BLOCK 4
BODY COMPOSITION, HUMAN PHYSIQUE AND SOMATOTYPING

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UNIT 10 HUMAN BODY COMPOSITION

Contents

Learning Objectives

After going through this unit you will:

- undertand about body composition and different factors affecting it;
- know the levels of body composition;
- comprehend the human body composition in relation to anthropometry;
- know the application and anthropometric significance of body composition;
- find out the methodology of human body composition following the standard protocol; and
- get the basic knowledge of human body composition and ethnic specificity and disease association.

10.0 INTRODUCTION

Human body composition and other somatic characteristics are known to be influenced by a variety of environmental agents and the lifestyle of the individual. Human body composition and physique phenotypes are complex multifactorial traits that cannot readily be reduced to simple Mendelian phenotypes and inheritance. These traits have evolved under the interactive influence of dozens of factors from the social, behavioral, physiological, metabolic, cellular and molecular domain (Chatterjee, 2006; 2009).

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10.1 BODY COMPOSITION -

As we all are aware, four main components, water, protein, fat and minerals are used to build the body. There are two models that describe fat theory of body

- one is body with fat component and
- another is fat free component.

Again, fats are mainly of two types one is stored fat and the other is essential fat. The essential fats are present in the important organs of the body like in bone marrow, heart, lungs, kidney, spleen, central nervous system, lipid rich tissues etc. The stored fat is only present in the adipose tissues of the body, from where energy is depleted in need. Amongst these two fats, essential fat is necessary to live life normally. An interesting finding that in women, essential fat percentage is higher than men due to the hormonal changes that take place throughout the life. Storage fat is also present as internal storage fats in internal organ of the body and also as subcutaneous fat under the skin. Subcutaneous fat works as an insulator of the body and helps in maintaining body temperature. In the life cycle of an individual the relationship of their subcutaneous fat and internal fat may not be the same. At this point it would interest you to know that there is also a term lean body mass found in body composition; it represents the weight of the muscles, bones, ligaments, internal organ etc. As the name reflects, this lean body mass is totally fat free and have small percentage of essential fats.

History of Body Composition study in Global Perspectives

Here we can understand about the different types of body composition in different racial groups, viz., Caucasoid, Negroid and Mongoloid. Body composition depends on various factors like, heredity environment and nutrition. Looking at the world scenario in this aspect, we find that people who live in different continents of different geographical regions and climates exhibit varieties of body composition both among males and females (Haroun et al, 2016). For example among Caucasoid groups who are mainly distributed in temperate zones, have medium to fat body build, lesser subcutaneous fat, tall stature, straight and narrow nose. Such characteristics are necessary to withstand the cold temperature. The Negroids have medium build, i.e., athletic type of physique, flat noses and variation in stature. The Mongoloids have short stature, medium nose, short stature, lean and medium build. We find some variation in the females of these racial groups. The physiological aspects too slightly differ in these groups. Body composition is sometimes in conformity with the climatic zones where they live (Chatterjee, 2014). Due to these physiological and different body compositions individuals comprising of these groups respond to extreme climatic conditions like cold and heat prevailing in arctic and desert conditions (Bhatt et al, 2014). The role of natural selection and its control on these populations cannot be ruled out. Hence, there is a relationship between, physiology, body composition and ecological conditions. Such factor is evident, at a glance made on the males and females, belonging to different racial and ethnic groups distributed in varieties of eco-niches in the world. North American Indians were particularly inclined to a centripetal distribution of fat (Pandit et al 2010). The trunk and upper body are much higher in Tokelau islander who had migrated to New Zealand than in non-migrants. Asians in U.S have a higher body fat percentage, a prominent abdominal obesity, a higher intraunion cellular lipid and/or a higher liver fat content compared to Caucasians. Prepubertal children in U.S have demonstrated that: 1) sex

differences in body fat distribution are present in prepubertal children but that the specific characteristics for Asians differ from African-Americans and Caucasians, and 2) differences in body fat distribution in Asian children, compared with African Americans and Caucasians, are present but vary by sex (Chatterjee, 2014; Bhatt et al, 2005). This comparison of African American, Asian, and Caucasian prepubertal children advocates phenotypic differences. There exist biological differences in the body composition of Blacks and Whites. Black Americans have a high occurrence of obesity-related diseases than the Whites. In general, Blacks have a greater bone mineral density and body protein content than do Whites, ensuing in a greater fat-free body density. Additionally, there are racial (Misra et al, 2004; Yajnik et al, 2003) differences in the distribution of subcutaneous fat and the length of the limbs relative to the trunk. 52% of Black women are overweight according to the third National Health and Nutrition Examination Survey (NHANES Ill). Blacks are inclined to have less subcutaneous fat in the extremities than in the trunk relative to the fat deposition patterning of Whites. Whites have larger amounts of subcutaneous fat on the front of their bodies while the Blacks tend to carry relatively more fat on the back and lateral portions of their bodies. (Kapoor et al, 2018)

History of Body Composition study in Indian Perspectives

The terms body structure and composition are separated for pedagogical reasons, which otherwise are both closely inter-related (Kshatriya et al, 2016, 2021). This is because the development of the three components in the body, i.e., muscles, bone and fat, is reflected in the physique or physical characteristics, or in other words, the structure of an individual. It is this concept of the human development that is related to our body function. It is said that different types of human body have presumably different advantages in different circumstances and at different times (Tyagi et al , 2005). The process of natural selection may favour first one build and then another. There is evidence for example, that the long, thin build of Nilotic Negro has arisen through the very definite advantage such a build, confers in maintaining physiological function in hot environment. The mean body-weight of populations in hot regions is demonstrably lower (in all continents) than that in temperate and cooler climates (Chatterjee et al, 2014). The ratio of sitting height to total height becomes less, as mean temperature increases geographically, i.e., lower limbs tend to be longer in hotter climates (Chatterjee, 2014). The tendency towards attenuation of limbs in hotter climate is seen also in upper limbs, since the ratio of span to height is greater. The dimensions of the trunk also become less in hotter climates. Further Khonsdier (2007) has shown that the body weight/surface area ratio declines from temperate to hotter climates. However, it should be noted that the correlation between body shape and mean temperature account for about 50 or 60 per cent of the total inter-population variance; clearly other factors, particularly population movements (Ghosh et al, 2020), also influence the variation in physique and body composition (Sarkar et al, 2016). Much of the diversity of human form mirrors not overall differences of body composition, but rather inter-individual differences in the regional distribution of fat, muscle and bone. Inter-individual differences in the regional distribution of body fat are viewed to both the relative proportions of deep and superficial fat, and variations in the distribution of subcutaneous fat over the body surface (Kanrar et al, 2021). A centralized or centripetal pattern of fat deposition can be differentiated from a peripheral accumulation of fat. Alternatively, soft-tissue radiographs suggest that within any given individual

there is a close relationship between the accumulation of fat in the upper and the lower limbs. Some of the inter-individual differences in the patterning of superficial fat have a recognizable relationship to the sex of the individual, chiefly the deposits of fat found in and around the breast of the mature female, which apparently constitute an essential reserve of nutrients.

10.2 FACTORS AFFECTING BODY COMPOSITION

Body composition is dependent on many factors like age, sex, genes, hormones and so many more.

Lets go through them briefly:

Age**:** People have a particular weight gaining and weight loss tendency in their total life span, like during aging weight loss happen due to slower metabolism.

Sex**:** Sex is also a factor in weight deposition in body, like women have more tendency to accumulate fat than men due to pregnancy cycle.

Genes**:** Genes that we have from our heredity play an immense role in our body type that a person can be lean or retain fat and which part of his body it will store.

Hormones**:** These can influence water retention and body composition (WHO, 1995).

