Anatomy of Child

Introduction

Infants and children are not miniature adults. Body size proportions, muscle bone and ligament us strengths are different and thus occupant packaging for crash protection need special consideration. This paper is an overview of pediatric size and proportional differences with considerations of some child injuries in car crashes along with a review of some biomechanical data.

GROWTH OF THE INFANT BODY AS A WHOLE

Growth and development of the human body occurs continuously from birth through senescence (old age). Such development is sporadic and non-uniform, yet it does not occur haphazardly. For the most part, incremental growth of any dimension or part of the body occurs according to predictable trends. Most body dimensions follow trends which involve rapid growth separated by a period of relatively slower or uniform growth. There are notable differences in the timing of these incremental growth spurts, for most tissues and organs of the body collectively reflect the general body growth. As an example, the brain grows rapidly during the period before birth and then slows considerably during the per-school years. At birth the brain is typically 25% of its adult size, although the body weight of the newborn is only about 5% of adult weight . Importantly, about half of the postnatal growth of the brain volume occurs during the first year of life, and attains about 75% of its adult size by the end of the second year. By contrast, genital organs develop very slowly during this period but, instead, reach their adult size during the second decade of life.

Subcutaneous tissue (body fat) is a body component infrequently considered as a factor in the proper design of protective devices for the infant body. This tissue tends to increase rapidly in thickness during the first nine months following birth, which growth of the body as a whole is much slower. After this period of high incremental change there is a period of less rapid growth, so that by five years of age the thickness of the subcutaneous layer is about half the thickness of the nine month old infant.

Loading of the body by strap-type restraints must occur in areas where the body is strongest, i.e., on solid skeletal elements. In some, the fatty subcutaneous tissue can produce bulges or ‘rolls’ of flesh in the areas of placement on such restraint straps. Thus, proper positioning of restraint straps on the chubby 1–3 year old may be difficult to maintain because of the abundance of this fatty tissue.

Changes in body weight similarly follow characteristic age group trends. From the 10th day after birth, when the post-birth weight loss is usually regained, there is a steady increase in weight so that during the first three months an average baby gains about two pounds per month, or nearly one ounce per day. Changes in body height and body proportions also have specific age trends .The newborn child is approximately 20 inches in total body length. During the first year this height is increased by approximately ten inches. Until about the seventh year, total body length should be doubled by the 4th year and tripled by the 13th year. The height of an adult is about twice the height of a two-year-old child. From the second to the 14th year, total body height increases (in inches) according to the formula: Height=age in years × 2.5 + 30 .

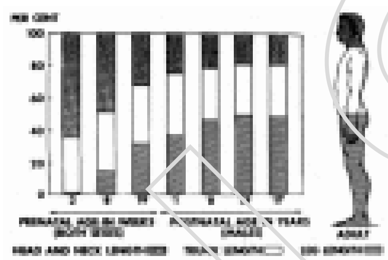

Fig. 1

Percentage distribution of body segments as related to pre- and postnatal development. (Modified from Salzmann, "Principles of Orthodontics.")

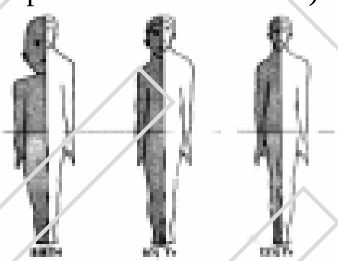

Fig. 3

Developmental change in body proportions as seen in direct comparison between the adult and the newborn, child and adolescent. (Modified from Chenoweth and Selrick, "School Health Problems.")

Age changes in the ratio between sitting (trunk) height and total body height cannot be overlooked when considering the dynamics of changing body proportions. (Fig. 4). Sitting height represents about 70% of the total height at birth, but falls rapidly to about 57% in the 3rd year. At 13-years of age in girls, and two years later in boys, the ratio of sitting height to total body height is about 50%.

