Thus, a six years old child has ~ 7 carpal centers, while the last carpal center (for pisiform) appears only at 12–13 years.

- *Bone age in early adolescence* is determined by X-ray of left elbow to see the centers for distal end of ulna and lesser trochanter, which appear at ~ 12 years of age. Fusion of capitulum with the shaft at elbow predicts onset of puberty within one year.
- *Bone age in late adolescence* is assessed on X-ray of left hip to see the center for ileac crest, which appears at ~ 16 years.

Commonly, either *Greulich-Pyle Atlas* or *Tanner-Whitehouse-2 individual bone method* is used for assessment of bone age.

Common abnormalities in skeletal maturation include:

Delayed bone age in: (a) prematurity (physiological), (b) nutritional deficiency, e.g. severe malnutrition, rickets, (c) endocrinal disorders, e.g. hypothyroidism, hypopituitarism and (d) genetic disorders, e.g. down syndrome, epiphyseal dysplasias, etc.

Advanced bone age is usually seen in endocrinal disorders, e.g. thyrotoxicosis, adrenal hyperplasia, precocious puberty, gigantism, pseudohypothyroidism. However, it may be advanced *only in affected bones* in rheumatoid arthritis and arteriovenous malformations.

2.3.4 BODY COMPOSITION

Although of little importance in assessment of growth, it is noteworthy to remember following changes in body composition with age:

a. *Decrease in total body water* from ~ 75% at birth to ~ 60% in adults, as well as its redistribution with gradual decrease in extracellular water and increase in intracellular water.
b. *Increase in skeletal muscle mass*, from ~ 25% at birth to ~45% in adults.
c. *Changes in adipose tissue mass*, which is higher in infancy and adolescence, i.e. ~ 25%, as compared to mid-childhood, i.e. ~ 20%.
d. *Changes in chemical composition* of lean body mass, due to accumulation of various minerals.
e. *Changes in visceral size,* which usually follow the changes in body size with some exceptions, e.g. postnatal regression of thymus.

2.4 GROWTH ASSESSMENT AND MONITORING

Growth assessment and monitoring is the essential part of child health surveillance, even in the absence of apparent abnormality. While *growth assessment* may be considered as one-point process, *growth monitoring* is more important and requires serial data, e.g. weight, to detect changes in growth parameters over a period of time.

Indications for growth assessment and monitoring are:

a. Routine pediatric examination*
b. Growth promotion
c. Identification of *at-risk* children
d. Early detection of causes of growth faltering
e. Pre-adoption assessment.

*Every child should be assessed for growth and development during all visit due to any cause as well as periodically, i.e. monthly in first year, alternate months in second year and every three months thereafter till at least five years of age.

Methodology: Growth assessment is a four-step process including:

a. Recording of appropriate growth parameter.
b. Comparing this value with reference norms.
c. Serial recording of assessed parameters on growth charts to assess growth velocity.
d. Interpretation and conveying the information to parents as well as suitable remedial action (*growth monitoring and promotion*).

Step I. Selection and recording of appropriate growth parameter depends on the purpose of assessment. Although previous text has discussed multitude of anthropometric parameters for growth, only three parameters are commonly used in practice—*weight*, *height* and *head circumference*.

Weight is the best indicator of acute growth insult, though it is of limited value for long-term growth assessment due to rapid fluctuations in health and disease. Height is a better indicator of long-term growth, as it is affected only after prolonged illnesses and remains abnormal for a long time after recovery. Recording of head circumference is essential in first 2–3 years of life as an indicator of brain growth.

Additional parameters are used in selected cases according to the purpose of assessment, e.g. to assess nutritional status (mid-arm circumference, skin fold thickness), to investigate short stature (body proportions, bone age), etc.

Step II. Comparing the child's anthropometric values with standard or reference norms: Anthropometric values of the child under assessment need to be compared with corresponding values in normal children of the same age for interpretation. These normal values are also referred as *reference norms*, when presented in tabular form and *reference curves* when presented in graphic form.

