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Adolescence in Indian Children

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Abstract

School-age child development describes the expected physical, emotional, and mental abilities of 6 to 9 and 9 to 14 years (grows 5 cm/yr until puberty-sexual development commences). By about 9 to 11 years in girls and 11 to 14 years in boys sexual development initiates physical growth-height gain is 27 cm to 29 cm in boys & 24 cm to 26 cm in girls; weight gain in both remains 25 kg to 30 kg. The affluent Indian children had puberty changes closure to European, American children. Children in a rural cohort showed that for their growth during adolescence to maintain their vital functions amino-acids from body muscles were mobilized, as demonstrated by increased serum enzyme activities i.e. LDH, ALP, AST, ALT, CK, CK-MB and CK-mm. The 31- phosphorus magnetic resonance spectroscopy showed that b-ATP and Pi were significantly increased at the cost of Pcr (Phosphocreatinine). These changes simulate myopathic status. In assessment of their adolescent growth spurt height gain was similar to affluent Indian children. However, deficit of early life in height was not corrected. No age period could be identified for peak height velocity. The weight gain was 38%, only as compared to the affluent Indian children. In sexual development boys had delayed maturation of: Genitals by 1.54 yr; Pubic hair by 0.82 yr and axilla hair by 0.65 yr. However, testicular volume was comparable. In girls breast development was delayed. These rural girls had delayed breast development and menarche by 2.19 yr. and 0.82 yr, respectively as compared to affluent Indian girls. These undernourished children had lower mental abilities, persistence of soft neurological signs (poor fine motor coordination), reduced frontal lobe size on MRI. In these children the reaction time did not improve even after nutritional rehabilitation. In addition Iron deficiency irreversibly altered neurotransmitters.

Keywords: Adolescence; Growth; Sexual development; Menarche; Brain; Soft neurological signs; Neurotransmitters; Brain MRI; Malnutrition; Iron deficiency

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Introduction

Growth is a continuous process commencing at conception and progressing at a varying pace till its completion about 2 decades later. The process of "growth" is accompanied with increase in body size and/or mass at varying rates. It is complex, still remarkably predictable. Boys and girls grow differently and each child has his or her distinct growth pattern. The distance growth curve (measurement for age) is a measure of size over time; it records height, weight, and brain size (skull circumference) as a function of age and gets higher with age. School-age child development describes the expected physical, emotional, and mental abilities of children ages 6 to 12 years. By about 9 to 11 yr in girls and 11 to 14 yr in boys sexual development initiates (Figure 1) [1-4]. There will be big differences in height, weight, and build among children of this age range. It is important to remember that genetic background, as well as nutrition and exercise, may influence their growth. The sedentary habits in school-age children are linked to a risk for obesity and heart disease in adulthood. Obese children initiate adolescence early. It is recommended that children in this age group should get 1 h of physical activity per day.

For Parents

Encourage children to express themselves openly and talk about concerns without fear of punishment. Children today are exposed, through the media and their peers, to many issues dealing with violence, sexuality, and smoking, chewing tobacco, and drinking alcohol. Discuss these issues openly with your children to share concerns or correct misconceptions.

- School-age children should participate in family chores such as setting the table and cleaning up.
- Limit screen time (television, smart phone and other media) to maximum 1 h a day.

Discuss body changes with your child

Your child needs to understand the physical changes that will occur in her/his body during puberty. There are many opportunities during this time of life for you to talk to your child about what she's experiencing. You should emphasize that these changes including menarche, as part of the natural process of growing into adulthood. Keep track of your child's bodily changes, while fully respecting privacy. As the age ranges above indicate, there are wide variations of "normal" in the time when puberty begins. Remind your child that while her friends will grow at different rates, they will eventually catch up with one another and have the same sequence of growth and sexual development.

Child as adolescent (puberty)

Adrenarche: Adrenarche (a process related to puberty, the adrenal cortex secretes increased levels of androgens such as DHEA (Dehydroepiandrosterone) and DHEAS (Dehydroepiandrosterone Sulphate), but without increased cortisol levels). The principal physical consequences of adrenarche are androgen effects, especially: i) pubic hair, ii) change of sweat composition that produces adult body odor, and the iii) increased oiliness of the skin and hair and mild acne may occur. In most boys, these changes are indistinguishable from early testicular testosterone effects occurring at the beginning of gonad puberty. In girls, the adrenal androgens of adrenarche produce most of the early androgenic changes of puberty: pubic hair, body odor, skin oiliness, and acne. Children born small for Gestational Age (SGA) because of Intrauterine Growth Restriction (IUGR) have an earlier onset of adrenarche and it also occurs prematurely in many children who are overweight/obese.

