

HUMAN LOCOMOTION

Anthropometry refers to the measurement of the human individual. An early tool of physical anthropology, it has been used for identification, for the purposes of understanding human physical variation.

Anthropometry involves the systematic measurement of the physical properties of the human body, primarily dimensional descriptors of body size and shape.

Anthropometry is the branch of anthropology concerned with comparative measurements of the human body and its parts as well as the variables which impact these measurements.

Anthropometric data consists of collections of measurements, often presented in tabular format or annotated diagrams of human figures.

The primary dimensions measured are of bone, muscle, and adipose tissue. This data is used in human factors/ergonomics applications in order to ensure that designs and standards are realistic.

Anthropomorphic data should be used with care.

Most data sets focus on particular populations, such as children, populations sharing a particular medical condition, or members of a profession, such as the military or an athletic sport.

Gait analysis is the systematic study of animal locomotion, more specifically the study of human motion, using the eye and the brain of observers, augmented by instrumentation for measuring body movements, body mechanics, and the activity of the muscles.

Gait analysis is used to assess, plan, and treat individuals with conditions affecting their ability to walk. It is also commonly used in sports biomechanics to help athletes run more efficiently and to identify posture-related or movement-related problems in people with injuries.

The **gait analysis** is modulated or modified by many factors, and changes in the normal gait pattern can be transient or permanent. The factors can be of various types:

- *Extrinsic: such as terrain, footwear, clothing, cargo*
- *Intrinsic: sex (male or female), weight, height, age, etc.*
- *Physical: such as weight, height, physique*
- *Psychological: personality type, emotions*
- *Physiological: anthropometric characteristics, i.e., measurements and proportions of body*
- *Pathological: for example trauma, neurological diseases, musculoskeletal anomalies, psychiatric disorders*

The **parameters** taken into account for the gait analysis are as follows:

- *Step length*
- *Stride length*
- *Cadence*
- *Speed*
- *Dynamic Base*
- *Progression Line*
- *Foot Angle*
- *Hip Angle*
- *Squat Performance*

Gait analysis involves measurement, where measurable parameters are introduced and analyzed, and interpretation, where conclusions about the subject (health, age, size, weight, speed, etc.) are drawn. The analysis is the measurement of the following:

Temporal / spatial

It consists in the calculation of speed, the length of the rhythm, pitch, and so on. These measurements are carried out through:

- Stopwatch and marks on the ground.
- Walking on a pressure mat.
- Range laser sensors scanning a plane a few centimeters above the floor.

Kinematics

Chronophotography is the most basic method for recording of movement.

Kinetics

Is the study of the forces involved in the production of movements.

Dynamic electromyography

Is the study of patterns of muscle activity during gait.

Gait analysis is used to analyze the walking ability of humans and animals, so this technology can be used for the following applications:

Medical diagnostics

Pathological gait may reflect compensations for underlying pathologies, or be responsible for causation of symptoms in itself. Cerebral palsy and stroke patients are commonly seen in gait labs. The study of gait allows diagnoses and intervention strategies to be made, as well as permitting future developments in rehabilitation engineering. Aside from clinical applications, gait analysis is used in professional sports training to optimize and improve athletic performance.

Gait analysis techniques allow for the assessment of gait disorders and the effects of corrective orthopedic surgery. Options for treatment of cerebral palsy include the artificial paralysis of spastic muscles or the lengthening, re-attachment or detachment of particular tendons. Corrections of distorted bony anatomy are also undertaken (osteotomy).

Biometric identification and forensics

Minor variations in gait style can be used as a biometric identifier to identify individual people. The parameters are grouped to spatial-temporal (step length, step width, walking speed, cycle time) and kinematic (joint rotation of the hip, knee and ankle, mean joint angles of the hip/knee/ankle, and thigh/trunk/foot angles) classes. There is a high correlation between step length and height of a person.

Comparative biomechanics

By studying the gait of non-human animals, more insight can be gained about the mechanics of locomotion, which has diverse implications for understanding the biology of the species in question as well as locomotion more broadly.

Pedobarography is the study of pressure fields acting between the plantar surface of the foot and a supporting surface. Used most often for biomechanical analysis of gait and posture, pedobarography is employed in a wide range of applications including sports biomechanics and gait biometrics.

FootMechanics

The feet are designed to support the weight of our bodies as we move about. The term “foot mechanics” refers to the proper or improper functioning of the feet in the performance of these all-important duties.

