth or growth-hormone through education, research, support and advocacy. It is composed of concerned parents and friends of children with growth problems and interested health professionals. Its objectives include:

- Support of research
- Family education and service
- Public education
- Education of health care professionals
- *Advocacy on behalf of individuals with growth or growth hormone disorders*

Author: Patricia A. Rieser, Family Nurse Practitioner-C
University of North Carolina at Chapel Hill
From original text by: Robert M. Blizzard



Human Growth Foundation



"How tall will my 2-year-old be when he grows up?"

"Doctor, my 12-year-old daughter is already 5 feet, 10 inches tall. Is there anything I can do to keep her from growing over 6 feet tall?"

INTRODUCTION

"My child has a cartilage problem and is very short. Will my other children also be short?"

These are questions often asked by parents when the growth of a child seems unusual. What determines how a child grows? How is height inherited? How does one recognize a growth problem? How are growth problems treated? Children may ask parents why they are not as tall as their playmates; parents ask doctors, and doctors ask endocrine (hormone) specialists and geneticists.

This booklet will explain normal and abnormal patterns of growth and answer some of the questions about growth that parents find puzzling.

Intrauterine Growth Retardation

Some infants are small at birth. When pregnancy ends earlier than usual, the baby is premature. These babies are small, but usually are normal size given their gestational age (length of time in the womb). However, some infants are shorter and weigh less than they should at birth. In other words, they had a chance to grow in the womb, but did not reach the length and weight they should have for their gestational age. This failure to grow normally in the womb is called **intrauterine growth retardation**.

This condition may result from a problem with the placenta, the organ in the mother's womb that supplies nutrients and oxygen to the baby. A viral infection, such as German Measles, during pregnancy may affect the placenta and infant and cause intrauterine growth retardation. Sometimes the cause of this condition cannot be identified. Some of these children will remain small throughout life, while others may reach normal size. Because there are so many different causes of intrauterine growth retardation, no single treatment is effective in increasing the height of these individuals. Studies are underway to see if growth hormone is effective in increasing the growth rate and adult height of these children; the

Girls with Turner syndrome have a genetic condition related to the absence or malformation of one of the sex chromosomes. This condition results in short stature and undeveloped ovaries (female sex glands) in otherwise normal females.



results are not yet known. More information about this type of short stature is available in the HGF booklet called "Intrauterine Growth Retardation" (IUGR).

Turner Syndrome

Short stature in girls may be caused by a genetic condition that affects the X chromosome. Chromosomes are small thread-like bodies in the nucleus of each cell; they contain the genetic material that determines the characteristics we inherit. Two of these chromosomes determine sexual development - the X and Y chromosomes. Boys have one X and one Y chromosome, and girls have two X chromosomes. In girls with **Turner Syndrome**, one of the X chromosomes is misshapen or missing in many or all body cells. Because of this, affected girls are short - they seldom reach 5 feet in height - and may have undeveloped ovaries (female sex glands that produce eggs and female hormones). Intelligence is normal. Turner Syndrome may be suspected because of the presence of certain physical features, but poor growth is sometimes the only sign. This condition is diagnosed by doing a special blood

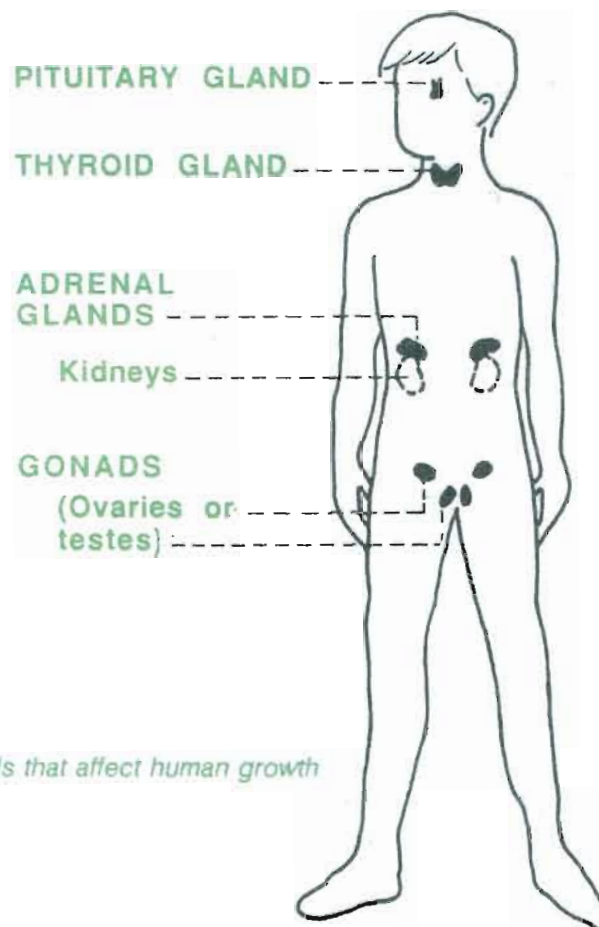


Children with precocious puberty look older than they are because they are tall for their age. Their growth plates fuse too soon, however so they may end up short adults.