Adolescence: In 2009, 1.2 billion population was estimated as Adolescents in (10 to 19 years of age), being 18% of the world population. Of these 88% lived in developing countries, India held 21% population as adolescents. Today, adolescents stand at the crossroads between childhood and the adult world. Around 243 million of them live in India (2019). In development each teenager (adolescent) is an individual with a unique personality and special interests likes and dislikes. In general, there are series of developmental tasks that everyone faces during the adolescent years. Pubescent children are those in whom secondary sexual characters and early genital changes are appearing. The WHO defines adolescent children as individuals in the age group of 10 to 19 years. The various physiological changes set with: a) Adolescent growth spurt, after hypothalamic –pituitary-gonadal maturation and function: In response to Gonadotrophin Releasing Hormone (GnRH) stimulation, pituitary releases Luteinizing Hormone (LH) and Follicle-Stimulating Hormone (FSH). In males, LH stimulates testosterone production, while FSH causes maturation of sperms. In females, both LH and FSH are required for production of estradiol while FSH is also required for ovulation. b) Change in body composition (muscle/fat) and c) Skeletal maturity. The time of onset and the rate of sexual development have individual variability but the sequence of events remains the same. From a biological perspective, puberty is the stage of physical and sexual maturation in which, an individual becomes physiologically capable of sexual reproduction. Adolescents are in biological age of development an unidentified status, with the increased: a) decision making, b) pressures and c) search for self. The biological changes are: physical growth, development of the sex glands and their endocrine as well as exocrine secretions. It is essentially the activation of the hypothalamic-pituitary-gonad axis that induces and enhances the progressive ovarian and testicular sex hormone secretion that are responsible for the profound biological, morphological and psychological changes to which the adolescent is subjected [2-6].

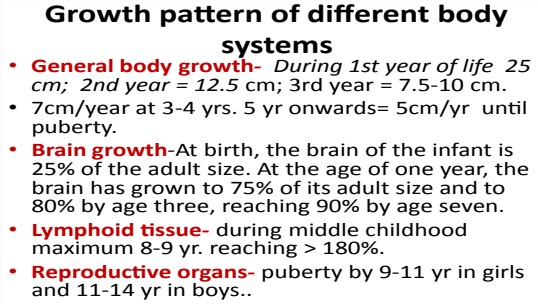


Figure 1: Physical development.

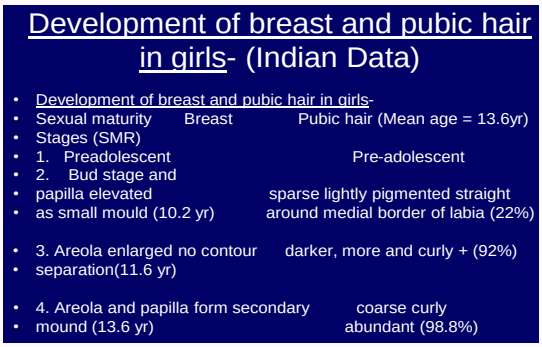


Figure 2: Development of Breast and pubic hair in girls.

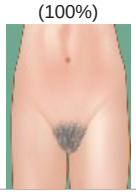
Initiation of puberty

Both primary and secondary sexual characteristics appear between 8 and 14 years of age in girls and 9 and 15 years of age in boys.

Girls: Breast enlargement, occasionally initially unilateral, is the first obvious sign of puberty, occurs between 10 to 11 years of age. Assessment stages in girls as breast development 'Sexual maturity ratings of Tanner 2 to 5 (B 2-5) are: Before Puberty (B1), Breast bud (B2- Breast development starts (Thelarche) and Breast stages- 3, 4 and 5 (Figure 2). Mean ages for SMR-5 could not be differentiated. After a year or so of puberty beginning, and for the next couple of years:

- Girls' breasts continue to grow and become fuller.
- Around 2 years after beginning puberty, girls usually have their first period (Menarche).
- Pubic hair become coarser and curlier, underarm hair begins to grow-some girls also have hair in other parts of their body, such as their top lip, and this is completely normal.
- Girls start to sweat more; girls often get acne (a skin condition that shows up as different types of spots, including whiteheads, blackheads and pus-filled spots called pustules).
- Girls have a white vaginal discharge; girls go through a growth spurt.
- From the time their periods start, girls grow 5 cm to 7.5 cm (2 to 3 inches) annually over the next year or two, and then reach their adult height.
- Most girls gain weight (which is normal) as their body

Table 1: Stages of normal puberty (Tanner stages) in girls for breast, pubic hair and in relation to the peak height velocity [4].