10.3 LEVELS OF BODY COMPOSITION

Body composition can be assessed by in five levels i.e. Atomic, Molecular, Cellular, Tissue, and Whole Body Level. This is known as Five componential model.

a) Atomic Level – Chemical analysis shows six elements like oxygen, carbon, hydrogen, nitrogen, calcium, and phosphorus are major elements of human body. The modern in *vivo* neutron activation analysis (IVNAA) may be the most accurate method to assess atomic level body composition.

b) Molecular Level – Considering molecular level – water, lipids, fats, proteins, minerals, and carbohydrates are most important molecules for body composition. Water is one of the major component of body composition, and it is of two types, i.e. intra cellular and extra cellular. Lipid is one of the most important molecule for body composition. It is also of two types i.e. Phospholipids or essential lipids and Triglyceride or non-essential lipids. It stores energy in the body. Apart from all these Protein, Minerals, and Carbohydrates are most important molecule for body structure followed by body composition.

c) Cellular Level – The materials of different categories are differentiated by intracellular and extracellular. Different types of cells and cellular materials are responsible for body composition i.e. muscle, adipose tissue, blood, bone, skin, liver, and others.

d) Tissue Level – Tissue are of different types. i.e. muscular tissue, connective tissue, epithelial tissue, nervous tissue, etc. Body weight depends on different types of materials as follows-

e) Body Weight – Water+Bone+Muscle+Tissue+Others+ Fat (Essential and Non-essential)

f) Whole Body – It may be direct insight of body structural makeup or setup considering statistical formula or using different kind of devices.

10.4 MODELS OF BODY COMPOSITION

a) One Compartment model - The use of models in the assessment of body composition allows for the indirect assessment of compartments in the body. Typically, a compartment is homogenous in composition (for example, fat), however, the simpler the model the greater the assumptions made and the greater the likelihood of error.

b) Two Compartment Model - The basic two-compartment (2C) model is derived from measuring the density of FFM by hydrodensitometry and subtracting FFM from total body weight thereby deriving fat mass (body weight" FFM=fat mass).

c) Three Compartment Model - A three-compartment (3C) model consists of fat, fat-free solids, and water. The water content of FFM is assumed to be between 70% and 76% for most species and results from cross-sectional studies in adult humans show no evidence of differences in the hydration of FFM with age. The fat-free solids component of FFM refers to minerals (including bone) and proteins.

d) Four Compartment Model - A four-compartment (4C) model involves the measurement of body density (for fat), total body water, bone mineral content by DXA, and residual (residual=body weight (fat+water+bone)). This model allows for the assessment of several assumptions that are central to the 2C model. The 4C approach is frequently used as the criterion method against which new body composition methods are compared in both children and adults.

e) Five Compartment Model - At the organizational level, a five-level model was developed where the body can be characterized at five levels. The following are the levels and their constituents: atomic=oxygen, carbon, hydrogen, and other (level 1); molecular=water, lipid, protein, and other (level 2); cellular=cell mass, extracellular fluid, and extracellular solids (level 3); tissue-system level=skeletal muscle, adipose tissue, bone, blood, and other (level 4); whole body (level 5).

Check Your Progress 1

1) What is Body Composition?

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2) What are the factors responsible for body composition?

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3) What are the different levels of body composition?

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4) What are the componential models of body composition?

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10.5 ASSESSMENT OF BODY COMPOSITION

The assessment of body composition and of somatic protein stores involves the measurement of different body compartments (water, fat, bone, muscle, and visceral organs). The fat-free mass (mainly composed of muscle) comprises the majority of the somatic protein mass. Generally, somatic protein stores are preserved at the expense of other body fuel sources, especially fat. However, when catabolic illnesses occur there will be fat-free mass depletion. Therefore, body composition techniques are important tools to diagnose protein depletion and to monitor efficacy of nutritional therapies. Simple anthropometric measures are practically useful whereas bioelectrical impedance analysis and dual-energy x-ray absorptiometry are more applicable for research purposes.

10.5.1 Anthropometric Method

Anthropometry is the means of quantifying variation in body size and shape and universally accepted and applicable in health sciences. Since the last two decades the scientific technique of anthropometry has emerged as an important method for population study in biomedical research. Now a days we have several new techniques available, but anthropometry still is non-invasive and less costly and its availability is abundance to detect the size, composition and proportion of the human body.

It is one of the most fundamental practical techniques of human biology, since nearly all-biological functions are in some way related to one or other aspect of the physical dimension of the body. Anthropometric techniques include measures of skinfold thickness, circumferences, and other somatic measurements to assess component mass and have been the subject matter of human body composition. Populations can be differentiated on the basis of BMI and body fat percentage relationship and somatotype. It reveals that although studies on relationship of overall adiposity, body fat distribution and body composition have been undertaken by several scholars from India but further work needs to be done considering the vast ethnic heterogeneity of Indian populations (Chatterjee, 2013; Beck, 2002; Vellas, 1999).

Anthropometric measurements with the standard instruments by standard methods maintaining protocol, such as for height, weight, sitting height, circumference measurements and skinfold measurements and the physiological variables readings taken with due precautions and standard procedure is recommended. Some derived variables i.e. BMI, sub-ischial height, arm fat, circumference, fat mass, fat free mass, fat mass index, are also considered (Ghosh and Chatterjee, 2006).

Let us try to understand briefly some of the anthropometric variables:

Body weight - Body weight of the individual is directly recorded into Kg. with the help of weighing machine.

Stature - It is the distance between vertex to floor using anthropometer.

Sitting height - The straight distance from sitting plane to vertex by anthropometer.

Skin fold thickness- Skinfold technique is a useful process to determine subcutaneous fat (fat just underneath our skin) from specific area of the body. The skinfold is picked up between thumb and forefinger and the jaws of skinfold calliper is applied exactly at the point marked. It's very economical and can be done easily in fields. Ideally, the sum of three area's skinfold is required and then the density of fat in the body can be estimated.

- ***Biceps skin fold-*** The skin fold is picked up on the front of the arm, directly above the centre of the cubital fossa.
- ***Medial calfskin fold-*** The skin fold is picked up at the level of the maximal circumference of the calf on the medial border of the leg.

Circumference: These are girth measurement taken around specified points. The most commonly used circumferences are:

Mid upper arm circumference - The circumference is taken horizontally at the mid of upper arm using flexible steel tape.

Abdominal Circumference- The subject stands with the arms by the sides and the feet together. The tape is placed around the subject at the level of the greatest anterior extension of the abdomen in a horizontal plane, the measurement should be taken horizontally from the plane through the umbilicus's centre.

Hip Circumference- The subject should stand erect in anatomical position. The measurer should stand erect at the side of the subject so that the buttock region of the subject could be seen properly.

Thigh Circumference- Measurement of the proximal and distal thigh circumferences is done by measuring tape.

Calf Circumference- The measurements are taken horizontally around the calf and moved up and down to locate the maximum circumference in a plane perpendicular to the long axis of the calf.

Two adiposity indices, BMI (overall adiposity) and WHR (central adiposity) are used and calculated by the following equation:

- BMI = Weight (kg) / Height (m) ².
- WHR = Waist circumference (cm) / Hip circumference (cm).
- WSR = Waist circumference (cm) / Stature (cm).

Percentage of body fat- Body fat percentage refers to the percentage of the body fat mass (the weight of the fat) in relation to body weight. Body fat percentage and body fat mass are determined by the following calculations:

$$\text{Body fat percentage (\%)} = \frac{\text{Body fat mass (Kg)}}{\text{Body weight (Kg)}} \times 100$$

10.5.2 Bioelectrical Impendence Analysis

Bioelectrical Impedance Analysis (BIA) describes intracellular and extracellular fluid of the body works as an electoral conductor. This technique is used to detect the total body water except the fat mass; it can be measured by machine. The current flows through the human body in the path of biological tissues with least resistance power, these biological tissues act as the insulators or conductor. The frequency helps in measuring this BIA, in low frequency near about 50 kHz extra cellular water (ECW) can detect and in high frequency near about 500–800 kHz intra cellular water (ICW) can be detected (Lukaski, 1987). TBW and FFM (Schoeller, 2005), are correlated with ECW, this made using this method usually use to estimate TBW and FFM. Body image is now being explored in relation to obesity, eating behaviours, body composition, and physical activity. According to American Council of Exercise (ACE) the cut offs are as following for healthy body composition (Chatterjee, 2013; Lohman, 1988; Nygard)

Table 10.1: Percentage of Body Fat in both Sexes

Type	Women	Men
Essential Fat	10% to 13%	2% to 5%
Athletes	14% to 20%	6% to 13%
Moderate Fitness	21% to 24%	14% to 17%
Acceptable	25% to 31%	18% to 24%
Obese	over 32%	over 25%

Source: ACE quoto by Chatterjee 2013, Lohman 1988

The above table indicates cut-off of essential fat in both sexes, that athletes have less body fat in body but contain more lean mass for gaining muscle in body. The extremely low body fat in body may harm in athletes also and it may cause

severe illness, in these issue female athletes suffers more. In the obesity management reduction of body weight does not mean drastic reduction of weight; it mean slow reduction of non-essential fat in body and increase of lean mass in body through exercise (Nygaard, 2008).