test (karyotype) to look for damaged or missing sex chromosomes. Replacement of the missing ovarian hormones enables these girls to develop normal female sexual characteristics. Treatment with biosynthetic growth hormone appears to be effective in increasing adult height in many of these young women, although long-term studies are still underway. The HGF booklet, "Turner Syndrome," supplies more information about this condition.

Precocious Puberty

One type of unusual growth pattern is caused by the early onset of adolescence. This pattern occurs more frequently in girls than boys. The term **sexual precocity** is used to describe this condition, which includes early development of adult sexual characteristics. Children with sexual precocity grow rapidly and are tall for their age initially, but their bones also mature rapidly, so they stop growing at an early age and may be short as adults. A recently developed synthetic hormone (LHRH) is useful in halting this type of early sexual development and allowing additional growth. Studies are underway to determine if the addition of growth hormone to this regimen



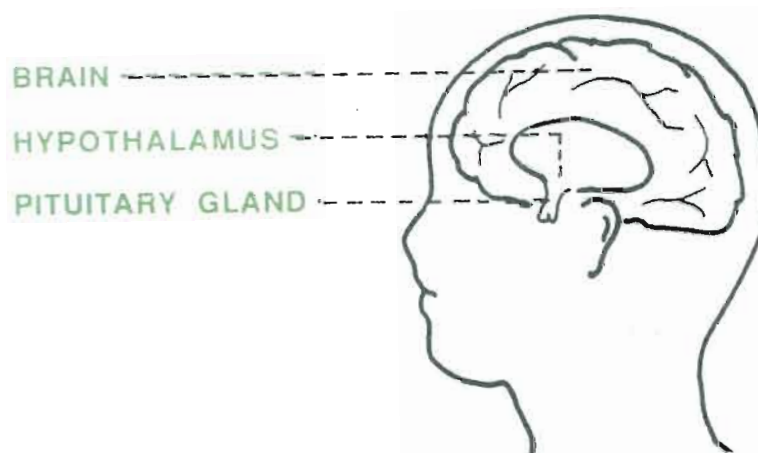
Location of various glands that affect human growth

increases adult height of children with sexual precocity.

Sometimes a tumor or disease of the ovaries, adrenal glands, pituitary gland or brain will cause premature sexual development. In these cases, removal of the tumor or treatment of the disease may interrupt the rapid sexual development and result in increased adult height.

Thyroid Hormone Deficiency

Hormone deficiencies may cause growth failure in addition to other problems. A child with thyroid hormone deficiency has slow growth and is physically and mentally sluggish. **Hypothyroidism**, or lack of thyroid hormone, may be present at birth or develop anytime during childhood or later in life. It is very important to treat hypothyroidism promptly, especially if it occurs during the rapid growth period of infancy. Untreated hypothyroidism during this time can cause permanent damage to sensitive, rapidly growing brain cells. Thyroid hormone deficiency is easy to diagnose with a simple blood test and easy to treat with a daily pill that replaces the missing thyroid



Location of the hypothalamus and pituitary gland

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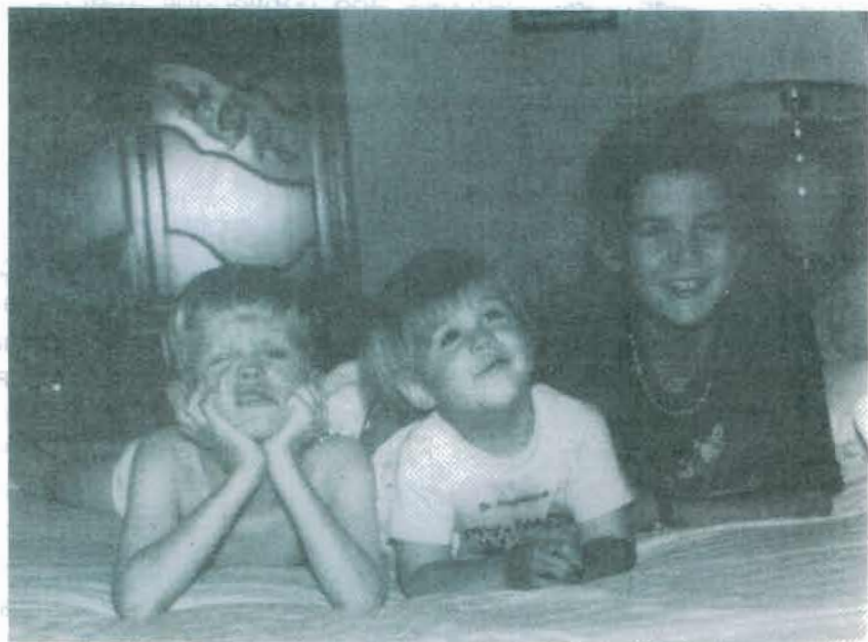
hormone. With early diagnosis and continuous treatment, these children grow and develop normally.