Tanner stage	Breasts	Pubic hair (mean age = 13.6 years)	Growth	Other features	Undernourished rural girls
Stage 1 (B-1)	Prepubertal: elevation of papilla only	Prepubertal villus hair only	Basal level: 5–6 cm/ year	Adrenarche: ovaries grow and enlarge	Height was lower by 15.3 cm versus affluent girl
Stage 2 (B-2)	Breast bud appears under an enlarged areola. Milk ducts begin to grow (mean age 10.2 years)	Sparse hair along labia (in 22%)	Accelerated growth: about 7 to 8 cm/year	Clitoral enlargement with labial pigmentation, uterine enlargement, increase in vaginal length, menarche attained in 10%	Breast development delayed by 2.2 years
Stage 3 (B-3)	Breast tissue grows beyond areola but without contour separation. The areola begins to darken in color. The milk ducts give rise to milk glands that also begin to grow (mean 11.6 years)age	Hair coarser and pigmented: spreads across pubes (becoming thicker, curly and darker in 92%)	Peak velocity: about 8 cm/ year	Axillary hair present in majority acne in majority menarche attained in 20%, (total 30%)	Peak height velocity not observed Height gain similar 24 cm to 26 cm; early life deficit not corrected
Stage 4 (B-4)	Projection of areola: papilla forms a secondary mound (mean age 13.6 years)	Adult pattern but without spread to medial thigh, growing faster and already forming sexual pubic triangle (in 98.8%)	Deceleration: less than 7 cm/year	Menarche: mean age = 12.6 years. Regular periods (around 14 years) menarche attained in total = 90%	Menarche delayed by 0.82 years
Stage 5 (B-5)	Adult breast contour with projection of nipple only (mean age 14.5 years)	Adult triangle is already developed. Hair are thick and often curly with spread to medial thigh but not up linea alba (100%) 	Cessation of growth at around 16 years	Adult genitalia menarche in all girls	Total period of growth in puberty shortened

shape changes girls develop more body fat along their upper arms, thighs and upper back; their hips grow rounder and their waist gets narrower.

Boys: Testicular volume increases from 2.0 ml to more than 4.0 ml or testes length from 2.0 cm to 3.2 cm between 12 to 13 years of age; 1 year later penile and scrotal enlargements occur.

Figure 3 Male External Genitalia Scale. Stage 1: Preadolescent-Testicular volume <4 ml or long axis <2.5 cm. Stage 2 (Enlargement change in texture): 4 ml to 8 ml volume (or 2.5 cm to 3.3 cm long), 1st pubertal sign in males Stage 3 (Growth in length and circumference of penis): 9 ml to 12 ml (or 3.4 cm to 4.0 cm long) Stage 4 (Further development of glands penis, darkening of scrotal skin) 15 ml to 20 ml (or 4.1 to 4.5 cm long) Stage 5 (Adult genitalia): >20 ml (or >4.5 cm long).

After a year or so of puberty starting, and for the next couple of years: The penis and testicles grow and the scrotum gradually becomes darker. There are no average length figures for teenagers because people grow at different rates. Most men's penises are somewhere around 9 cm (3.75 in) long when not erect, but it's normal for them to be shorter or longer than this. Some things can make your penis temporarily smaller, such as swimming or being cold. Research has found the average erect penis size varies from around 13 cm to 18 cm (5 in to 7 in). You cannot make your penis larger or smaller with exercises or medication. Pubic hair becomes thicker and curlier, underarm hair starts to grow, boys start to sweat more. Breasts can swell slightly temporarily and boys may have "wet dreams" (involuntary ejaculations of semen as they sleep). Wu et al. [7] in 1,168 American girls of 8 to 16 yr age found SMR-B2 (Budding of breast) in Afro-American at 9.5 yr and in Whites at 10.3 yr of mean age with pubic hair appearance at 9.5 yr and 10.6 yr, respectively. They had menarche at 12.2 yr and 12.6 yr, respectively. The Indian affluent 1,291 girls age 8 to 17 yr had B2 at 10.2 yr; menarche at 12.6 yr, and 22% had pubic hair at B2 [4]. Herman Giddens et al. [8] in 2114 American boys of 8 to 19 yr age SMR-2 was observed in Afro-American at 9.5 yr and in Whites at 10.1 yr, while pubic hair appeared at 11.2 yr and 12.0 yr, respectively. The corresponding values for Indian affluent boys 1,779 were 11.3 yr and pubic hair in 52.3% [4].