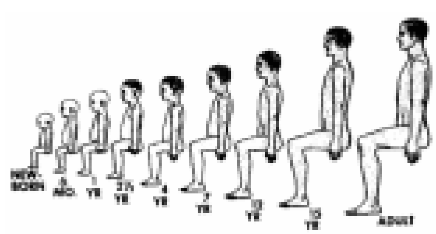

Fig 4

Changes in sitting height from birth to adulthood.

Longitudinal growth of limb bones occurs as long as the epiphyseal cartilage prolificates; growth ceases when the cartilage ossifies and fuses to the bone segments surrounding it. Since the fusion of epiphyses in the lower extremities occurs earlier in girls than in boys, girls tend to have a lower 'sitting height-total body height' ratio than boys, between eight and 12 years, and a higher one between the 14th and 18th year.

Thus, especially in the early years of life, the infant is markedly elongating in stature. Also, the postural changes of the infant, from a recumbent one to that of a slouched, upright position, is completed within a relatively short period of time.

In general, children of either sex are of the same height, weight, and general body proportions up to 10 or 11 years of age; yet, not infrequently one sees girls slightly taller than their male counterparts even at ages 6–10. Girls tend to have an earlier pubertal growth spurt between 11 and 14 years and, in general, are taller than boys of this age. In the early to mid-teens, the boys catch up, and then surpass the girls in. These variations in total height at the 10–14 year age span reflect the differences in sitting height between boys and girls.

The mid-point of the body is slightly above the umbilicus (navel) in the newborn, and a 2 years the mid-point of the body is slightly below the umbilicus; at about 16 years, this mid-point is near the pubic symphysis.

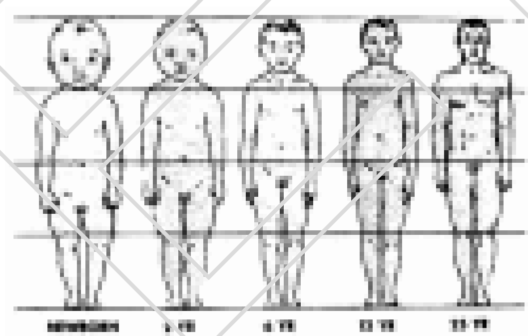

Fig 5

The proportional changes in body segments with age.

The center of gravity of the child varies according to age, child size, weight, and body form as well as sitting posture. A study by, of individuals at ages 5, 10, 12, and 18 years, indicated that the center of gravity (CG) cannot be located accurately and precisely in groups of seated children. They found that a plot of the CG would fall within an asymmetrically ellipsoidal area. In these children it was found that the CG was located vertically on the torso well above the lap belt level. This high CG in children must be considered when adult lap belts are used to restrain children, since the greater body mass above the belt may cause the child to whip forward more than in the case of an adult. In a subsequent study of infants aged 8 weeks–3 years, it was found that the CG is located even higher on the body

THE HEAD

In automotive collisions, the child's head is the body area most frequently and most seriously involved. In a study of children's injury patterns in 14,520 rural automobile accidents involving 31,925 occupants, it was found that children (birth through 11 years) had a frequency of 77% head injuries . This was a much greater frequency than either adolescents (69%) or adults (70%) in this study, although it was found that child head injuries were of a more minor variety than either adolescents or adults. identified head injuries in 50% of children, either lap-shoulder belted or unrestrained. Contributing to specific head impact problems are the large head of the child, the relatively soft, pliable, and elastic bones of the cranial vault, and the fontanelles. This heavier head mass and resulting higher seated CG in young children, coupled with weaker neck supporting structures, may be, in part, the basis for this higher frequency of head injury.

At birth the facial portion of the head is smaller than the cranium having a face-to-cranium ratio of 1:8 (cf. adult ratio of 1:2.5). These growth spurts occur during the first 6 months after birth, during the 3rd and 4th year, from the 7th to 11th year, and again between the 16th and the 19th year. The first growth spurt is chiefly olfactory as associated with the vertical growth of the upper portion of the nose and nasal cavity. The last spurt is related to adolescent sexual development.

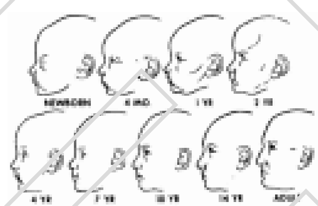

Fig. 6

Soft tissue profile changes of the head and face.