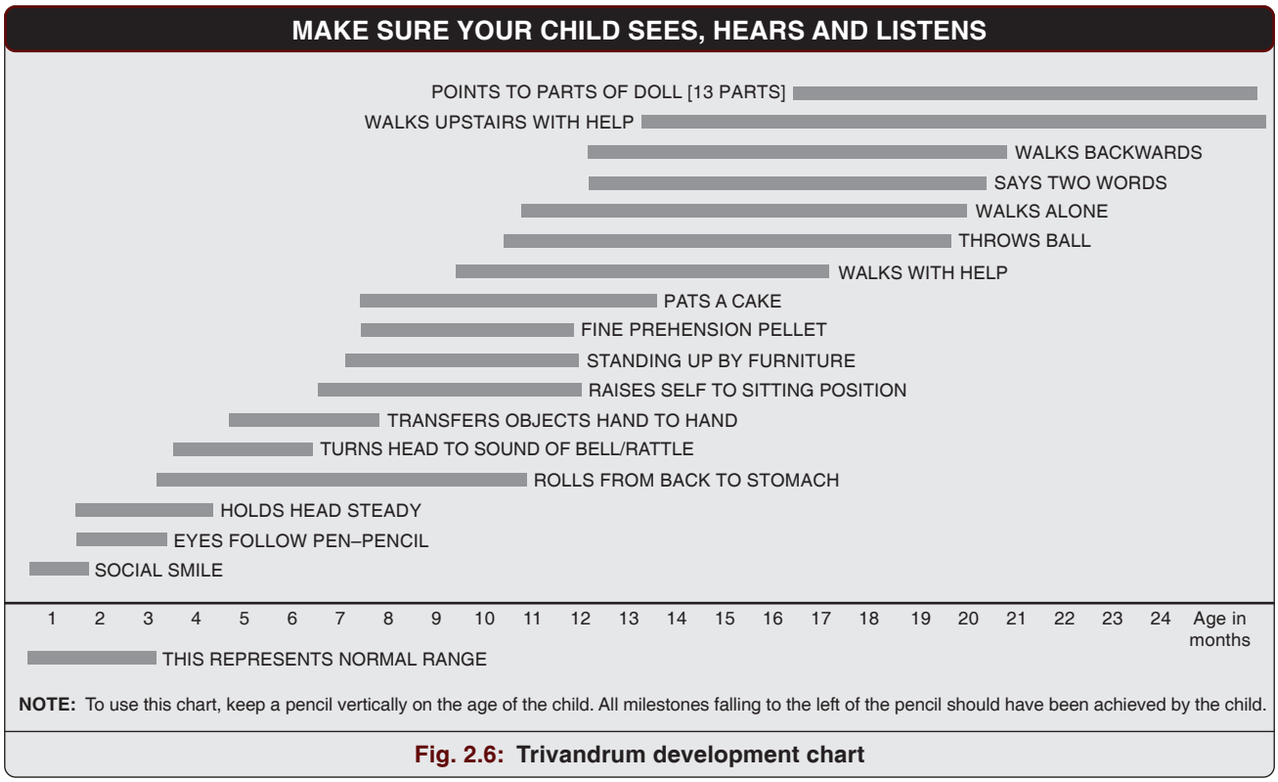

Fig. 2.6: Trivandrum development chart

Source : Indian Academy of Pediatrics, IAP Guidebook on Immunization, 2005-2006.

Wechsler intelligence scale for children (WISC), is the most commonly used intelligence test for children (6–16 years), that can be completed without reading or writing. Current WISC-V version takes ~ 48–65 minutes to administer and generates a full scale IQ that represents a child's general intellectual ability. It also provides five primary index scores (i.e. verbal comprehension index, visual spatial index, fluid reasoning index, working memory index and processing speed index) in more discrete cognitive domains. Many Indian adaptations for WISC, e.g. *Malin's* or *Mahindrika Bhat's tests* are available commercially for use in Indian children.