Growth spurt: Both primary and secondary sexual characteristics appear between 8 and 14 years of age in girls and 9 and 15 years of age in boys. Sexual development and physical growth period extends for 4 years in girls and 6 years in boys (longer by 2 years in boys) to cross "sexual maturity stages" 2 to 5. Height gain is 27 cm to 29 cm in boys & 24 cm to 26 cm in girls; Weight gain in both 25 kg to 30 kg. This is the most rapid period of human growth, in the postnatal life (average weight gain being 19 g/day in boys & 16 g/day in girls). Normally this velocity is seen in infants around 3 month of age. Growth in this age begins distally with enlargement of:

1). Hands and Feet, followed by the Arms & Legs and finally by the Trunk and Chest. Growth begins in distal parts like feet and hands, which also stop growing first. It is followed by growth of arms, legs, trunk and chest. The growth of trunk changes upper segment/ lower segment (US/LS) ratio becomes 1.1 at 10 to 11 years, 0.98 to 1 at 13 to 14 years and 1 to 1.1 at completion of puberty.

2). Larynx, pharynx and lungs growth-Voice.

3). Androgens- a) Sebaceous glands- Acne, b) Optic globe-myopia and c) dental- jaw growth, loss of deciduous teeth eruption of permanent cuspids (canine), premolars, and finally molars.

Differences between Girls and Boys (To Revise)

For girls, the hormone that dominates development is an estrogen called estradiol, which rises earlier and reaches higher levels in women. It promotes growth of breasts and uterus, and is responsible for the pubertal growth spurt, epiphysis maturation and closure. Girls attain reproductive maturity about 4 years after the first physical changes of puberty appear. In contrast, boys accelerate more slowly but continue to grow for about 6 years after the first visible

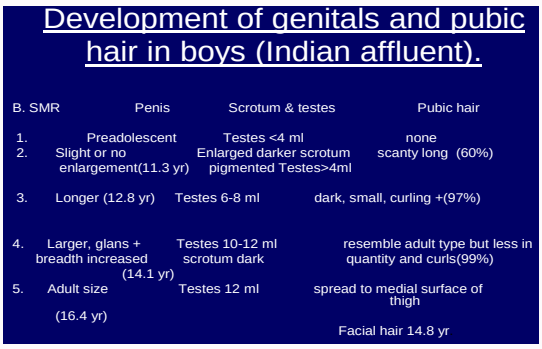


Figure 3: Development of genitals and pubic hair in boys.

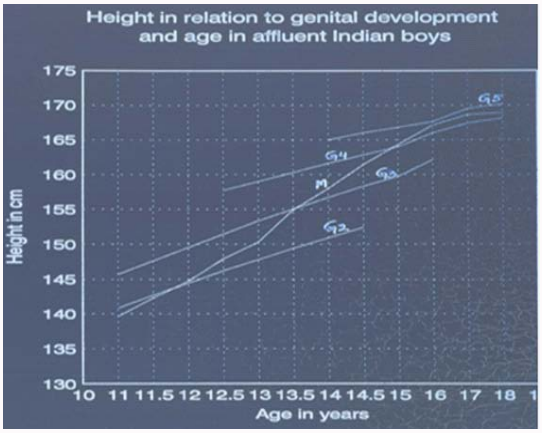


Figure 4: Show height means for age in relation to sexual maturity rating.

pubertal change (2 to 3 years extra) that is why they are finally taller.

For boys, testosterone is the principal sex hormone. It induces the characterization known as virilization. A substantial product of testosterone metabolism in males is estradiol, though levels rise later and more slowly than in girls. The male "growth spurt" also begins later, accelerates more slowly and lasts longer before the epiphysis fuse. Although boys are on average similar in height or 2 cm shorter than girls before puberty begins, adult men are on average about 13 cm taller than women. The growth spurt occurs later than in girls because testosterone is a poor stimulator to GH responsiveness than estradiol in girls. Testosterone is required in relatively higher concentration to produce the same growth effect.