10.5.3 Other Important Methods for Assessing Body Composition

The following methods are invasive and direct method for assessing the body composition. All the following methods needs a lab setup or institutional setup, so it is very difficult use in ideal field situation as non-invasive method.

DEXA (*Dual Energy X-Ray Absorptiometry) Scan* – DEXA scan actually perform in medical practices to check the bone density. It's actually a dual energy X-ray that absorption detect the density of the bone. Dual energy X-ray absorptiometry (DXA) was developed to measure bone mineral mass, which is calculated from the differential absorption of X rays of two different energies. Because this calculation requires allowance for (and hence quantification of) overlying soft tissue, values of fat and FFM are also calculated for whole body scans, using instrument specific algorithms.

Hydrostatic Weghing- This method helps in understanding the weight of body submerged in water.

Body Density- Body Density can give the most accurate calculation of body composition. Determining body composition there is a model, Four Compartment Model. In this model the detection of body density is important. Overall density of the body can be proportional to the composed density of each compartment.

Body Volume Indicator- The Body Volume Indicator (BVI) is a method that used to measure the body shape of individual. This BVI technique does light scanning to measure the shape of the person. Now 3D technique develops to make this measurement more aureate.

Corpulence Index (CI) Or Ponderal Index (PI)- It is a measurement of leanness of a person and this leanness has relation with height. It's also correlating the BMI and cholesterol percentage of the body, that determines the rate of mortality.

Densitometry: This approach distinguishes FM and FFM, assuming specific densities of these two tissues, and therefore requires measurement of total body density (body mass/body volume). While the density of fat is indeed relatively constant, that of FFM varies according to its composition. This variability is partly explained by the process of chemical maturation that occurs before adulthood, but interindividual variability is also significant, even in healthy children.

Isotope Dilution (Hydrometry): Deuterium dilution can be used to measure TBW, allowing estimation of FFM. Samples are generally analysed by isotope ratio mass spectrometry; however, clinical services could be based as substantially cheaper but more labour intensive spectrophotometric technique.

Computerized Axial Tomography (*CAT*) : Computed Tomography (CT) (Computerized Axial Tomography (CAT)) a radiologic imaging modality that uses computer processing to generate an image (CAT scan) of the tissued density in a "slice" as thin as 1 to 10 mm in thickness through the patient's body.

These images are spaced at intervals of 0.5 to 1 cm. Crosssectional anatomy can be reconstructed in several planes without exposing the patient to additional radiation.

- ***Magnetic Resonance Imaging*** **(MRI):** MRI is an imaging technique that estimates the volume rather than the mass of adipose tissue. By analysing the absorption and emission of energy in the radio frequency range of the electromagnetic spectrum, the technique produces images based on spatial variations in the phase and frequency of the energy absorbed and emitted. It primarily addresses hydrogen nuclei, located either in water or fat, and uses these data to discern tissue types in "imaging slices" which can then be summed to calculate regional tissue volumes.

Check Your Progress 2

5) What are the different methods for assessing of body composition?

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10.6 APPLICATION OF BODY COMPOSITION STUDY

Nutritional status is measured comparing with the cut-off value recommended by World Health Organization (1995) and classified in to three categories underweight (> 18.50), normal (18.50 – 25.00) and overweight (< 25.00) (Ghosh, 2006; Kwok, 1991).

Nowadays obesity is a global epidemic and associated with other communicable diseases and become the cause of mortality and morbidity. Body Mass Index (BMI) is mainly used to detect the obesity level in human, however, BMI cannot differentiate the fat and lean mass in body composition and an increasing number of studies are reporting that the relationship between BMI and %BF is different among different populations.

Furthermore, to evaluate the nutritional and health status of the body is best to perform body composition assessment. To detect obesity, the most useful anthropometric parameters are waist-to-hip ratio (WHR), waist circumference (WC) and waist-to-stature ratio (WSR), these are better than only estimating the BMI. Still in Indonesia, the anthropometric assessments and body composition measurement and their association benefits are very limited. This may happen due to less field base works in this population (Chatterjee, 2013; Leslie, 2006; WHO, 1995). Most of the studies suggested the beneficiary points of prediction the equations from the anthropometric measures and the bioelectrical impedance analysis (BIA) to give elaborated assessment of body composition. Body composition and fat distribution differs with gender, with men having less body fat but a relatively greater central distribution of fat. The differences start early in life and become more apparent in puberty due to changes in sex hormone

levels (Stevens et al., 2010). Relationship between body composition and obesity also varies between race and ethnicity.

10.7 ANTHROPOLOGICAL SIGNIFICANCE OF BODY COMPOSITION STUDY

Health policy of a nation is very much important to avoid the health hazards of the people of the nation. There is correct dosage of medicine for treating an illness, but there is a correct dosage of health consciousness and health perception for promoting health benefits. Contemporary medical technology is developed to a great extent and increase the life expectancy of the people. Now medical technology developed largely and increases the life expectancy of the people by introducing lifesaving drugs and modern gadgets, the problem lies in the child health remain the same. Human Body composition in terms of obesity is well recognized in human variation study. Population specific body composition is now the cutting-edge research in the world. Different anthropometric measurements and other methods are used for assessing the human body composition and ethnic specificity and disease association.

Obesity leads the non-comunicable disease, and anthropometry and body composition is very much ethnic specific in nature. Non-communicable disease like Cardiovascular Disease (CVD), Hypertension, Type 2 Diabetes are very much associated with body composition and ethnic specific in nature.

Check Your Progress 3

6) What are the applications of body composition study?

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7) What is the Anthropological significance of body composition study?

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10.8 SUMMARY

Body composition and growth are key components of health in both individuals and populations. The ongoing epidemic of obesity in children and adults has highlighted the importance of body fat for short term and long term health. However, other components of body composition also influence health outcomes, and its measurement is increasingly considered valuable in clinical practice. Hormone, nutrition, gene and several factors are responsible for body composition. Five level of body composition is very important i.e., atomic, molecular, cellular, tissue and whole-body level. One to five componential model are used to study body composition. Anthropometric, BIA and other methods are also used to assess the body composition. Body composition is very much ethnic specific, and it has a close association with population variation and disease association study.

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10.10 ANSWER TO CHECK YOUR PROGRESS

1) Body composition has four main components: water, protein, fat and mineral. For details refer to section 10.1
2) Body composition is dependent on factors like age, genes, hormones and others. For details refer to section 10.2
3) Body composition can be assed at atomic, molecular, cellular, tissue and whole body level. For details refer to section 10.3
4) There are five componential models of body composition. For details refer to section 10.4
5) Body composition can be assessed by various measures. For details refer to section 10.5
6) Body composition holds significance for nutritional status. For details refer to section 10.6
7) The study of body composition is an intrinsic part of Human Growth and Development. For details refer to section 10.7

UNIT 11 SOMATOTYPING AND HUMAN PHYSIQUE

Contents

Learning Objective

After going through this unit, you will be able to understand:

- body shape by using somatotype method using body size variables i.e., anthropometry;
- body shape and size have definite ethnic specificity and has a great role in population variation; and
- the conceptual change over body shape study or phenotypic expression study over time by using Sheldon, Pernell and Heath-Carter method.