Once the developmental abnormality has been confirmed on formal evaluation, etiological diagnosis requires elaborate history, clinical examination and relevant investigations. Common developmental disabilities in children include cerebral palsy, mental retardation, learning disabilities, disorders of vision or hearing and behavioral disorders, discussed in later chapters.

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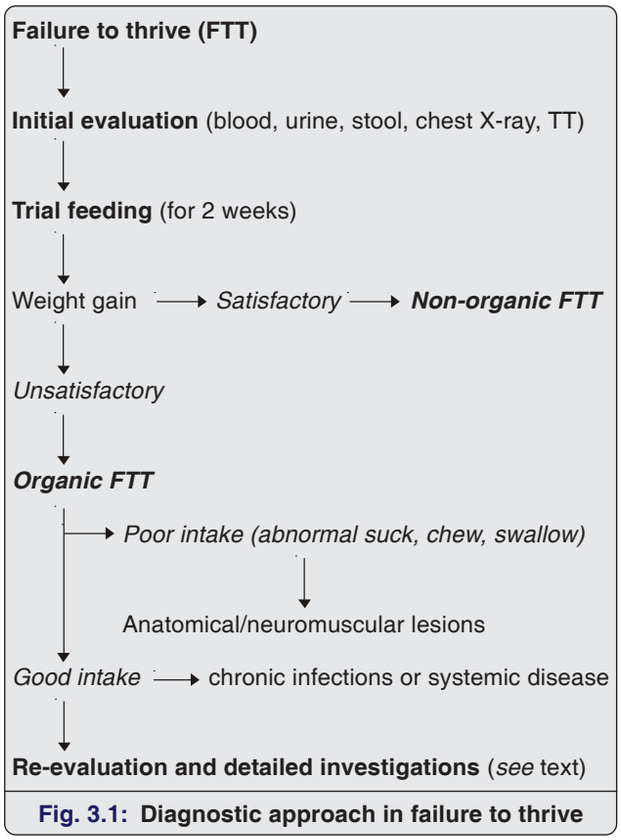

Fig. 3.1: Diagnostic approach in failure to thrive

neglect and developmental history. Available case records, e.g. growth charts should be reviewed to estimate the age of onset for FTT.

b. *Physical examination,* specially related to anthropometric values and signs of malnutrition, vitamin/mineral deficiencies, systemic infections/illnesses and abuse/neglect, etc.

c. *Baseline investigations* to exclude common causes, i.e.
- Complete hemogram for anemia, infections, etc.
- Urine analysis for UTI, chronic renal disease, etc.
- Stool analysis for malabsorption, worms, etc.
- X-ray chest and Tuberculin test for TB.
- Skeletal survey to assess bone age.

Step II. Trial feeding: Although many cases may be managed at home with nutritional counseling and periodic follow-up, hospitalization is indicated in cases with—(i) severe undernutrition with weight <60%, (ii) suspected child abuse/neglect, (iii) suspected organic disease, and (iv) doubtful dietary intake.

In hospital, all FTT cases should receive *trial feeding*, i.e. supervised, unlimited high caloric diet (150–200 cal/kg/day) for minimum 14 days, if necessary by naso-gastric tube, along with daily weight record. A weight gain of ~ 50 gm/day from 4–5th day onward and sustained for at least a week is considered as satisfactory, suggestive of non-organic etiology. Absence of satisfactory weight gain on trial feeding indicates organic FTT.

Step III. Re-evaluation with detailed investigations is indicated in non-responsive cases to trial feeding and include:
- *Biochemical investigations*, e.g. blood sugar, serum proteins, liver/renal function tests, screening tests for renal tubular acidosis/aminoaciduria.
- *Endocrinal studies*, e.g. thyroid function tests, growth hormone assays including somatomedin C levels, cortisol levels, etc.
- *Genetic studies* for inborn errors of metabolism, including molecular studies and enzyme assays in selected cases.