Normal puberty in girls

First sign of ovarian estradiol secretion is breast development "Thelarche" [breast budding, B-2 or Tanner's Sexual Maturity Rating (SMR)-2 with "growth in height". Estradiol being a good stimulator of "growth hormone" doubles the growth velocity. The maximum height velocity [peak height velocity (PHV) = 9 cm to 10 cm/year] coincides with B-3, following B2 in by 1 year. Thus the maximum gain in height is pre-menarche in SMR- stages –B-2 & B-3. Height velocity reduces at menarche; the growth in the post menarche period is limited as girls can gain 5 cm to 6 cm/yr in linear growth, for 1 to 2 yr only. Remember the first visible evidence of puberty in girls is a nickel-sized lump under one or both nipples. Breast buds, as these are called, typically occur around age nine or ten, although they may occur much earlier, or somewhat later. True breast buds are firm to the touch. The Growth starts now so parents, doctor; health care giver should look after nutrition, vitamins and calcium supplement, active exercise and help psychologically. Puberty in girls is associated with change in body shape like hip growth, increase in body fat from 16% to 28% and reduction in lean body mass from 80% to 72%. Estradiol is the main hormone in females influencing the pubertal development, i.e. breast and genitals, promotes uterine maturation and fat deposition in typical female contours, while androgens from adrenals and ovaries are responsible for pubic and axillary hair and the typical body odor and acne.

- Change in body shape
- Hair growth under arm followed by secretion
- Adult size breast

Menarche follows "Peak Height Velocity" by 14 to 18 months or usually occurs about 2 to 3 years after the start of breast development (Thelarche/B-2). The age of menarche is around 12 to 13 years (12.6 yr in Indian affluent girls). Girls experience menarche at different ages [4]. In a recent south Indian study (cross-sectional) on 536 healthy menstruating females aged 10 to 19 years: Mean age of menarche was 13 ± 1.1 years with wide variations, i.e., 10 to 17 years. 73.1% had cycle duration of 21 to 35 days. More than half of them reported 5 to 6 days' duration of menstrual blood flow and 12% of the participants had >7 days of flow. Long blood flow duration was more prevalent in early than in late adolescence. 30.1% reported abundant blood loss. 66.8% had dysmenorrheal periods [5]. Various estimates have placed it at 13 years. The average age of menarche is about 12.5 years in the USA, 12.72 years in Canada and 12.9 years in UK as genetic and environmental factors. Menstrual cycle- is the regular natural change that occurs in girl's reproductive system (especially the uterus and ovaries) that make pregnancy possible. The cycle is required for production of ovocytes, and to prepare uterus for pregnancy. Symptoms 1 to 2 weeks before menses- acne, tender breast, irritability, bloating, tiredness and mood change. In young girls period is around 21 to 45 days; adult 21 to 35 days (average 28 days) bleeding lasts 2 to 7 days. Menarche is the culmination of a series of physiological and anatomic processes of puberty:

- Attainment of a sufficient body mass (typically 17% body fat).
- Secretion of estrogens by the ovaries in response to pituitary hormones.
- Over an interval of about 2 to 3 years, oestrogen stimulates growth of the uterus (as well as height growth, breast growth, widening of the pelvis, and increased regional adipose tissue).

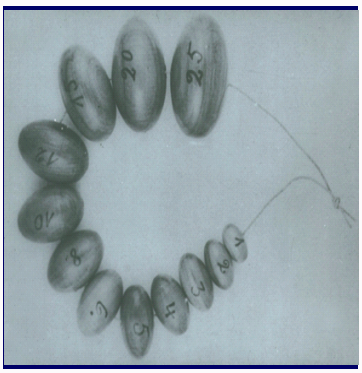


Figure 5: Showing Prader's Orchidometer.

Table 2: Genital development and growth in boys during puberty (the values in parenthesis are for Indian boys [4] see also Figure 3.