11.0 INTRODUCTION

Modern human diversity is the result of demographic history, and selective effects that have acted to adapt different populations to their environments. Present day Biological Anthropology integrates multiple level of analysis, from ultimate (evolutionary) to proximate (molecular) causes. Apart from that, biological attributes in the form of phenotypic traits related to anthropometric variability are remarkable due to the influence of different factors, such as nutritional and socio-economic factors. Human body composition and physique phenotypes are complex multifactorial traits. These traits have evolved under the interactive influence of dozens of effectors from the social, behavioural, physiological, metabolic, cellular and molecular domain and expressed as qualitative and quantitative observable variables. Worldwide variation in body size, body proportion and body physique exist between the genders and among different populations. Anthropometric somatotyping is essentially an updated and developed version of Sheldon's methodology, which was later developed by

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Pernell, but it gained traction in the last two decades after Heath and Carter introduced a simpler method for somatotyping. The changes in the physique of human body have always been an interesting concept to physical anthropologists and human biologists. To understand the morphological structure of body, it becomes important to analyse the factors which are associated with determining the physique of body. It is expressed in a form of rating (three form rating) that indicates the three physique segments namely endomorphy, mesomorphy, and ectomorphy (Heath and Carter, 1990).

11.1 SOMATOTYPING

Human physique classification and research can be traced all the way back to ancient era, when people with strong bodies and great ability to fight, hunt, and lead, had to stand out and be recognised by society, including the kings. Greek philosopher and physician, Hippocrates who lived in the fifth century BC, distinguished between two types of bodies: slim and lean people with long limbs and short people with thick and massive bodies. According to Singh, although the former is thought to be more susceptible to tuberculosis, the latter were much more susceptible to cardiovascular diseases (Singh, 2007)

An individual's body physique is influenced by a multitude of factors such as gender, age, ethnicity, dietary pattern, genetic and evolutionary factors, and multiple environmental factors as well. A person's physique not only defines the form of his or her body, but it is also a primary determinant of a healthy life.

Somatotyping is a unique system of evaluation and classification of human physique. The somatotype is an attempt at general human taxonomy or classification with the aim of providing the subject with some kind of identification tag. It conveys the sense of the human body's totality of morphological features and reflects the body's overall outlook. Endomorphy, mesomorphy, and ectomorphy are the three elements of somatotyping, which are used to describe body types. Endomorphy refers to a person's "relative fatness" , while mesomorphy refers to a person's "relative musculoskeletal robustness", and ectomorphy refers to a person's "relative linearity or slenderness". A somatotype is normally represented by a three-number composite, with each number indicating the intensity of the individual component pieces.

Heath and Carter method of anthropometric somatotype is the most widely and commonly used method.

There are certain factors that influences the determination of somatotype which are: age, physical performance, nutrition, smoking habits, genetic factors, high altitude and occupation. There are various limitations that comes at the time of assessing somatotyping because of the stigma that had been in the research areas that relates biological causes of crimes. As per the surveys, it has been reported that Sheldon's method of somatotyping was consuming less time in comparison to other methods and is less expensive. The other limitation of this approach that it requires subjects to get naked for the purpose of measurement, and along with that pictures were also taken, with that some of the subjects were not comfortable.

11.2 METHODS IN THE ASSESSMENT OF PHYSIQUE

11.2.1 Viola's Method (1921)

In the 20th century, an Italian physician named Viola, suggested a classification of physique based on anthropometric measurements. All these measurements are combined with each other and derives to originate different indices, which are further used for the classification of human body.

The ten measurements for the purpose are

a) Sternum length,

b) Upper abdominal height,

c) Lower abdominal height,

d) Arm length,

e) Leg length,

f) Transverse thoracic diameter,

g) Antero-posterior thoracic diameter,

h) Transvere hypochondric diameter,

i) Antero- posterior hypochondric diameter,

j) Biiliac diameter.

The following values or indices were then calculated using different measurements of human body:

Thoracic Index = 'Length of thoracic' + 'breadth of thoracic' + 'depth of thoracic'

Upper Abdominal Index = 'Breadth of upper abdominal' + 'Length of upper abdominal' + 'Depth of abdominal'

Lower Abdominal Index = 'Breadth of lower abdominal' + 'length of lower abdominal' + 'depth of abdominal'

All these above measurements are used to calculate the Total Abdominal Index,

Total Abdominal Index = Index of upper abdominal + index of lower abdominal

Then, these measurements are further combined with each other to derive the trunk and extremities values in a following manner,

Trunk Value = Index of Thoracic + Total abdominal Index

Limb value = Length of upper extremity + Length of lower extremity

Other factors were also taken into account, such as stature, trunk height, and total abdominal height. A measure of trunk volume and four morphological indices are calculated , namely the thoracic index, upper abdominal index, lower abdominal index, and total abdominal index, using all of these measures.

He grouped physique as four types (Singh , 2007)

a) **Longitype** having relatively long limbs compared to the trunk, massive thorax compared to the abdomen, and greater transverse diameters relative to the antero-posterior ones;

b) **Brachitype** or broad type, having the characteristics opposite to those of the longitype;

c) **Normotype** which fall in between the above two categories and

d) **Mixed type** who show characteristics of different types in different parts of the body, i.e. they maybe brachitype in one part, longitype in the other and normotype in still another, etc

11.2.2 Kretschmer's Method

A German psychiatrist named Kretschmer (1921) defined and explained the attributes/ characteristics of three forms of humans which are : pyknic or fatty, athletic or muscular, and leptosome or lean, in the early twentieth century. His approach consisted of anthroposcopic studies of human subjects. Kretschmer also linked a person's physique to their personality traits, such as temperament. (Singh, 2007).

In the first edition of his book "Korperbau und Charakter" (Physique and Character) published in 1921, Ernst Kretschmer identified four physical and psychic types: pyknic, athletic, asthenic, and dysplastic physiques. Later, leptosomic was used instead of asthenic.

According to this method,

a) **Pyknic type** has a short stature. They have thick bodies and narrow shoulders. These types of individuals have large and heavy head, massive thoracic and abdomen, and their extremities are more developed.

b) **The leptosome** is characterized by linearity of trunk, limbs, and face. The bones are small and there is little musculature.

c) **Athletic physique** also called as leptosome, has a well-developed musculature and bony structure and the body is generally well proportioned They have less amount of fat in their bodies, but have substantial muscle amount.

d) **Dysplastic category** covers individuals with incongruous admixtures of the other three types.

Check Your Progress 1

1) What is Somatotype?

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2) Write the Viola's and Kretschmer's method of Somatotyping.

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11.2.3 Sheldon's Method

When you look into the aspects of life, there are various factors required to be taken into consideration. These things involve the basis of our thoughts, what is believed to be true, and what is believed to be false. This is the constitutional theory that majorly concentrates on the findings and the results behind the behavior of crime and how this theory is dealing with the crime and criminology. Let's study in detail about this method,

William Herbert Sheldon (1898-1977), an American physician was a pioneer in the field of research, having established Somatotyping as a method for analysing and measuring human body shape. In the year 1940, Sheldon along with the contribution of S.S Stevens and W.B Tucker, presented the concept of somatotype in the book '*The Varieties of Human Physique*". They coined the name and definition of somatotype. As the three basic elements determining body builds, the focus of Sheldon was on intestines which are produced from embryological Endomorphy, bones and muscles developed from Mesomorphy, and skin, sensual organs, and nervous development from Ectomorphy, and then they are combined to classify into a few categories. Sheldon also proposed that every individual (instead of being a specific type) was a combination all the three elementary physical characteristics which are:

- Ectomorphy
- Mesomorphy, and
- Ectomorphy

Endomorphy: As per Sheldon, endomorphy is described as a virtual preponderance of soft roundedness in the human body. The term endomorphy refers to a feature of the body that is derived from the endoderm, the innermost embryonic layer. The predominance of digestive viscera appears to be the cause of the characteristic endomorphs with fatty deposition and soft rounded features. There are tendencies to overeat, and as a result, the body assimilates more than is needed.