Growth Hormone Deficiency

Although many hormones work together to stimulate normal growth, growth hormone is one of the most important. It is produced by a bean-sized gland called the pituitary, which is located beneath a special part of the brain (hypothalamus) in the middle of the skull. The pituitary gland makes other hormones that stimulate other glands, so it is sometimes called the master gland. Pituitary abnormalities can cause a number of problems that result in poor growth: hypothyroidism, discussed earlier, may result from a pituitary malfunction, as may hypercortisolism (excess stress hormone). Growth hormone deficiency may result from abnormal formation of the pituitary gland or hypothalamus, or damage to one of these areas occurring during or after birth.

Children with growth hormone deficiency grow slowly, but have normal body proportions. Without treatment, few would reach 5 feet

Children with growth problems who receive proper care can lead happy, healthy lives.



in height as adults. A variety of tests may be necessary to diagnose this condition. A child with growth hormone deficiency also may be missing other pituitary hormones, (thyroid, adrenal or stress hormones, sex hormones). All hormones must be present in the proper balance for normal growth to occur, so these hormones must be replaced if they are missing. Biosynthetic human growth hormone, produced by recombinant DNA technology, is available for the treatment of growth hormone deficiency. Children who are diagnosed promptly and respond well to treatment can expect to reach normal adult height. More information about this condition is presented in the HGF booklet, "Growth Hormone Deficiency."

Abnormal Tall Stature

Most tall children have tall parents and are healthy and normal, but there are some medical conditions that cause abnormal tall stature and rapid growth. A small tumor in the pituitary gland may cause too much growth hormone to be secreted, resulting in unusually fast growth and tall stature. Growth hormone excess (also called acromegaly) may be treated with medication or with surgical removal

of the tumor. Some genetic conditions cause abnormal tall stature; Marfan's syndrome and Klinefelter's syndrome are two examples. These syndromes are associated with distinctive physical traits in addition to tall stature. Precocious puberty, discussed earlier, results in tall stature during childhood, although early closure of the growth plates results in short adult height.

Tall children, like short children, may stand out from their classmates and experience stress and teasing because of their size. They often look older than they are, so adults may expect too much of them. It is important for parents and teachers to be aware of the stress these children may experience as a result of looking different from their peers.

There are many causes of slow growth. Some are temporary and merely variations of normal growth patterns, and others are inherited or associated with other physical problems. These require evaluation by a doctor who can differentiate among various types of growth problems. A rule of thumb for parents who suspect a growth problem in their child is that any child who grows less than 2 inches a year after their second birthday should be seen by a physician. One of the most important things a parent can do to safeguard a

SUMMARY

child's growth and general health is to have the child examined and measured regularly by a pediatrician, family doctor, or other qualified health care provider.

Many of the conditions associated with short stature or abnormal growth can be treated. Researchers are working on developing better methods of diagnosing and treating many types of growth problems. Even though no treatment exists for some of these conditions, there are many ways a child and family may benefit from thorough evaluation of the situation. Doctors, nurses, psychologists, social workers and other professionals can work together to assist children with growth problems and their families in setting and attaining appropriate physical, emotional and educational goals. More information about the psychological and social aspects of growth problems is available in the HGF booklet called "Short & OK."