Tanner stage	Genitalia	Pubic hair	Growth	Other	Undernourished rural boy
Stage 1 G-1	Prepubertal: testes less than 2.5 cm or less than 2-0 mL	Villus hair only	Basal height velocity 5 cm-6 cm/ year	Adrenarche	Height at 13 years was short by 13.6 cm versus affluent Indian boy
Stage 2 G-2	Thinning and reddening of scrotal skin (mean age 11.3 years). Testes 2.5 cm to 3.2 cm or 4 mL	Sparse growth at base of penis (60%)	As above	Total body fat 16% -18%	
Stage 3 G-3	Growth of penis (mean age 12.8 years). Testes 3.3 cm -4.0 cm or 6 mL-8 mL	Thicker hair: spreads to mons pubis (97%)	Accelerated growth: 7 cm to 8 cm/year	Gynecomastia voice break increase in muscle mass	Genital development delayed by 1.54 years
Stage 4 G-4	Growth of penis and glans with darkening of scrotum (mean age 14.1 years) testes 4.1 cm to 4.5 cm or 10 mL to 12 mL	Adult but no spread to medial thigh (99%)	Peak velocity about 10.0 cm/ year	Axillary hair voice change acne	Delayed appearance: axillary hair by 0.65 year; pubic hair by 0.82 year no peak height velocity noted
Stage 5 G-5	Adult genitalia (mean age 16.4 years) Testes greater than 4.5 cm or 12 mL (adult volume 18 mL)	Adult with spread to medial thigh but not linea alba	Deceleration and cessation (about 17 years)	Facial hair (mean age 14.8 years) muscle mass increases further and beyond stage -5	Total weight gain only 38% as compared to affluent Indian boy

- Estrogen stimulates growth and vascularity of the endometrium, the lining of the uterus.
- Fluctuations of hormone levels can result in changes of adequacy of blood supply to parts of the endometrium.
- Death of some of the endometrial tissue from these hormone or blood supply fluctuations leads to deciduation, a sloughing off part of the lining with some blood flow from the vagina.

The menstruum, or flow, consists of a combination of fresh and clotted blood with endometrial tissue. The initial flow of menarche is usually brighter than mature menstrual flow. It is often scanty in amount and may be very brief, even a single instance of "spotting." Like other menses, menarche may be accompanied by abdominal cramping. In most girls, menarche does not mean that ovulation has occurred. In post menarche girls, about 80% of the cycles were anovulatory in the first year after menarche, 50% in the third and 10% in the sixth year. Regular ovulation is usually indicated by predictable and consistent intervals between menses, and consistent patterns of flow (e.g., heaviness or cramping). Continuing ovulation typically requires a body fat content of at least 22%.

Note: Menstruation is a phenomenon unique to girls. She is shedding the egg that can result in the conception of a new life in her womb. It is a sign of a mature woman capable of reproduction. In India many girls and women are subject to restrictions in their daily lives simply because they are menstruating. Not entering the "puja (worship)" room is the major restriction among urban girls whereas, not entering the kitchen is the main restriction among the rural girls during menstruation. During puberty girls should be examined for growth, sexual development, every 3 to 6 monthly, and provided- Multivitamins, iron, calcium for growth and appropriate immunizations (Table 1).

Puberty in boys -development of genitals and pubic hair

The first sign of puberty is testicular enlargement, which usually occurs between ages of 12 to 13 years. The pre-pubertal testis is about 2 ml in volume with puberty taken to begin when a volume of around 4 ml is attained (10 years of age) enlargement of seminiferous tubules, epididymis, seminal vesicles and prostate starts, this depends on increased FSH, it heralds onset of nocturnal pulsatile gonadotrophin at testicular volume of 4 ml. Rapid pubertal growth occurs once testes are more than 6 ml. Signs of growth in penis, scrotum (reddening and thinning) and pubic hair growth follow 1 to 2 years after testicular enlargement. A greater and later growth spurt occurs in boys and ultimately achieves an average 13 cm with greater height in adult men (Table 2). The growth spurt in boys is on an average 2 years later than girls. The anthropometric measurements during adolescence must be compared in relation to sexual maturity rating data for age [4]. See Figure 4 boy at 14 yr of age measures 150 cm in SMR G2, while in G4 he measures 162 cm. From 9 years in girls and 11 years in boys sexual assessment is important to assess physical growth and sexual development for the later child can be provided the Tanner's sexual maturity rating diagrams and he/she will simply write the STAGE [1-5]. For boys Prader's orchidometer will be of use to measure privately the testicular volume (Figure 5).