Management of FTT aims not only to nutritional rehabilitation but also to resumption of appropriate emotional environment and treatment of the underlying organic cause. A multi-disciplinary approach is necessary in most cases, including:

a. *Nutritional therapy* with increasing volume, frequency and caloric density of meals, avoidance of low-caloric foods and dietary supplementation.

b. *Psychological support* and modification of home environment.

c. *Treatment of underlying cause* and associated problems, e.g. vitamin deficiencies, anemia, etc. All children should be immunized to their age-appropriate level.

d. *Parental counseling* regarding correct nutritional and hygienic practices.

e. *Periodic growth monitoring and regular follow-up* after discharge, as FTT frequently recurs due to persistence of etiological factors.

Prognosis: Although initial catch-up growth is excellent in most of the adequately treated cases, it tends to slow-down over time and recurrence of FTT is not uncommon. Long-standing FTT in early life may lead to persistent development problems, e.g. cognitive, behavioral and language disorders, as >90% of brain growth completes in infancy.

3.2 OBESITY

Body fat content changes from high adiposity state in infancy to the lowest level at 5–6 years, followed by gradual increase till adolescence. Although frequently used interchangeably, the terms *overweight* and *obesity* have different connotations and all overweight children are not obese.

Obesity in children >2 years is defined as the body mass index (BMI)* ≥95th percentile while those with

Language is a function on which the speech is constructed. Normal development of speech requires: (a) normal hearing, (b) normal neurological functions to understand, process and formulate appropriate response, and (c) proper motor structures and neuromuscular coordination required for phonation. In addition, stimulative social and emotional environment is also essential for development of verbal skills and language.

Etiologically speech disorders may be due to:

a. *Disorders of receptive language*, e.g. hearing impairment, which is the commonest cause of speech defects in children.
b. *Disorders of central processing*, e.g. CNS disorders.
c. *Disorders of expressive language* due to orofacial or phonation problems (Table 3.15).

Clinically, speech disorders may be broadly classified as follows, though many patients have multiple defects.

a. ***Resonance disorders:*** Hyper/hyponasality.
b. ***Voice disorders***: Abnormal pitch/quality of voice.
c. ***Fluency disorders:*** Stuttering, stammering, etc.
d. ***Articulation disorders***, e.g. imprecise production of sounds. For example,
  – *Substitution*, i.e. replacement of one sound with another, e.g. height for light.
  – *Omission*, i.e. failure to produce some sounds, e.g. boo. for book.
  – *Distortion*, i.e. inappropriate sounds replacing the correct one.
e. ***Language disorders***, i.e. problems in formulation of proper language. For example,
  – *Telegraphic speech*, i.e. inability to form sentences.
  – *Word-finding disorders*, i.e. difficulty to name a picture or use of gestures to explain it.
  – *Narration disorders*, i.e. inability to describe an experience or tell a story.

Table 3.15: Causes of speech/language delay

- ***Hearing loss*** since birth or early infancy
- ***Central processing defects***
  - Mental retardation or learning disorders
  - Autistic spectrum disorders
  - Post-meningitic/encephalitic sequelae
- ***Phonation organ defects***
  - *Structural:* Cleft palate, adenoid hypertrophy
  - *Neuromuscular:* Cerebral palsy, bulbar palsy
  - *Breathing disorders:* Chronic lung diseases
- ***Environmental factors***
  - Speech problems in parents
  - Emotional deprivation
  - Bi-lingualism

Diagnosis: *Early warning signals* for speech problems in a baby include:

1. Does not babble by 6 months
2. Does not speak monosyllables by 9 months
3. Does not speak > 3 words by 18 months
4. Does not repeat 2-word phrases by 2 years
5. Excessive (jargon) speech beyond 2 years
6. Cannot speak simple sentences by 3 years
7. Stutters beyond 4 years
8. Any speech sound error beyond 7 years
9. Presence of pitch abnormalities at any age.

Management: Presence of speech defects need careful evaluation, intervention and follow-up, as many of them are easily manageable. Principles of management include:

- Correction of hearing impairment, etc.
- Speech and phonation therapy.
- Behavioral support and counseling.
- Training in alternate modes of expression, e.g. sign-language, etc.

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