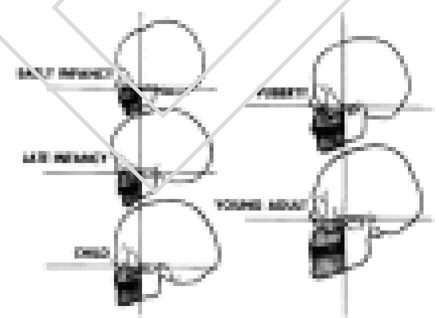

Fig. 7

Sequential changes of various head and face regions.

Infant head shape also differs significantly from that of the adult (Fig 8). In the infant the cranium is much more elongate and bulbous, with large frontal and parietal (side) prominences (Fig. 8). At birth the circumference of the head is about 13–14 inches. It increases by 17% during the first 3 months of life, and by 25% at 6 months of age. It increases by about 1 inch during the 2nd year, and during the 3rd through the 5th year head circumference increases by about one-half inch per year. There is only a 4 inch increase in herd circumference from the end of the 1st year to the 20th year (Fig 9).

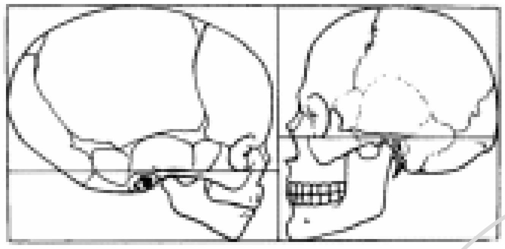

Fig. 8

A comparison of face-braincase proportions in the child and adult. The horizontal line passes through the same anatomical landmarks on both skulls.

Fig. 9

Skull profiles showing changes in size and shape. (Modified from Morris' "Human Anatomy.")

Head circumference increases markedly during the first postnatal year due to the progressive and rapid growth of the brain as a whole. The important relation of brain size and cranium size can be demonstrated on a percentage basis, which shows that 70% of the adult brain weight is achieved at 18 months, 80% at 3 years, 90% at 5–8 years and approximately 95% at the 10th year. In the adult the average brain weight is 1350 g.

Infant and child skulls are considerably pliable, due to the segmental development and arrangement of the skull bones, plus the flexibility of individual bones which are extremely thin. The mastoid fontanelle, between the occipital and parietal bones, closed about 6–8 weeks after birth. However, a much larger midline junction between the frontal and parietal bones, i.e., frontal fontanelle, is not closed by bone growth until approximately the 17th month.

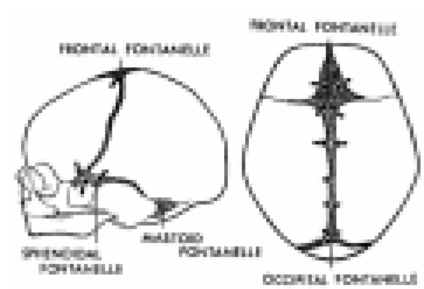

Fig. 10

Size and location of the fontanelles. Arrows indicate direction of fontanelle closure.

At birth all of the potential structures for the development of teeth are present. The early teeth first erupt at bout 6 months of age and continue to erupt progressively. The child begins to lose his deciduous teeth about 5–6 years of age after which they are replaced by the permanent teeth.

Trauma to the jaws of infants or small children, especially in the area where the unerupted teeth are found can lead to serious problems in tooth eruption, tooth spacing, tooth arrangement and alignment. Traumatic injuries to the child's lower jaw (mandible) may be related to abnormal facial profiles with increasing age. The normal changes in size and position of the lower jaw are dependent upon a growth site in the mandible located near its junction with the skull. If this important growth site is significantly traumatized, the normal changes in size and position of the mandible diminish resulting in a smaller mandible and a recessive chin.