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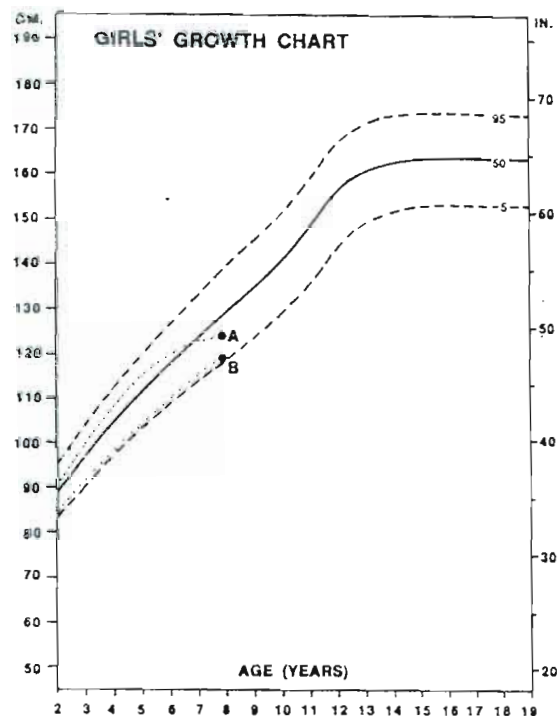
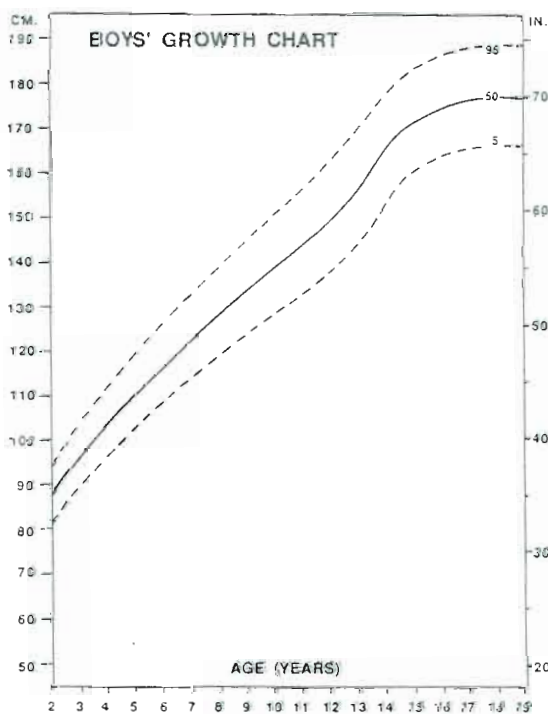
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Growth charts are used to compare a child's height and growth rate with those of other children the same age and sex. A line connecting several height measurements should fall along or parallel to one of the lines on the growth chart. On the girl's growth chart, Girl A is more likely to have a growth problem than Girl B because her growth rate has slowed over the past 2 years. Although Girl B is shorter than 95% of girls her age, she is growing at a steady, normal rate.

Let's discuss the process of normal growth before we talk about its variations and abnormalities. While we all start out about the same size at birth, some of us end up tall and some end up short. Most of us wind up with about the same build as our parents - the characteristics a child inherits will reflect those of the parents.

NORMAL GROWTH

A baby is about 20 inches long at birth (give or take an inch) and will grow another 10 inches over the first year to reach about 30 inches by 1 year of age. During the second year of life, growth is half this fast, so at 2 years of age, the child will be about 35 inches tall. From 2 years until about 12 years of age, the child will grow at a steady rate of 2 to 2½ inches a year. The growth spurt that goes along with adolescence begins at about age 11 in girls and 13 in boys. This pubertal growth spurt usually lasts 2 years and is accompanied by sexual development. Growth ceases between 16 and 18 years of age, when the growing ends of the bones fuse. A person's adult height is determined by many factors, including the heights of his or her parents, the age at which puberty begins and the length and vigor of the pubertal growth spurt. An x-ray of the hand or knee allows the doctor to assess the maturity of the bones (bone age) and estimate how much growth potential remains.



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Normal But Unusual Growth Patterns

Variations from the usual pattern of growth may occur and still be within the range of normal. Some children are taller than expected at a given age, and some are shorter. Parents are more often concerned when their children are shorter than their age-mates than when they are taller, although most short children fall within the normal range of height.

Many children are short because they have inherited shortness from their parents. Even though the American population is taller than in previous generations, there will always be healthy individuals whose height will be in the low part of the normal range. This is called **familial short stature**.

A common variant of the usual growth pattern occurs when a child is shorter than average for most of his or her life, then is late entering puberty. This condition is called **constitutional growth delay with delayed adolescence or delayed maturation**. More boys than girls seek medical attention for this condition, although it is not known whether it is really more common in boys. These children generally are the shortest among their age-mates. A 10-year-old

Four 14-year old boys who illustrate the wide range of normal growth and pubertal development at this age. The boy in the white shirt has constitutional growth delay with delayed adolescence.



child with this condition may be about the size of a 7-year-old; their bone age and growth potential will also be more like that of a 7-year-old. Typical children with constitutional growth delay have been behind their age-mates in height since very early in childhood, but have continued to grow at a slow normal rate. They will enter puberty 2, 3 or even 4 years later than other children their age, but will have a normal growth spurt and end up about as tall as their parents. It is not unusual for this type of growth pattern to run in families - often a father remembers that he didn't have his growth spurt or begin shaving until much later than other boys his age or a mother remembers being late starting her periods.