Mesomorphy: The mesoderm, or middle embryonic layer, is responsible for the formation of bones, muscles, and connective tissues. The second portion of physique, or mesomorphy, contains these constituents. Mesomorphy refers to the body's virtual predominance of muscle, bone, and connective tissue. The shape of a mesomorphic body is usually heavy, hard, and rectangular.

Ectomorphy: Ectomorphy denotes a preference for linearity and fragility over other characteristics. As a result, tissues originating from the ectodermal embryonic layer are comparatively dominant in his bodily economy.

A person's somatotype is determined by the contribution of the three components described above. To put it another way, Sheldon determined that each person was a mix of all three components of physique rather than belonging to a single form, and that the components were present in varying degrees in different people. Sheldon analysed 4000 male college students to determine the spectrum of human physique variations. Sheldon uses other parameters as well such as height, weight and three photographs of a front, side and rear views of the naked participants in a standardized format.

To prevent deformation when photographing the students, special attention was paid to the type of camera, lens, camera distance, and lighting. Somatotyping was performed using visual observations on naked images of the student in the three poses. From the above-mentioned survey, he was able to identify as many as 79 different types of physiques.

Somatotype can be written in three numeral forms where the first numeral is for Endomorphy, the second is for Mesomorphy and, third indicates Ectomorphy. Sheldon's components of physique were rated on a 7- point scale, with each component ranging from 1 to 7, where 1 value was assigned to the least or minimum possible development, 4 indicating moderate expression, and 7 was assigned to the maximum development. Sheldon's rating scale consisted of no rating higher than 7 and no rating lower than 1 for any one variable. Because of the fact that no human displays a complete lack of any physique segment, zero value was not assigned.

Sheldon found out that there were three extremes in physique/body size. 7-1-1 indicates the first extreme, which represents Endomorphy. 1-7-1 indicates extreme mesomorphy, 1-1-7 indicates Ectomorphy which represents the third extreme. 711, 171 and 117, all of which had a negligible proportion in the entire sequence, suggesting that these extreme types are extremely rare. 4-4-4 represents a balanced somatotype with all the three body components being equally represented. Sheldon also found out that an individual cannot have extreme somatotypes of 7-7-7 or 1-1-1. A person with an extreme is one component cannot have an extreme in another component of physique. Sheldon identified 76 different somatotypes, with 3-4-4, 4-3-3, and 3-5-2 being the most common. The somatotype is determined by the number of the ratings for each variable, which must be no less than 9 and no more than 12.

The Somatotypes with the extreme value were as follows; with Extreme Endomorphic people (i.e Somatotype rating is 7-1-1) having soft and round body parts, round head, flat abdomen, weak legs, the thighs and upper arms which are fatty and weak, well developed and built wrists, and ankles, less linearity and muscularity, more fat deposition. Sheldon also highlighted that Endomorphic people were more susceptible to diabetes and depression. Extreme Mesomorphic (i.e Somatotype rating is 1-7-1) means the relative predominance of bone, muscles, connective tissue with muscled arms and legs, uneven body with the rectangular outline. Broad shoulders, massive head in a cubical form, chest, less fat deposition and linearity. Extreme Ectomorphy (1-1-7) is characterised by linearity which is a common trait, the face is slim, the forehead is high, the chin is receding; the chest and abdomen are thin and narrow; there is less weight and muscularity. Ectomorphy has been attributed to pulmonary tuberculosis, anxiety, and schizophrenia susceptibility.

Later in 1954, Sheldon published "Atlas of Men," a book focused on a massive survey of 46,000 human subjects ranging in age from 18 to 64 years old and from all walks of life. Tables of the distribution of height over cube root of weight ratios at various ages were created using this extensive data. Using this distribution, the somatotyping process was rendered less time-consuming and subjective. At any given height-to-weight ratio, only a few somatotypes are possible. First, the height-to-weight ratio is determined, as well as the somatotypes that can be assigned to that ratio. Then the somatotype photograph of the subject is compared with standard photographs available in an atlas, to make out with which it tallies most and a final decision is made regarding his somatotype.

Sheldon later created somatotype-HWR (height weight ratio) tables to aid raters in rapid somatotyping. These tables show the various somatotypes for a given height-to-weight ratio. It is considered to be easier to find out the most suitable and ideal somatotype from a limited range. Based on people with 18 years and above, 1175 somatotype photographs were given. Four criticisms persisted despite this approach: (1) somatotypes alter, (2) somatotyping, method is non-objective, (3) instead of three, there are two primary components, since both ectomorphy and endomorphy are basically opposite of each other, and (4) somatotyping ignores one of the most important factors i.e., size. In reply to the above discussed criticism and negative responses to his somatotype scheme, which was reported and then published in '*The Varieties of Human Physique*' and in the '*the Atlas of Men*', Sheldon developed a new index method for new trunk. The trunk index is the "ratio of the area of the thoracic trunk to the area of the abdominal trunk" in a subject's somatotype photograph. Planimetric measurements of a typical somatotype photograph were used to determine the required ratio. A planimeter is a basic geometrical instrument that is useful in areas of calculation of non-uniform figures. A new somatotyping method was developed based on the trunk index and 7 –point scale was retained in the new method. Moreover, the sum of the three components of the somatotype may vary from 7 to 15.

The trunk index method bore no resemblance to Sheldon's previous methods, but it did not appear to address any of the critiques levelled at the original Sheldon somatotyping process. It lacked scientific accuracy and was not based on a theory that had been tested. On the basis of anthropometric measurements, several attempts by various scholars were made later in this direction to make somatotyping more objective, simpler and to be easily executed. The Heath-Carter somatotyping process, which is based on anthropometric measurements, is one such attempt to meet those criteria to a large degree and is commonly used

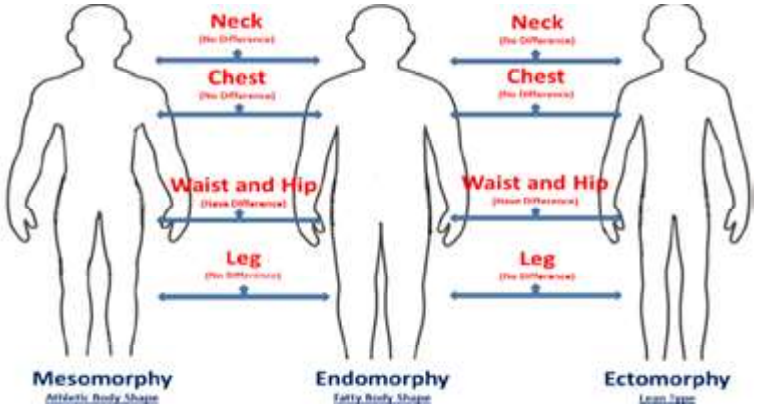

Fig. 11.1: Comparison of Body types

around the world. The Heath-Carter somatotyping approach has been widely used in anthropology, sports sciences, human biology, and infant development research, among other areas.

Sheldon was consistently criticized for his work on somatotyping because of certain features:

- The changes in relation to somatotyping
- Somatotyping is not considered to be objective
- Somatotyping does not consider size as a factor

Sheldon described a new method of Trunk Index to meet all these above discussed criticisms. It is derived from the ratio of the thoracic and abdominal areas measured on the photographs taken for somatotrophic measurements.

- This index is presumed to be constant throughout the life and it is also possible that in the series of different life stages, the area of the thoracic trunks to the trunk of abdomen remains constant. These two areas increase/ decrease in size in respect of one another.
- He also reported a method for measuring the massiveness i.e., HWR, a trunk index that is a separator for the different types of masses into mesomorphy and endomorphy, then, finally a measure of rate of stretching out to a respective height. When the last two factors are known, that is called what ectomorphy is defined as.
- In this new approach, height is used as one of the factor to measure size, and it is a substitute for ectomorphy.
- The original matrix that is come out to be of 76 somatotypes and it is expanded to 88, thus the matrix of trunk index provides 267.