THE NECK

There are several unique aspects of the anatomy of the child's neck. Neck muscle strength increases with age yet, with the greater head mass perched on a slender neck, the neck muscles generally are not developed sufficiently to dampen violent head movement, especially in children. Articular facets, the contact areas between the vertebrae, are shallow; neck ligaments, as elsewhere in the body, are weaker than in adults. The disproportionately large head, the weak cervical spine musculature, and laxity, can subject the infant to uncontrolled and passive cervical spine movements and possibly to compressive or distraction forces in . certain impact deceleration environments.

The articular facets of the infant and young children are oriented in an even more horizontal direction than in the adult . The "cervicocranium", the base of the skull, C1, C2 and the C2/C3 disc is a distinct unit in infants and small children, . Using dynamic cervical spine radiographs it has been shown that the fulcrum for flexion is at C2-C3 in infants and young children, at C3-C4 at about age 5 or 6 and at C5-C6 in adults .

THE CHEST

Thoracic injuries in children subjected to impact usually occur to the internal organs. The thoracic walls are thinner and the ribs more elastic in infants and young children than in the adults. Therefore, impact to the thorax of an infant or a small child will produce larger amounts of chest wall deflection onto the vital thoracic organs, e.g. heart, lungs. As clinicians well know, closed cardiac massage in infants can be performed by using only one or two fingers which well demonstrates the highly elastic nature of the chest wall.

THE ABDOMEN

Although statistically meaningful studies on child abdominal injuries have not been conducted, the effect of blunt abdominal trauma to children, as compared to adults, has been suggested in the literature. Only cerebral injuries and burns outrank injury to the abdominal organs as a form of serious accidental injury to children. In adults, blunt injury to the abdominal viscera presents the most difficult diagnosis and treatment, and results in the highest mortality rate . Thus, any blunt abdominal injury can be potentially serious, but such injuries to the infant and child are much more critical due to their developing and immature structure, large organ relationships, and almost complete lack of overlying muscle or skeletal protection.

Posteriorly, a similar relative migration of the bony thorax downward occurs to provide some protection for the spleen, kidneys, and suprarenal glands as the infant ages. At birth, for example, the kidneys occupy a large portion of the posterior abdominal cavity owing to their relatively large size.

In the newborn, the urinary bladder lies close to the lower abdominal wall with only its lower portion located behind the pubic bones. During childhood, much of the bladder descends into the pelvic area where it is more protected by the bony pelvis.

THE VERTEBRAL COLUMN

Normal development of erect posture involves a gradual transition from the early crawling stages involving interrelationships of the extremities, spine, and pelvis, to the well-balanced weight- bearing relationships typical of the adult. When the infant first stands, the pelvis is tilted far forward on the thighs and an erect posture is first attained in infancy concurrent with the development of the lumbar (low back) curve. As a result of this lumbar curve, combined with increased tonic activity of abdominal wall muscles the infant develops his characteristic sway-back and abdominal prominence which is maintained throughout pre-school years. The infant pelvis gradually rotates upward and forward beginning to establish an adult-like posture. The curvature of the sacrum as seen in the adult is already present at birth; however, in infants the vertebral column above the sacrum is usually straight

THE LIMBS

In considering the growth of the extremities it is necessary to examine factors of skeletal embryology and subsequent dimensional changes . Considering first the trends in dimensional growth of the limbs, it is generally noted that the lower limbs increase in length more rapidly than do the upper limbs. At about 2 years of age, for example, their lengths are equal but in the adult the lower limb is about on-sixth longer than the upper limb. The adult relations of the different limb segments are well established prenatally; however, there is some reduction in the relative length of the hand and of the foot after birth. At birth the lower limb forms about 15% of the body volume and in the adult reaches about 30%. In contrast the upper limb constitutes about 8% of the body weight at birth and maintains this same proportionality thereafter.