This type of growth delay may create stress for a child. Nature's timetable can be speeded up by giving a low dose of sex hormone (testosterone or estrogen), although there is a small risk that this will speed up closure of the growth plates, resulting in a slightly shorter adult height. Studies are being done to determine the physical and psychological effects of growth hormone treatment in children with severe constitutional growth delay; the results of these studies are not yet known.

A second type of normal, but unusual, growth pattern is that of the



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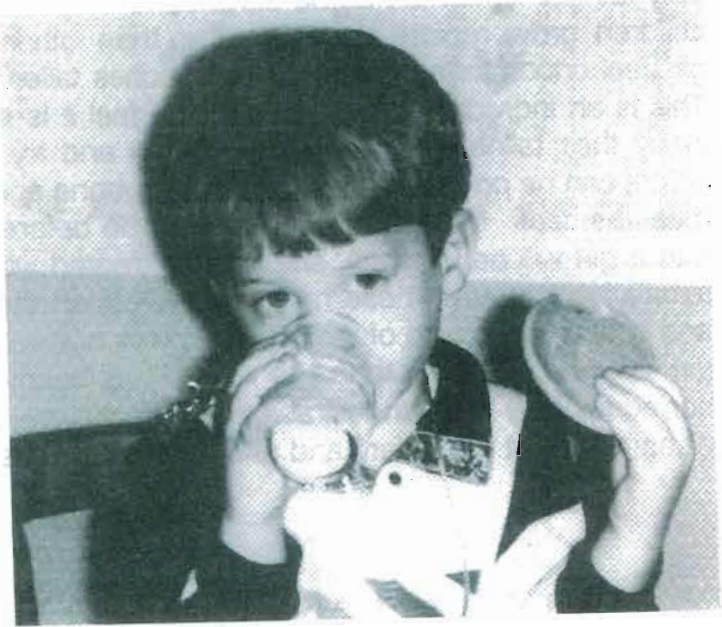
very tall girl. It comes as no surprise to very tall parents that their children grow rapidly and are taller than other children. Some girls feel uncomfortable being 5 or 6 inches taller than their friends. This is an individual matter; some girls feel it is an advantage and enjoy their tallness, while others slouch and try to hide it. Adult height can be predicted on the basis of a bone age x-ray and height measurement. If a height prediction made before age 12 indicates that a girl will be very tall, she can be treated with a high dose of female hormones. These hormones will push the girl into puberty and speed up closure of the growth plates of the bones, so that the girl will end up shorter than she would have been otherwise. These hormones may have undesirable side effects, however, and doctors disagree about the safety and effectiveness of this treatment.

Poor Nutrition and Systemic Diseases

There are many diseases and disorders that can cause short stature and growth failure. Nutritional deficiencies will cause poor growth eventually - a balanced diet with adequate calories and protein is

ABNORMAL GROWTH PATTERNS

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essential for growth. There are a number of intestinal disorders which may lead to poor absorption of food. Failure to absorb nutrients and energy from food then leads to growth failure. Children with these conditions may have complaints that involve the stomach or intestines (bowels) and may have bowel movements that are unusual in pattern, appearance and odor. Treatment of these conditions often involves a special diet. Normal growth usually resumes after the condition has been treated.

Diseases of the kidneys, lungs and heart may lead to growth failure as a result of inadequate intake of nutrients or buildup of waste products and undesirable substances in the body. Children with diabetes, or "high sugar," may grow slowly, particularly when their blood sugar is not kept near the normal range.

Any disease that is severe, untreated or poorly controlled can have an adverse effect on growth. Severe stress or emotional trauma can also cause growth failure.



Most children with skeletal dysplasias (abnormal bone growth) are very short and have abnormal body proportions, but otherwise are just like other children.



Bone Disorders

One form of extreme short stature is caused by abnormal formation and growth of cartilage and bone. Children with a **skeletal dysplasia**, or chondrodystrophy, are short and have abnormal body proportions; intelligence is normal. Some chondrodystrophies are inherited, others are not. The underlying causes of most of these skeletal dysplasias are not known, although researchers are working to identify the genetic and biochemical mechanisms that are involved. The chances of parents having a second child with the same problem cannot be estimated until the specific type of skeletal dysplasia is identified from physical examination and bone x-rays. The HGF booklet, "Achondroplasia," provides more information about a common form of this group of bone disorders.

Children who will be very short as adults and adults with short stature may benefit from social contact with others having similar growth problems and with short adults who are living full and happy lives. The Little People of America is an organization that provides opportunities for such contact. More information can be obtained by writing to LPA, P.O. Box 9897, Washington, DC 20016.



Some children with IUGR grow normally after they are born; others do not.