11.2.4 Parnell's Method

R.W Parnell, British physician described the first method of somatotyping based entirely on anthropometry in his 1958 book titled Behavior and Physique. Parnell determined the physical kinds on the chart in term of several factors such as Fat, Linearity, and Muscularity. This corresponds to the Sheldon's classification: Endomorph, Mesomorph, and Ectomorph respectively. Parnell devised a rating system based on anthropometric measurements, and he reported the results in M.4 deviation charts, which he used in conjunction with the photographs. Parnell's method to determine somatotype provides supervision on the dominance of components related to somatotype in an healthy individual.

- To estimate the somatotype by Sheldon objectively and precisely.
- To predict the women's somatotype possible.
- To reduce the labour, time and cost at the time of conducting somatotyping.

A method was devised known as Parnell's M.4 deviation chart approach that determines somatotype objectively. Therefore, Parnell's method was more objective in comparison to the Sheldon's method.

Height, weight, and measurements of biceps and calf muscle girth, femoral and humeral epi-condylar diameters, and skinfold thickness in three areas (triceps,

subscapular, and suprailiac) are all needed in Parnell's somatotyping process. Assessments of fat, muscularity and linearity were obtained to the nearest quarter point on a seven scale, giving phenotypes similar to Sheldon's somatotypes.

Parnell replaced Sheldon' component name with fat, muscular (muscularity), and thin type (linearity), abbreviated as F, M and L, respectively.

The fat (endomorphy type) type decision is based on skinfold measurement while the muscular type (mesomorphy type) works based on height, bone diameter, and limb thickness. The thin type (ectomorphy type) works based on HWRs. The phenotype, not the somatotype, was the focus of this method of somatotyping (Duquet, 2001; Carter, 1980).

Check Your Progress 2

3) Write Parnell's method of Somatotyping.

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4) Write Sheldon's Method of Somatotyping.

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11.2.5 Heath-Carter Method

During the last two decades, the Heath-Carter somatotyping approach has been commonly used around the world. It has a wide range of applications in sports sciences, anthropology, human biology, child development, and other fields. It is based on anthropometric measurements which are easy to take on the subjects. Heath (1963) investigated the flaws in Sheldon's approach and proposed changes and modifications. Heath and Carter developed their own somatotyping system in 1967. Though this approach varies from Sheldon's in that it assesses the body shape or physique at a given time as opposed to Sheldon's unchanging somatotype. The ratings of three primary components of physique are allocated from the tables or can be determined directly using equations given by Carter (1980), Heath and Carter (1990), and Carter (1996).

In Health and Carter Method, there are three way to obtain somatotype,

- Anthropometric method, where the anthropometry measurements are used to predict the somatotype criteria.
- Photoscopic method, where to obtain the ratings, standard photograph are used.

- Anthropometric plus Photoscopic, where the combination of both develops a criterion method.

Sometimes, most people somehow do not get the opportunity to become raters of criterion using photographs, the anthropometric approach has proven to be the most helpful for number of applications.

Somatotype is described by the Health-Carter method as a quantitative description of the current shape and composition of the human body. Endomorphy, mesomorphy, and ectomorphy are three components of physique that are represented by the somatotype in a three-number rating. Endomorphy refers to relative fatness, mesomorphy refers to relative musculo skeletal robustness, and ectomorphy refers to relative linearity. Ratings on each somatotype component of ½ to 2½ years are considered low, 3 to 5 are moderate, 5½ to7 are high, and 7½ and above are very high. It is applicable to both the genders from childhood to old age.

Heath and Carter calculated somatotype using both photoscopic and anthropometric methods (Carter, 2002).

The following are the somatotype components and measurements used in the Heath-Carter anthropometric protocol to determine each component:

1) **Endomorphy** the first aspect, is described as the total of three skinfolds: triceps, subscapular, and suprailiac. It refers to a person's physique's relative fatness.
2) **Mesomorphy** the second aspect, refers to relative musculoskeletal growth that has been calibrated for stature. It is defined as the ratio of fat-free mass to stature. Mesomorphy is calculated using biepicondylar breadths of the humerus and femur, flexed-arm circumference corrected for triceps skinfold thickness, and calf circumference corrected for the thickness of the medial calf skinfold. Subtracting the skinfold thickness from the circumference is what it takes to correct the circumferences. These four measurements are then adjusted for stature.
3) **Ectomorphy** the third part, is the relative linearity of the build. The reciprocal ponderal index is used to calculate it..

There are three ways of obtaining the somatotype (Carter, 2002).

1) The anthropometric method, in which anthropometry is used to estimate the criterion somatotype
2) The photoscopic method, in which ratings are made from a standardized photograph.
3) The anthropometric plus photoscopic method, which combines anthropometry and ratings from a photograph -it is the criterion method.

The anthropometric method has proven to be the most useful for a wide variety of applications. Following anthropometric measurements are required for obtaining the somatotype: height, weight, triceps skin fold, subscapular skinfold, supraspinale skinfold, calf skinfold, humerus biepicondylar diameter, femur biepicondylar diameter, bicepsgirth, calf girth.

Measurement Techniques-

1) **Stature (height).** Taken against a height scale or anthropometer.

2) **Body mass (weight).** The subject, wearing minimal clothing, stands in the center of the scale platform.

3) **Skinfolds**- Raise a fold of skin and subcutaneous tissue firmly between thumb and forefinger of the left hand and away from the underlying muscle at the marked site. Apply the edge of the plates on the caliper branches 1 cm below the fingers of the left hand and allow them to exert their full pressure before reading at 2 sec the thickness of the fold.

   Triceps skinfold. With the subject's arm hanging loosely in the anatomical position, raise a fold at the back of the arm at a level halfway on a line connecting the acromion and the olecranon processes.

   Subscapular skinfold. Raise the subscapular skinfold on a line from the inferior angle of the scapula in a direction that is obliquely downwards and laterally at 45 degrees.

   Supraspinale skinfold. Raise the fold 5-7 cm above the anterior superior iliac spine on a line to the anterior axillary border and on a diagonal line going downwards and medially at 45 degrees.

   Medial calf skinfold. Raise a vertical skinfold on the medial side of the leg, at the level of the maximum girth of the calf.

   Biepicondylar breadth of the humerus, right. The width between the medial and lateral epicondyles of the humerus, with the shoulder and elbow flexed to 90 degrees.

   Biepicondylar breadth of the femur, right. Seat the subject with knee bent at a right angle. Measure the greatest distance between the lateral and medial epicondyles of the femur with firm pressure on the crossbars in order to compress the subcutaneous tissue.

4) **Upper arm girth, elbow flexed and tensed, right**. The subject flexes the shoulder to 90 degrees and the elbow to 45 degrees, clenches the hand, and maximally contracts the elbow flexors and extensors.

   Calf girth, right. The subject stands with feet slightly apart. Place the tape around the calf and measure the maximum circumference.

Standard protocol is followed for taking measurements. Read stature and girths to the nearest mm, biepicondylar diameters to the nearest 0.5 mm, and skinfolds to the nearest 0.1 mm (Harpenden caliper) or 0.5 mm on other calipers.

The algorithms for estimating a somatotype with the Heath-Carter anthropometric protocol are as follows (Carter, 2002)

a) **Endomorphy** = $-0.7182+0.1451\ (X)-0.00068(X^2)+0.0000014(X^3)$

   Where, X = "3 skinfolds viz. triceps, subscapular and supraspinale skinfolds; and adjustment for stature is made where X is multiplied by 170.18/ height(cm).

b) Mesomorphy = (0.858 × humerus breadth + 0.601 × femur breadth + 0.188 × corrected arm girth +0.161 × corrected calf girth) -(0.131× stature) +4.50

Where, Corrected arm girth = Arm Girth –Triceps skinfold in cm and Corrected calf girth = Calf girth (in cm) – medial calf skinfold in cm

c) Ectomorphy = 0.732× HWR -28.58 (If HWR>40.75)

= HWR × 0.463-17.63 (If HWR>38.25 but equal or less than 40.75)

= 0.1 (If HWR is equal to or less than 38.25)

Where HWR = Height in cm divided by cube root of weight in kg

Anthropometric somatotyping has the following advantages: 1) It is an objective method of somatotyping.2) In the absence of a photograph, the best estimate of a criterion somatotype.