Muscle Growth

Body takes on a more muscular and angular shape because of testosterone in boys. This generally begins around age 12.5 years when testosterone causes muscle mass to increase. The greatest effect can usually be seen in the upper chest and shoulder muscles. Testosterone also causes bones to lengthen, giving young men a heavier bone structure and longer arms and legs. At the end of puberty, adult men have heavier bones and nearly twice as much skeletal muscle as compared to girls. Some of the bone growths (e.g. shoulder width and jaw) are disproportionately greater resulting in noticeably different male and female skeletal shapes. The average adult male has about 150% of the Lean Body Mass (LBM) of an average female, and about 50% of the body fat. Muscle growth can continue even after boys are biologically adult. The peak of the so-called "strength spurt", the rate of muscle growth, is attained about 1 year after a male experiences his peak growth rate.

Bone growth - completes in adolescence

Quantitatively important bone mineral accretion occurs - increase in bone density during SMR-2 to 4 (Cortical bone growth). Bone mineral density 50% completes during first month of life to puberty onset; 30% in puberty and 20% in late adolescence to adult. A 1 cm height gain needs Ca - 20 g; 30% gets absorbed (need 1300 mg/d Natl Acad. Sci. USA - 97-98; AJCN 2005; -p 175). Take 4 cups of milk/ day. DEFICIECY- results in fractures... **Face:** 25% of the total height of the mandible ramus occurs between 12 years and 20 years of age.

Eyes: Growth in axial diameters results in a tendency to "myopia" in adolescence. Parents should get the eyes checked if child complaining of headache, tiredness in reading or seeing the class blackboard.

Voice: Growth of larynx, pharynx and lungs leads to typical voice.

Sexual dimorphism

- Shoulder growth in boys and hip growth in girls.
- Both start puberty with similar fat (16%) and lean body mass (80%) content. Girls finally have 27% fat and boys 18%, from 16%.
- In boys gain in lean body mass is twice than the girls. But girls reduce "Lean Body Mass" from 80% to 74%. These changes are due to sex hormones.
- Maintenance cost of lean body mass needs more energy. Thus boys have increased deposition of protein and minerals e.g. Fe/Ca/Zn. Sports- need oxygen & nutrition.

For comparison

1. Growth data - Somatic and Sexual growth data and the table prepared for ADOLESCENT children (2 to 4) are the best available sets on affluent Indian children.

2. Pondicherry 40 yr data-secular growth in 20 yr has plateaued [6]. Indians are shorter than Europeans.

Body odor and acne

Rising levels of androgen hormone can change the fatty acid composition of perspiration resulting in a more "adult" body odor. As in girls, another androgen effect is increased secretion of oil (sebum) from the skin and the resultant variable amounts of acne. Acne cannot be prevented or diminished easily, but it fully diminishes at the end of puberty.

Factors affecting puberty

The genetic factors account for half of the variation of pubertal timing; association of timing is strongest between mothers and daughters. The environment factors are clearly important as well; puberty gets delayed at higher altitudes and in undernourished children. It is advanced in obese children. We discussed child's transition thru adolescence; including the Indian affluent children. Let's think of over 80% adolescents in India who suffer from "hidden hunger", a form of under nutrition, and less than 10% of boys and girls consume fruits and eggs daily, according to a new UNICEF report released on Thursday. October 31, 2019. Almost all adolescents in India take unhealthy or poor diets leading to one or the other form of malnutrition in them, revealed a UNCIEF report released on Thursday in association with NITI Aayog. Over 50% of adolescents (about 63 million girls and 81 million boys) in the age group of 10 to 19 years in India are, short, thin, overweight or obese, the report said. It also said that over 80% of adolescents also suffer from 'hidden hunger', i.e. the deficiency of one or more micronutrients such as iron, folate, zinc, vitamin A, vitamin B12 and vitamin D. The studies on adolescents growing in endemic under nutrition will highlight altered physical growth, muscle function, sexual development and mental deficits like poor fine motor coordination. Puberty in Nutritional Deprivation (Indian rural children) Agarwal & Agarwal ICMR data 1982 to 92 children in "Endemic under nutrition"- A cohort of rural school children was followed for their growth and development in Varanasi. These "undernourished adolescents" to achieve growth maintained their vital functions by mobilizing amino-acids from body muscles as demonstrated by increased serum enzyme activities i.e. LDH, ALP, AST, ALT, CK, CK-MB and CK-mm [6,9]. A 31- phosphorus magnetic resonance spectroscopy showed that b-ATP and Pi were significantly increased at the cost of Pcr (Phosphocreatinine). These changes simulate myopathic status [9]. Height gain was similar to the affluent Indian children in adolescent growth spurt. Deficit of early life in height was not corrected.