The Human Growth Foundation is a national organization of parents of children with growth problems and other interested persons. Chapters of HGF are located in major cities across the nation. The members of HGF help to:

- educate the public about growth problems
- refer children with growth problems for evaluation
- provide information about growth problems to affected families
- provide guidance for the physical, psychological and social development of children with growth problems
- teach short children to cope with living in a bigger world
- sponsor research on growth
- raise funds for these activities

You can obtain more information about HGF activities from your local chapter or the National office by writing: Human Growth Foundation, 997 Glen Cove Avenue, Glen Head, N.Y. 11545, 1-800-451-6434. You can help your child and the thousands of children with growth problems by participating in the activities of HGF.



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997 Glen Cove Avenue • Glen Head, New York 11545

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email: hgf1@hgfound.org • web site: www.hgfound.org

Contributions to the Human Growth Foundation are tax deductible.

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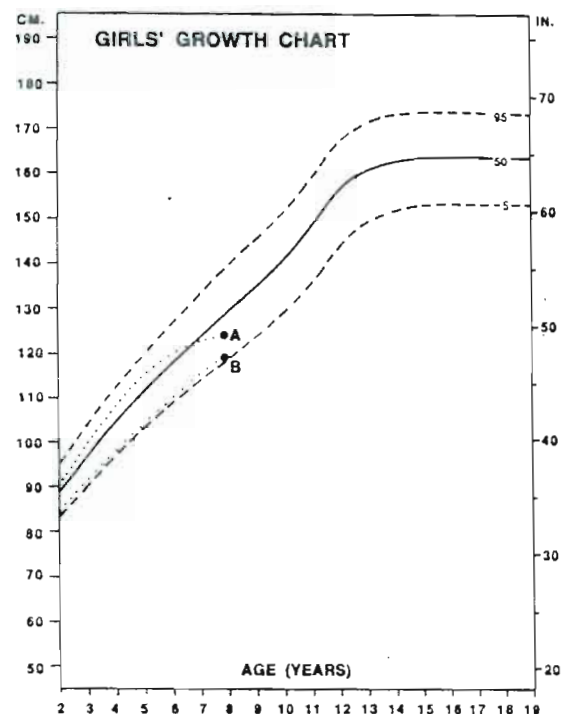
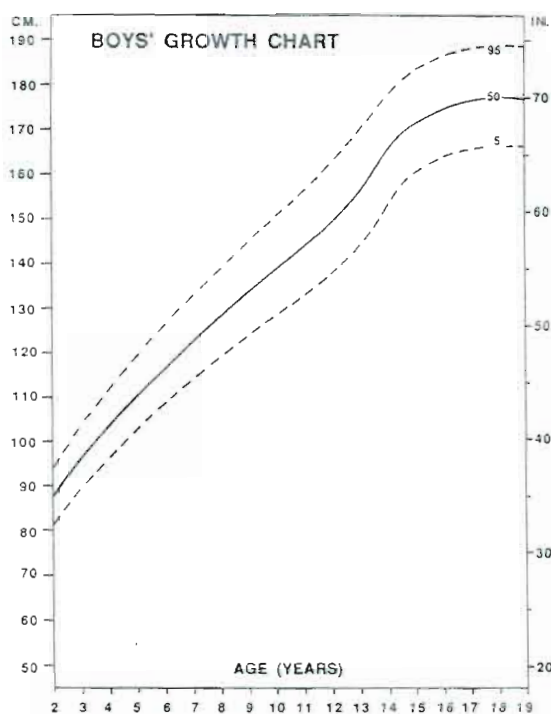
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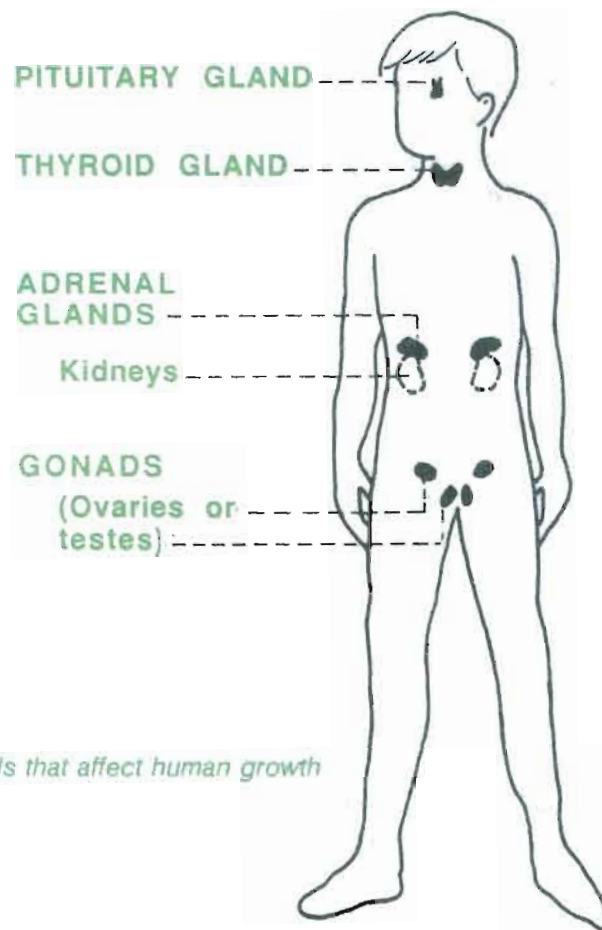
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test (karyotype) to look for damaged or missing sex chromosomes. Replacement of the missing ovarian hormones enables these girls to develop normal female sexual characteristics. Treatment with biosynthetic growth hormone appears to be effective in increasing adult height in many of these young women, although long-term studies are still underway. The HGF booklet, "Turner Syndrome," supplies more information about this condition.

