GAIT ANALYSIS OF 7-10-YEAR-OLD CHILDREN OF KARACHI FROM NUTRITIONAL-STATUS PESPECTIVE

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ANATOMICAL AND PHYSIOLOGICAL TERMS

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Definition of Anatomical Terms

L_A = Limb or Joint A/Body Landmark A • L_B = Limb or Joint B/Body Landmark B

- L_A is **superior** to L_B means L_A is nearer to the head as compared to L_B.

  For example, nose is superior to chin.
- L_B is **inferior** to L_A means L_B is farther way from the head as compared to L_A.

  For example, chin is inferior to nose.
- L_A is **lateral** to L_B means that L_A is farther away from the midline of the body as compared to L_B.

  For example, the right elbow is lateral to the right scapula.
- L_B is **medial** to L_A means that L_B is closer to the midline as compared to L_A.

  For example, the right scapula is medial to the right elbow.
- L_A is **proximal** to the point of attachment of a limb with respect to L_B means that L_A is nearer to that limb as compared to L_B.

  For example, the left elbow is proximal to the left shoulder joint as compared to the left wrist.
- L_B is **distal** to the point of attachment of a limb with respect to L_A means that L_B is farther away from that limb as compared to L_A.

  For example, the left wrist is distal to the left shoulder joint as compared to the left elbow.
- **Anterior point** is a point, which is nearer to or in front of the body.

  For example, naval is an anterior point.
- **Posterior point** is a point, which is nearer to or at the back of the body.

  For example, scapulae are posterior points.
- **Abduction** refers to a motion that pulls a body part away from the midline of body.

  For example, in physical-education exercises, hands are outstretched, so wrists are abducted.
- **Adduction** refers to a motion that pulls a body part towards the midline of body.

  For example, in physical-education exercises, hands are held above the head, palms touching each other, so wrists are adducted.

These terms are relative. They are used to compare any two arbitrary points on the body.

Right-Handed-Coördinate Mesh in Anthromathematics

One needs to choose a **consistent system of units** (length cannot be taken in *meters*, when mass is recorded in *slugs*). One shall, also, need to choose a **proper coördinate system**.

By convention, a **right-handed-coördinate mesh (system)** is used in most representations. A right-handed-coördinate mesh means if one curls the fingers of one's right hand so that the fingers represent rotation of the *x* axis (the *y* axis, the *z* axis) towards the *y* axis (the *z* axis, the *x* axis) through smaller of the two angles, one's thumb should point in the direction of the positive *z* axis (*x* axis, *y* axis). For example, a right-handed screw would come up (go down) if one turns it counterclockwise (clockwise). Similarly, a right-handed tap shall open (close) if one rotates it counterclockwise (clockwise).

Representing three-dimensional-coördinate system on a two-dimensional book-page (chalkboard, computer-screen) through slanted lines may give a wrong perception (in student's mind) that all of these lines are lying in the same plane. A better representation may be to draw the *x* axis (mostly, a horizontal line by convention; positive direction towards the right) and the *y* axis (normal to the *x* axis; positive direction towards the top) and show the *z* axis by a dot, circumscribed by a small circle, $\odot$, when the positive of *z* axis is coming out of the plane. When the positive of *z* axis is going into the plane, it is represented by a cross circumscribed by a small circle, $\otimes$.

The word 'mesh' is used in the spirit that the unit vectors, $(\hat{\boldsymbol{e}}_1, \hat{\boldsymbol{e}}_2, \hat{\boldsymbol{e}}_3)$, along *x* axis, *y* axis and *z* axis, respectively, are related through orthonormality conditions

$$\hat{\boldsymbol{e}}_\mathrm{i} \times \hat{\boldsymbol{e}}_\mathrm{j} = \in_{\mathrm{ijk}} \hat{\boldsymbol{e}}_\mathrm{k}$$

$\in_{\mathrm{ijk}}$ is Levi-Civita symbol (in fact, it is a tensor density), which takes the value +1 (–1) for even (odd) permutation of *ijk* and is zero otherwise. To cite an example, 123 is +1, 321 is –1 and 313 is zero.