As in the skull, the long bones of the extremities pass through successive developmental stages which, when compared to adult morphology, make the limb bones less tolerable to trauma. In early development before birth, long bones are typically represented by a shaft of bone which grows in diameter by addition of new bone on its surface with concomitant erosion within the shaft. This development of the shaft can best be described as a tube that progressively increases in diameter. Impact tolerances of children's bones are dependent upon the changing girth of the bone and relative proportions of the marrow cavity and bony walls, as well as the proportions of inorganic and organic materials that form bone tissue. In the early development of bone tissue, organic materials outweigh inorganic components. The degree of flexibility or torsional strength of the bone itself is directly related to the organic component of the bone structure. The preponderance of organic material continues through adolescence after which there is a gradual buildup of inorganic bone substance

Child psychology

Child psychology is one of the many branches of psychology and one of the most frequently studied specialty areas. This particular branch focuses on the mind and behavior of children from prenatal development through adolescence. Child psychology deals not only with how children grow physically, but with their mental, emotional and social development as well.. Today, psychologists recognize that child psychology is unique and complex, but many differ in terms of the unique perspective they take when approaching development. Experts also differ in their responses to some of the bigger questions in child psychology, such as whether early experiences matter more than later ones or whether nature or nurture plays a greater role in certain aspects of development.

The Different Contexts of Child Psychology

When you think of development, what comes to mind? If you are like most people, you probably think about the internal factors that influence how a child grows, such as genetics and personal characteristics. However, development involves much more than the influences that arise from within an individual.

Some of the major contexts that we need to consider in our analysis of child psychology include:

- **The Social Context:** Relationships with peers and adults have an effect on how children think, learn and develop. Families, schools and peer groups all make up an important part of the social context.
- **The Cultural Context:** The culture a child lives in contributes a set of values, customs, shared assumptions and ways of living that influence development throughout the lifespan. Culture may play a role in how children relate to their parents, the type of education they receive and the type of child care that is provided.
- **The Socioeconomic Context:** Social class can also play a major role in child development. Socioeconomic status (often abbreviated as SES), is based upon a number of different factors including how much education people have, how much money they earn, the job they hold and where they live. Children raised in households with a high socioeconomic status tend to have greater access to opportunities, while those from households with lower socioeconomic status may have less access to such things as health care, quality nutrition and education. Such factors can have a major impact on child psychology.

Remember, all three of these contexts are constantly interacting. While a child may have fewer opportunities due to a low socioeconomic status, enriching social relationships and strong cultural ties may help correct this imbalance.

The following are just some of the major subjects that are essential to the study of child psychology:

- Genetics
- Environmental Influences
- Prenatal Development
- Social Growth
- Personality Development
- Language
- Gender Roles
- Cognitive Development
- Sexual Development

Child Psychology & Mental Health

Understanding your child is one of the most important things that you should learn as a parent. It is very helpful in becoming effective in guiding and nurturing your child as they grow and mature. You need to bear in mind that your child has a unique personality trait that remains consistent throughout life.

One of the ways you can understand your child is by observing them as they sleep, eat, or play. Look for the consistent traits. Which activities do they like best? Is adjusting to changes easy for them or do they need time to become familiar with these things? These things are the normal characteristics of a child and your child may not be an exception.

As much as possible, have time to talk to your children as this is crucial to gaining information and understanding. In the case of young children, they require less verbal language and more facial expression and body language in order to understand their thoughts and feelings. Asking them questions will allow them to share their feelings to you.

Self-esteem is a major key to success in life. The development of a positive self-concept or healthy self-esteem is extremely important to the happiness and success of children and teenagers. A positive parent-child relationship provides the framework and support for a child to develop a healthy respect and regard for self and for others. Children crave time with parents. It makes them feel special. Parents are encouraged to find time to spend playing with their kids on a regular basis. This should include one to one with each child and group time with all of the adults and kids in the home. If you are a single parent or have an only child, occasionally invite family or friends over to play.

For one reason or another, some children do not develop social skills as easily as others. They may earnestly seek peer relationships and then, having endured rebuffs, if not downright cruelty, retreat to the safety of home, family, and their own company. There is probably nothing so painful for a parent as the rejection of his child. Parents need to take the long view of social problems and to map out a plan to solve them quite as carefully and thoughtfully as they would consider academic or health problems. There are guidelines which, if followed, will help these children if the parent is willing to take time and initiative.

Most parents will encounter a few bumps in the road as their child moves from baby to teen to adult. The Child Psychology section provides guidelines and referrals to trusted resources for such problems