Precocious Puberty

One type of unusual growth pattern is caused by the early onset of adolescence. This pattern occurs more frequently in girls than boys. The term **sexual precocity** is used to describe this condition, which includes early development of adult sexual characteristics. Children with sexual precocity grow rapidly and are tall for their age initially, but their bones also mature rapidly, so they stop growing at an early age and may be short as adults. A recently developed synthetic hormone (LHRH) is useful in halting this type of early sexual development and allowing additional growth. Studies are underway to determine if the addition of growth hormone to this regimen



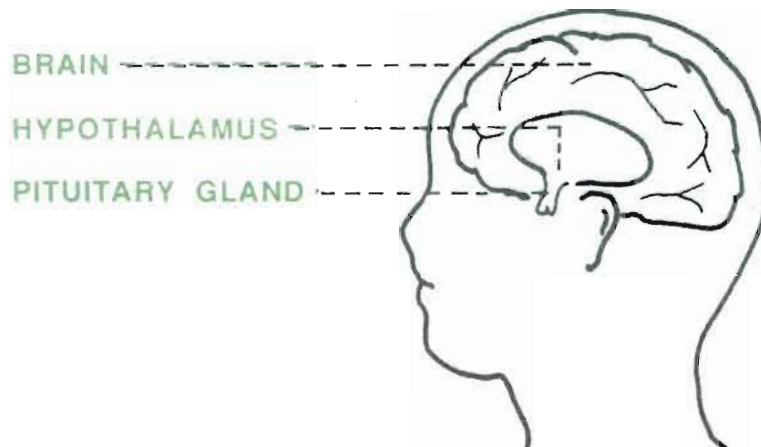
Location of various glands that affect human growth

increases adult height of children with sexual precocity.

Sometimes a tumor or disease of the ovaries, adrenal glands, pituitary gland or brain will cause premature sexual development. In these cases, removal of the tumor or treatment of the disease may interrupt the rapid sexual development and result in increased adult height.

Thyroid Hormone Deficiency

Hormone deficiencies may cause growth failure in addition to other problems. A child with thyroid hormone deficiency has slow growth and is physically and mentally sluggish. **Hypothyroidism**, or lack of thyroid hormone, may be present at birth or develop anytime during childhood or later in life. It is very important to treat hypothyroidism promptly, especially if it occurs during the rapid growth period of infancy. Untreated hypothyroidism during this time can cause permanent damage to sensitive, rapidly growing brain cells. Thyroid hormone deficiency is easy to diagnose with a simple blood test and easy to treat with a daily pill that replaces the missing thyroid



Location of the hypothalamus and pituitary gland

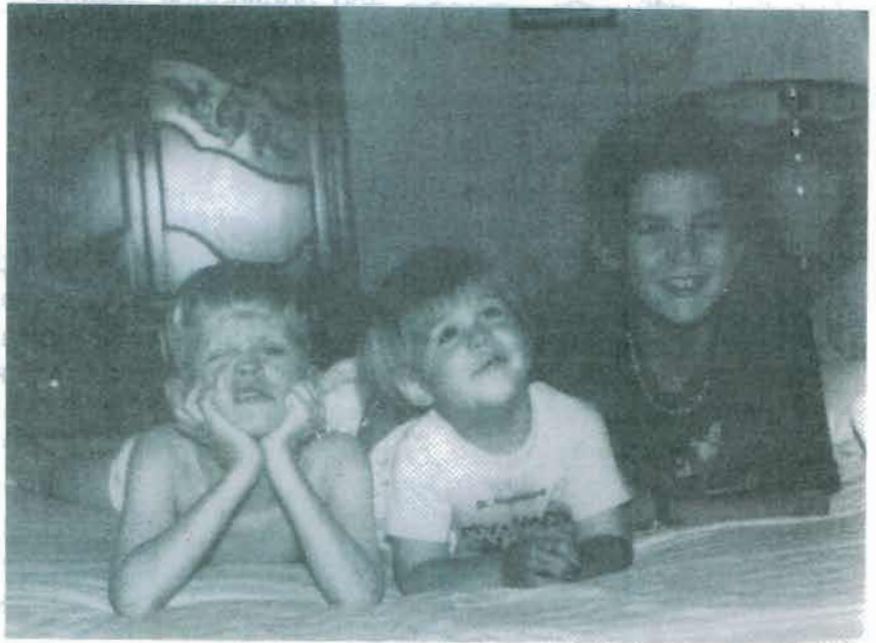
hormone. With early diagnosis and continuous treatment, these children grow and develop normally.