Proper Foot Mechanics

In walking, the feet behave very much as springs which propel the body forward with every step a person takes. At its most basic, there are two components of foot mechanics that everyone experiences to some degree:

- **Pronation** – This is a flattening of the arches of the feet and an inward “tipping” of the ankle which occurs each time the foot strikes the ground. This happens to absorb shock from the heel impacting the ground and assist in balance when the person’s body is in mid-stance.
- **Supination** – The polar opposite of pronation, this is an outward “tipping” of the ankle that supports the stability and rigidity of the foot each time a person first pushes off from the ground to take a step. Supination also provides leverage for the person’s weight as they “take off” and helps create a natural rolling motion off the toes as the step is initiated and the foot first leaves the ground.

Every person’s feet and ankles pronate and supinate. The question, however, is to what degree. Moderate pronation and supination is normal and healthy. Excessive pronation and supination, however, can be quite problematic.

The study of **Biomechanics** comprises the processes involved in the movement of living beings. The use of force plates supply precise information on the magnitude and behaviour of the forces involved in these processes. The instrument used in the Biomedical Lab in the School of Engineering is a combination force plate-pedobarograph that is utilized for the Biomechanics. It is designed to measure the three orthogonal components of the resultant force acting on the platform, and the three components of the generated moment in the same orthogonal co-ordinate system.

As a pedobarograph the instrument is used as a gait analysis tool that measures the pressure distribution on the bottom of the foot through all stages of the gait cycle. The optical pedobarograph in the Biomedical Engineering lab uses digital video capture technology to record the pressure variations on the sole of the foot. The subject walks across the force plate fitted with an illuminated glass plate. As the foot hits the device, the glass surface deflects due to the force, causing the horizontal light beams to reflect downwards and be read by the video camera. The amount of light reflected is proportional to the pressure caused by the foot striking the plate.

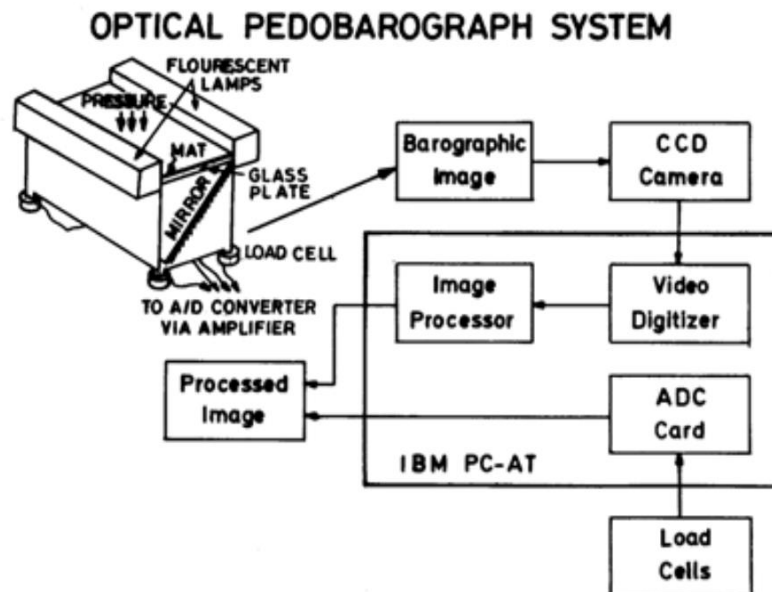
Types of Pedobarograph

1. Optical Pedobarograph
2. Musgrave Foot pedobarograph

Musgrave Foot pedobarograph

It is computerized form of gait analysis that is used in the measurement and evaluation On the bottom of the foot through all stages of the gait cycle.

Optical Pedobarograph



An **Optical Pedobarograph** uses digital video capture technology to record the pressure variations on the sole of the foot. The Subject walks across the force plate fitted with an illuminated glass plate. As the foot hits the device, the glass surface deflects due to the force, causing the horizontal light beam to reflect downwards and be read by the video camera. The amount of light reflected is proportional to the pressure caused by the foot striking the foot.

Construction

- Thick tempered glass plate
- Glass plate illuminated at two edges by fluorescent lights
- Top surface of glass is covered with a sheet of photographic paper and thin sheet of plastic
- Video camera which captures the image of the foot when subject steps on it
- As light enters the glass plate through the sides, the light rays which have an angle of incidence $>$ critical angle will experience total internal reflection between top and bottom surface of the glass.
- When subject is made to step on the apparatus, the plastic sheet deforms and comes in contact with the top surface of the glass.