Smart Choice of Axes

If one has three vectors ***A***, ***B*** and ***C***, one may choose the *x* axis along the direction of ***A*** so that

$$\boldsymbol{A} = A\hat{\boldsymbol{e}}_1$$

Further, the *y* axis may be selected so that ***B*** lies entirely in the *xy* plane (positive of the *y* axis is selected so that at least one of the components of ***B*** remains positive)

$$\boldsymbol{B} = B_{\mathrm{x}}\hat{\boldsymbol{e}}_1 + B_{\mathrm{y}}\hat{\boldsymbol{e}}_2$$

Once, these two axes are fixed in space, the *z* axis is, automatically, determined using the right-hand rule

$$\boldsymbol{C} = C_{\mathrm{x}}\hat{\boldsymbol{e}}_1 + C_{\mathrm{y}}\hat{\boldsymbol{e}}_2 + C_{\mathrm{z}}\hat{\boldsymbol{e}}_3$$

This choice should result in solution of the problem with minimal difficulty.

The coördinate system is fixed with the human body (position and orientation change as the body moves). Hence, this is a non-inertial, body-coördinate system. For biomechanical calculations, involving application of Newton's laws, one needs to transform the equations to laboratory frame.

Cardinal Planes and Anatomical Axes

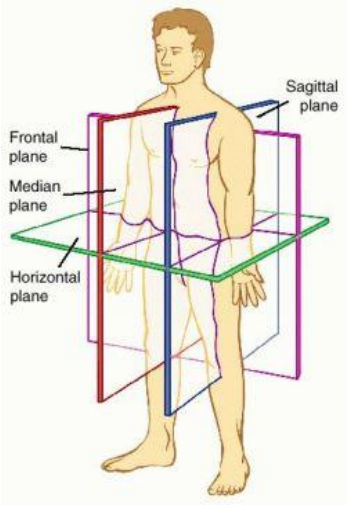
CARDINAL PLANES

- **Frontal Plane** is the vertical plane dividing the body into anterior and posterior parts.
- **Transverse Plane** is the horizontal plane dividing the body into superior and inferior parts.
- **Sagittal Plane** is, generally, defined as the vertical plane dividing the body into left and right portions. However, in the figure below the above-mentioned vertical plane is termed as *median plane*, whereas sagittal plane is shown to be parallel to median plane.

These planes remain the same regardless of body orientation with respect to earth.

ANATOMICAL AXES

- **Anteroposterior (Dorsoventral) Axis** (generated by the intersection of transverse and sagittal planes) is perpendicular to the frontal plane passing through the body from front to back.
  An example of rotation about anteroposterier axis is cartwheel movement performed by children.
- **Longitudinal (Craniocaudal) Axis** (generated by the intersection of frontal and sagittal planes) is perpendicular to the transverse plane passing through the body from top to bottom.
  An example of rotation about longitudinal axis is rotation of torso performed by dancers.
- **Transverse (Left-Right) Axis** (generated by the intersection of frontal and transverse planes) is perpendicular to the sagittal plane passing through the body from side to side.
  An example of rotation about transverse axis is performance on vault by gymnast.



Other Terms

MUSCLES

- **Triceps-Surae Muscle** is pair of muscles located at the calf. These muscles both insert into the 'calcaneus' (bone of the heel) and form major part of the muscle of the posterior leg, recognized as 'calf muscle'.
- **Tibialis-Anterior Muscle** is a muscle that originates in the upper two-thirds of the lateral surface of the tibia (the lager and stronger of the two bones in the leg below the knee) and inserts into the medial 'cuneiform' (located around the middle foot) and the first 'metatersal' (group of five long) bones of the foot.
- **Gluteus Maximus** is the largest and the most superficial of the three 'gluteal muscles' (group of muscles, which make up the buttocks).

STEPS OF GAIT

- **Flexion and Extension** describe movements that affect the angle between two parts of the body. For the purposes of scoliosis testing and anthropometry, an angle of 180^0 corresponds to extension, any angle lesser than 180^0 denotes flexion.
- **Neutral** is the position of ankle, where the bones that make up the joint are placed in the optimal position for maximal movement.
- **Dorsiflexion** describes the movement in which toes are brought closer to shin. This maneuver decreases the angle between *dorsum* (area between midfoot and forefoot, facing upward while standing) of the foot and the leg.
- **Planter flexion** describes the movement, which decreases the angle between sole of the foot and posterior leg.

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