Growth Hormone Deficiency

Although many hormones work together to stimulate normal growth, growth hormone is one of the most important. It is produced by a bean-sized gland called the pituitary, which is located beneath a special part of the brain (hypothalamus) in the middle of the skull. The pituitary gland makes other hormones that stimulate other glands, so it is sometimes called the master gland. Pituitary abnormalities can cause a number of problems that result in poor growth: hypothyroidism, discussed earlier, may result from a pituitary malfunction, as may hypercortisolism (excess stress hormone). Growth hormone deficiency may result from abnormal formation of the pituitary gland or hypothalamus, or damage to one of these areas occurring during or after birth.

Children with growth hormone deficiency grow slowly, but have normal body proportions. Without treatment, few would reach 5 feet

Children with growth problems who receive proper care can lead happy, healthy lives.



in height as adults. A variety of tests may be necessary to diagnose this condition. A child with growth hormone deficiency also may be missing other pituitary hormones, (thyroid, adrenal or stress hormones, sex hormones). All hormones must be present in the proper balance for normal growth to occur, so these hormones must be replaced if they are missing. Biosynthetic human growth hormone, produced by recombinant DNA technology, is available for the treatment of growth hormone deficiency. Children who are diagnosed promptly and respond well to treatment can expect to reach normal adult height. More information about this condition is presented in the HGF booklet, "Growth Hormone Deficiency."

Abnormal Tall Stature

Most tall children have tall parents and are healthy and normal, but there are some medical conditions that cause abnormal tall stature and rapid growth. A small tumor in the pituitary gland may cause too much growth hormone to be secreted, resulting in unusually fast growth and tall stature. Growth hormone excess (also called acromegaly) may be treated with medication or with surgical removal

of the tumor. Some genetic conditions cause abnormal tall stature; Marfan's syndrome and Klinefelter's syndrome are two examples. These syndromes are associated with distinctive physical traits in addition to tall stature. Precocious puberty, discussed earlier, results in tall stature during childhood, although early closure of the growth plates results in short adult height.

Tall children, like short children, may stand out from their classmates and experience stress and teasing because of their size. They often look older than they are, so adults may expect too much of them. It is important for parents and teachers to be aware of the stress these children may experience as a result of looking different from their peers.

There are many causes of slow growth. Some are temporary and merely variations of normal growth patterns, and others are inherited or associated with other physical problems. These require evaluation by a doctor who can differentiate among various types of growth problems. A rule of thumb for parents who suspect a growth problem in their child is that any child who grows less than 2 inches a year after their second birthday should be seen by a physician. One of the most important things a parent can do to safeguard a

SUMMARY

child's growth and general health is to have the child examined and measured regularly by a pediatrician, family doctor, or other qualified health care provider.

Many of the conditions associated with short stature or abnormal growth can be treated. Researchers are working on developing better methods of diagnosing and treating many types of growth problems. Even though no treatment exists for some of these conditions, there are many ways a child and family may benefit from thorough evaluation of the situation. Doctors, nurses, psychologists, social workers and other professionals can work together to assist children with growth problems and their families in setting and attaining appropriate physical, emotional and educational goals. More information about the psychological and social aspects of growth problems is available in the HGF booklet called "Short & OK."



The Human Growth Foundation is a national organization of parents of children with growth problems and other interested persons. Chapters of HGF are located in major cities across the nation. The members of HGF help to:

- educate the public about growth problems
- refer children with growth problems for evaluation
- provide information about growth problems to affected families
- provide guidance for the physical, psychological and social development of children with growth problems
- teach short children to cope with living in a bigger world
- sponsor research on growth
- raise funds for these activities

You can obtain more information about HGF activities from your local chapter or the National office by writing: Human Growth Foundation, 997 Glen Cove Avenue, Glen Head, N.Y. 11545, 1-800-451-6434. You can help your child and the thousands of children with growth problems by participating in the activities of HGF.



Human Growth Foundation

997 Glen Cove Avenue • Glen Head, New York 11545

1-516-671-4041 • 1-800-451-6434

email: hgf1@hgfound.org • web site: www.hgfound.org

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