- Weight gain was 38% of the affluent Indian child.
- No age period could be identified for peak height velocity.
- Boys had delayed maturation of: Genitals by 1.54 yr.
- Delayed appearance of Pubic hair by 0.82 yr and axillary hair by 0.65 yr.
- Testicular volume gain was similar.
- Girls had delayed breast development by 2.19 yr.
- Menarche was delayed by 0.82 yr.

Under/malnutrition affects brain

Intrauterine as well as nutrition deprivation in early childhood (brain growth period) affects brain functions i.e. deficit in higher mental abilities related to personal and current information, orientation, mental control, logical memory, attention span, visual reproductive and associative learning: Impairment in overall memory function in set formation and conditional learning [10-15].

Persistence of soft neurological signs in undernourished adolescents

Soft neurological signs observed in preschool years persisted affecting repetitive speed movements more with higher degree of overflow and dysrythmia, showing that chronic under nutrition affects brain function for finger coordination [16-18].

MRI and cognitive evoked potential studies

Endemic undernourished children showed that in-MRI and cognitive evoked potential studies.

Frontal lobes- Size was reduced & Asymmetry of anterior as well as posterior lobes was less pronounced. Thus supporting EEG abnormalities in frontal lobe.

P3 latency was normal, but the P2 and P3 amplitudes were higher suggesting neuronal compensation [19]. **Reaction Time** (RT) studies by Audio-visual Reaction Time apparatus and electromyography: - showed affects on perceptual abilities, information processing and analytical capabilities. On rehabilitation, those becoming normally nourished showed raised RT, due to early life under nutrition [20].

Malnutrition in animal model- Wheat and/or legume diets (form common staple diet in rural India) in rat model, such diets affect fetal brain growth without altering body size (Dissociation) an important finding as majority of our rural and poor population live on cereal and pulse diets. These rats also showed reduced brain proteins and partially reversible changes in neurotransmitters [21-24].

Deprived Children

Children who had been in an orphanage at any time in their lives had much smaller gray matter volume in the cortex of the brain and had smaller white matter volume than those who had never been in an orphanage. Even if children were placed in loving foster homes, the formerly institutionalized children's gray matter didn't catch up. White matter, however, seemed to be more resilient. As orphaned children placed in high-quality foster care had the same white matter volume as those who were never in an orphanage [25].

Iron and brain - In India rampant anemia in pregnancy/lactation necessitates understanding how it affects the growing brain. MRI-maps iron distribution in the brains of children and adolescents. The highest concentrations are found in: Globus pallidus, caudate nucleus, putamen and substantia nigra. Human brain iron-MRI studies in anemia, showed- In "Fe" deficiency (Ferritin <20 ng) *vs.* Thalassemia (Ferritin >1000 ng), "Fe" content in – Globus Pallidus, Caudate nucleus, and Dentate nucleus was similar in both the conditions [26].

Fetal latent iron deficiency in rats- brain neurotransmitters-showed irreversible reduction. Glutamate metabolism- GAD, GDH, GABA-T and their receptors-Binding of H3 Muscimol at pH 7.5 and 1mg protein/assay (GABA receptor) increased by 143%, but glutamate receptor binding decreased in the vesicular membranes of latent iron deficient rats by 63% [27]. Brain MRI Spectroscopy in "iron deficiency: There was an increase in creatinine and aspartate and reduction in choline concentration. Such changes are also observed in Huntington's chorea and Alzheimer's disease. Reduction of choline, in latent iron deficiency is a significant finding. Choline is synthesized in the brain in very small amounts; its uptake is Na^+ dependent, which requires oxygen [26,27].

Iron Builds a Better Brain R Williams Scientist 2012 Jan 9th. Teen Brain- diffusion tensor imaging-Myelin function - found a strong positive correlation between teen iron levels and myelin integrity. The simplest message is that the iron in your diet as a teenager is associated with better brain integrity when you grow up. When it comes to the growing brain, we're learning pretty definitively that the right level of iron is required for healthy neurotransmission, or the way the brain sends and receives "signals" from one area to another [28,29].

Iron is essential for myelination - the process by which the brain produces a fatty insulation around the nerves. The insulation helps speed transmission of electrical signals.

Based on studies of lab animals, we know iron has clear effects on the function of dopamine and probably serotonin, two brain chemicals that help send and receive signals (neurotransmitters) and have many roles in the brain. When iron deficiency anemia occurs in the young animal, important changes in both myelin and neurotransmitters persist to adulthood, despite iron therapy in infancy.

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