- The amount of pressure applied to the plastic is proportional to how intimate the contact with the glass plate will be and how much internal reflection will be broken.
- The areas which are in contact with the glass plate are observed as low intensity regions in the image.
- The mirror collects the reflected light beam and it focuses on the camera and the image is captured.

Applications

- To study clinical conditions like diabetes mellitus, rheumatoid arthritis, etc
- To study the severity of deformity of patients with foot dysfunction
- Used in forensics to examine the shoe marks found at scene of crime.

Disadvantages

- Proper calibration is not possible
- Transducer material is used instead of plastic sheet materials

Elements of Blood and Blood Rheology

The fluids associated with the human body include air, oxygen, carbon dioxide, water, solvents, solutions, suspensions, serum, lymph, and blood. The major body fluid which acts as the lifeline of the living organisms is "Blood". Blood is an extremely complex biological fluid. It consists of blood cells suspended in plasma and other different types of cells which include white blood cells, platelets etc. The blood flow in arteries and veins are closely linked to the blood vessel properties. Carrying the oxygen and nutrients to various tissues and organs of our body, delivering carbon dioxide to the lungs and accepting oxygen, bringing the metabolic by products to the kidneys, regulating the body's defence mechanism, that is, the immune system and facilitating an effective heat and mass transfer across the body are some of the major functions which blood performs in the human body. Blood consists of the red blood cells or erythrocytes, white blood cells or leukocytes, and platelets or thrombocytes. The cells which are involved primarily in the transport of oxygen and carbon dioxide are known as Erythrocytes. The cells which are involved primarily in phagocytosis (the process of destruction of unknown particulate matter) and immune responses are known as Leukocytes; thrombocytes are the components of blood which are involved in blood clotting. In addition to these 55 to 60 percent of blood by volume consists of plasma. Plasma is the transparent, amber-coloured liquid in which the cellular components of blood are suspended. Plasma contains constituents such as proteins, electrolytes, hormones, and nutrients. The

serum is blood plasma from which clotting factors have been removed. Blood accounts for 6 to 8 percent of body weight in normal, healthy humans. The density of blood is slightly greater than the density of water at approximately 1060 kg/m^3 . The increased density comes from the increased density of a red blood cell compared with the density of water or plasma. Rheology is the study of the deformation and flow of matter. Blood Rheology is the study of blood, especially the properties associated with the deformation and flow of blood. Blood is a non-Newtonian fluid. However, often the non-Newtonian effect is very small due to various reasons. Thus, it is important to know about the blood rheology. One of the characteristics of blood that affects the work required to cause the blood to flow through the arteries is the viscosity of blood. The viscosity of blood is in the range of 3 to 6 cP, or 0.003 to 0.006 Ns/m². Blood is a non-Newtonian fluid, which means that the viscosity of blood is not a constant with respect to the rate of shearing strain. In addition to the rate of shearing strain, the viscosity of blood is also dependent on temperature and on the volume percentage of blood that consists of red blood cells. If blood is made stationary for several seconds then clotting begins in the blood, as a result of which the viscosity of the blood increases. When the stationary state is disturbed with increasing shear rate, the clot formation is destroyed and the viscosity decreases. Moreover, the orientation of red blood cells present in the blood also affects the viscosity of blood. Thus, we can say that blood is a shear thinning fluid, i.e., viscosity decreases with increase in shear rate. Beyond a shear rate of about 100s^{-1} , the viscosity is nearly constant and the blood behaves like a Newtonian fluid. Blood is a viscoelastic material, i.e., viscous and elastic because the effective viscosity of blood not only depends on the shear rate but also on the history of shear rate. It is also important to note that the normal blood flows much more easily compared to rigid particles, for the same particle volume fraction. This is due to the fact that red blood cells can accommodate by deforming in order to pass by one another.

Fåhræus-Lindqvist effect

Robert (Robin) Sanno Fåhræus, a Swedish pathologist, and hematologist, and Johan Torsten Lindqvist, a Swedish physician, observed that when blood flows through vessels smaller than about 1.5 mm in diameter, the apparent viscosity of the fluid decreases. The viscosity of blood decreases as the percent of the diameter of a vessel occupied by the cell-free layer increases. However, when the diameter of the tube approaches the diameter of the erythrocyte, the viscosity increases dramatically. For blood flow through tubes less than

approximately 1 mm in diameter, the viscosity is not constant with respect to the tube diameter. Therefore, blood behaves as a non-Newtonian fluid in such blood vessels.

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