Limitations of Health-Carter Method

1) Endomorphy i.e., the first segment signifies the fat free mass and the mesomorphy i.e., the second component represents the fat mass. The somatotype concept of Sheldon only refers to shape of the body, but not to the composition of body. Although, both type of methods uses somatotype term but derives different meaning.
2) Endomorphy correlates ideally in terms of body fat, though fat free mass links poorly with the mesomorphy. Additionally, the relation between muscularity of limbs and mesomorphy is comparatively low in case of athletes on the basis of dual ray X-ray absorptiometry. The validation is required of the relationship obscured in the concepts defining physique.
3) In the Health-Carter method, the variation in the duplicability of the somatotype components is directed by intra and inter- observer measurements.
4) This method is not proved to be valid for 6 years children or below than that. This could be one of the factors characterized to studies that projects high mesomorphy ratings in young children.

11.3 FACTORS WHICH AFFECT SOMATOTYPE

Human body shape is a complex phenomenon with sophisticated detail and function. The general shape or figure of a person is defined mainly by the moulding of skeletal structures, as well as the distribution of muscles and fat. Skeletal structure grows and changes only up to the point at which a human reaches adulthood and remains essentially the same for the rest of his or her life (Norton, 1996).

Female traits

Widening of the hip bones occurs as part of the female pubertal process, and oestrogens (the predominant sex hormones in females) cause a widening of the pelvis as a part of sexual differentiation. However, not all females adhere to this stereotypical pattern of secondary sex characteristics.

Male traits

Widening of the shoulders occurs as part of the male pubertal process. Expansion of the ribcage is caused by the effects of testosterone during puberty.

Fat distribution

Estrogen causes fat to be stored in the buttocks, thighs, and hips in women. When women reach menopause and the estrogen produced by ovaries declines, fat migrates from their buttocks, hips and thighs to their waists. Later fat is stored in the belly. Thus females generally have relatively narrow waists and large buttocks, and this along with wide hips make for a wider hip section and a lower waist-hip ratio compared to men. Hormonal and genetic factors may produce male-like distribution of fat in women i.e. around the belly instead of buttocks and thighs.

Estrogen increases fat storage in the body, which results in more fat stored in the female body. Body fat percentage recommendations are higher for females, as this may serve as an energy reserve for pregnancy. Males have less subcutaneous fat in their faces due to the effects of testosterone; testosterone also reduces fat by aiding fast metabolism. Males generally deposit fat around waists and abdomens due to the lack of estrogen.

Muscles- Testosterone helps build and maintain muscles through exercise. On average, males have around 10 times more testosterone than women. Prominent muscles of the body include the latissimusdorsi, trapezius, pectoral muscles as well as biceps and triceps in the arms and quadriceps and hamstrings in the thighs (Cameron, 1984; Bell, 1993; Norton, 1996).

Check Your Progress 3

5) Write Heath-Carter Method of Somatotyping.

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6) Write factors related with Somatotype.

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11.4 SUMMARY

Anthropometry is the means of quantifying variation in body size and shape and universally accepted and applicable in health sciences. Human body composition and physique phenotypes are complex multifactorial traits. These traits have

evolved under the interactive influence of dozens of effectors from the social, behavioural, physiological, metabolic, cellular and molecular domain and expressed as qualitative and quantitative observable variables. Worldwide variation in body size, body proportion and body physique exist between the genders and among different populations. An individual's body physique is influenced by a multitude of factors such as gender, age, ethnicity, dietary pattern, genetic and evolutionary factors, and multiple environmental factors as well. A person's physique not only defines the form of his or her body, but it is also a primary determinant of a healthy life. Somatotyping is a unique system of classification of human physique. It conveys the sense of the human body's totality of morphological features and reflects the body's overall outlook. Endomorphy, mesomorphy, and ectomorphy are used in the assessment of physique derived from various methods such as Viola's Method, Kretschmer's Method, Sheldon's Method, and Heath – Carter Method. Finally, somatotyping is regarded as a reasonable tool for quantifying existing human body shape and structure, and it has undergone continuous development in terms of methodological issues.

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11.6 ANSWERS TO CEHCK YOUR PROGRESS

1) Somatotyping is a unique system of evaluation and classification of human physique. For details refer to Section 11.1

2) Viola suggested classification of physique based on anthropometric measurements. Kretschmer explained the three forms of human: pykni or fatty; atheletic or muscular and leptosomes or lean. For details refer to section 11.2.1 and 11.2.2

3) Parnell's determined the physical kinds on chart in terms of fat, linearity and muscularity. For details refer to section 11.2.4

4) Sheldon was a pioneer establishing somatotyping as a method for analysing and measuring human body shape. For details refer to section 11.2.3

5) Heath –Carter method has been commonly used worldwide. For details refer to section 11.2.5

6) Human body shape is a complex phenomenon. For details refer to section 11.3

UNIT 12 HUMAN PHYSIQUE

Contents

Learning Objectives

After reading this unit, you will be able to:

- understand variation in human physique;
- learn the gender and ethnic difference in human physique; and
- comprehend the association of physique and health in different ethnic groups.

12.0 INTRODUCTION

Human Physique refers to an individual's body form. It is the configuration of the whole body rather than its particular features. Human Physique can be observed easily, and it is helpful in understanding variation in physiques among individuals in the same or different populations. Human physique can be evaluated by a method known as somatotyping, which is a physique classification system of quantified expression. It is the description of body type on the basis of three component parts, namely ectomorphy, mesomorphy and endomorphy. Ectomorphy refers to relative slenderness, mesomorphy refers to relative musculo-skeletal robustness and endomorphy refers to relative fatness of physique.

William Herbert Sheldon, an American psychologist and physician introduced the concept and the word 'somatotype' in 'The Varieties of Human Physique' (Sheldon and Tucker, 1940). Somatotype is expressed as a combination of three numbers; each number shows the strength of the respective component parts, endomorphy, mesomorphy and ectomorphy. Physique has been found to be associated with a variety of behavior, performance, health and diseases.

Sheldon perceived the usefulness of his somatotype constitutional studies in linking body types with physical fitness, proficiency, behavioral and diseases. Extreme endomorphy is characterized by rounded and soft body parts, feeble arms, fatty thighs and arms. They have slim ankles and wrists. They are usually susceptible to diseases such as diabetes and depression. Extreme mesomorphy is characterized by relative predominance of muscles, bone and connective tissues. Mesomorphic people have muscled legs and arms. They usually have broad

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shoulders and chest. They are hard, heavy and rectangular in outline. Mesomorphy has been associated with coronary heart disease and hysteria. Extreme Ectomorphys characterized by fragility and linearity. They have narrow chest and abdomen. Endomorphic people have less muscle and fat. Ectomorphy has been linked to pulmonary tuberculosis and anxiety issue.

Somatotyping technique is used to assess body shape and composition. Though there are various methods of studying physique, Heath and Carter's classical method of anthropometric somatotype method is the most widely used technique of somatotyping. The anthropometric method of assessing physique has become prominent. It has exhibited to be the most useful method for a wide range of applications. To calculate the anthropometric somatotype, there are 10 anthropometric measurements that are required, which include height, bodyweight, triceps skinfold, supra spinale skinfold, subscapular skinfold, calf medial skinfold thickness, two limb girths (arm flexed and tensed calf) and two bone breadths (biepicondylar humerus and femur). Anthropometric somatotype can be calculated by entering the data into a somatotype rating form or by adding the data into equations derived from the rating form. The analysis of somatotype components allows a definition of body type. It describes the physical features of the body.

Check Your Progress 1

1) What is Human Physique?

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2) Explain Somatotyping.

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12.1 VARIATION IN HUMAN PHYSIQUE

Biologist and Anthropologist recognized the existence of distinct human body types and have been trying to understand the multidimensional range of human variation. Analysis of Physique has been a vital matter in courses on human biology. The history of human physique analyses and classification can be traced back to as early as 5thcentury BC. Existence of numerous classification systems of human body types indicates the considerable interest in constitutional investigation.

There was remarkable advance in the study of human physique over preceding system of classification with the formation of Sheldon's somatotype method of physique analyses. Sheldon's concept of somatotype, providing three dimensional systems for human physique analyses, and modifications of Sheldon's method by Health and Carter have created a valuable research tool for the study of human physique variation. In somatotype, the theoretical approach is built on the principle that persistent difference happens in the distribution of physique, therefore the variation is related to differential contributions of three components parts, endomorphy, mesomorphy and ectomorphy which are termed based on three embryonic germ layers.

Each of these three components is individually rated at from 1 to 7 (1 as minimal development and 7 as maximal development). Somatotype is classified by number. 711 is the extreme endomorph, 171 is the extreme mesomorph, and 117 is the extreme ectomorph. 443 and 344 are somatotypes which occur commonly among male population. These may be considered as types in which all three somatotype components have approximately equivalent development. By the three-fold seven-rank system, three hundred and forty-three different somatotypes are made theoretically possible but, since the components are to some extent mutually contradictory, not all the types can appear in nature. In practice, Sheldon and his followers observed that seventy-six different somatotypes appeared in a group of four thousand male students, and that only thirteen accounted for over fifty percent of the group (Sheldon and Tucker, 1940).

12.2 GENDER DIFFERENCES IN HUMAN PHYSIQUE

There are gender differences in body size and shape throughout life starting from first trimester of the prenatal stages of human growth and development. Males are larger and more muscular, with longer and heavier body as compared to females. Males also have larger lean body weight than females. Even during early stage in life when sexual dimorphism is not much visible, boys are noticeably larger than girls of the same age. There are differential rate of growth and development in boys and girls of the same population. Gender differences in weight gain have also been observed.

Body constitution is the totality of morphological, physiological and psychological characters of a person. Body constitution in males and females are different with variation in the different component parts. Body constitution is governed mostly by genetics and affected by differing degrees by environmental factors.

Somatotype is independent of size as it is an overview of the total physique. Somatotyping provides an evaluation that reduces many physical characteristics to the three-digit somatotype rating. Somatotyping describes the biological features of the human body. It allows a description of body type through the assessment of metric characters. Anthropological studies conducted among populations showed variations in the somatotyping components in males and females. Mean value for endomorphy was found significantly higher among females than males in different age groups. It further strengthens the assertion that females are relatively fatter than their male counterparts in all life stages. There was a gradual increment of endomorphic component from the youngest age group till fourth decade of life and declined slightly thereafter in the older

age groups among males. Among females there was no specific age trend found among the younger age groups but the value was found maximum in fifth decade and declined in the oldest age group. Among both males and females relative fatness was found maximum in middle age.

Mesomorphy was found higher among males than females in most of the age groups. There was a gradual increment of mesomorphic component from the youngest till fourth decade in males and in females till fifth decade and slightly declined thereafter but the value was still higher when compared to the youngest age group. Males showed more relative muscularity than females. Mesomorphic value was found maximum among individuals in middle age groups.

The mean value for ectomorphy was found to be significantly higher among males than females in all the age groups. It showed that relative linearity was more in males than their female counterparts in all age groups. Ectomorphic value was found maximum in the youngest age group and gradually declined till fourth decade in males and fifth decade in females and slightly increased thereafter in the older age groups.

Somatotyping showed that females are fatter than their male counterparts and males are more muscular and linear. Somatotypes show great variation among individuals and populations, and although such variability can be genetically determined to a certain extent, environmental factors also play an important role on the modification of the genetic contribution (Bouchard, 1988; Mungreiphy 2010).

Adult males are normally taller than females in various populations and across different socioeconomic groups. The increased height in male is overtly expressed in the appendicular skeleton, which is a factor of substantial importance in designing and operating vehicles and equipment. Adult male usually has more lean body weight than female. This sexual dimorphism in lean body weight ratio is reflected in differential basal energy requirements in males and females. It is also reflected in the caloric allowances set in Recommended Dietary Allowances guideline. Males are much taller and heavier than females though there are significant variations in height in different populations. The differences in height and weight are attributed to both genetic and environmental factors such as geographical location, culture, physical activity, hormones and nutrition.

The shape of the different bones and relative proportions are more of inherited characteristics, even though dimensions may be altered by vigorous training if this commenced before closure of the epiphysis had been achieved (Shephard et al., 1978). Overall and regional variations in body form can be attributed to adaptive value. Various anthropometric measurements are essential in evaluation of physique. The diameters of wrist, elbow, knee and ankle which are measures of bone width of the extremities, and biacromial breadth, bicristal breadth and bitrochanteric breadth which represent the trunk region showed different age trend in males and females. There was no similar age trend observed among males and females in most of the diameter measures, except for biacromial breadth which showed decreasing age trend and bicristal breadth showed increasing trend till fifth decade of life and decline thereafter. The decrease in biacromial breadth with age and overall increased in bicristal breadth with age have been observed in various studies (Damon et al., 1972; Mungreiphy, 2010)

The diameters of wrist, elbow, knee and ankle were significantly more among males than females in different decadal age groups. Among males, the differences in mean value for wrist, elbow and ankle diameter between age groups were all statistically non significant whereas among females there were significant differences in mean values between age groups. It showed more variations in bone diameters and therefore more heterogeneity in females. Biacromial breadth and bicristal breadth were found more among males than females in all the age groups, whereas bitrochanteric breadth was found more among females in some age groups. It showed significant sexual dimorphism in all the diameters and breadths with higher value among males except for bitrochanteric breadth, which is in consistence with females having broader hip (Mungreiphy, 2010).

Circumference measurement is another important anthropometric measurement which is the cross-sectional measurement of subcutaneous fat, skeletal mass and muscle mass. Circumference measures regional fat and muscle mass. Hip circumference is taken of the widest portion of hips. Waist circumference which is the measurement made at the around the narrowest point between the lower margin of the last palpable rib and the top of the iliac crest is an index of deep adiposity. Waist circumference is a common measurement used to evaluate abdominal fat content. The presence of excess body fat in the abdomen, when out of proportion is considered an independent predictor of risk factors and ailments associated with obesity. Waist circumference has been identified as a simple predictor of health risks.

There are distinct sexual dimorphisms observed in different circumferences measures. Waist and hip circumferences are usually higher among females than among males which showed that females localise excess body fat mainly around waist and hip region. Fat on the hips is typical for women and is referred to as gynoid or lower body fat distribution. Other circumference measurements such as upper arm circumference and calf circumference are more among males than females. Chest circumference at normal respiration, maximum inspiration and maximum expiration are higher among males depicting more musculature and better chest expansivity among males.

Circumferences measurement of upper arm, chest at normal respiration, maximum inspiration and maximum expiration, waist, abdomen, hip and calf showed age related increasing trend till middle age mostly up to the 59 years of age and declined in the oldest age group among both males and females. Various investigations also showed continuous increase of upper arm, waist, abdomen and hip circumference with age till fifth decade of life but thereafter showed a decline with age in both males and females (Kapoor and Tyagi, 2002; Mungreiphy, 2010).

Skinfold thickness is an index of subcutaneous fat and hence it measures fat content in the body. The use of circumference taken at the abdomen or waist and hips had been useful for assessing regional fat distribution, but measuring skinfold thicknesses on the trunk region and extremities mainly the subscapular skinfold thickness also appear to be useful (Bray and Gray, 1988).

There are gender differences and age trend in skinfold thickness taken at different sites. This is due to gender differential responsiveness and redistribution of fat with age. Skinfolds thickness measures showed age related increasing trend from young adult till middle age group and a decline thereafter among males. Among

females, biceps, triceps, suprailiac, calf posterior and calf medial skinfold thickness were found maximum among young adult and decreasing trend among older age groups. Subscapular and abdomen skinfold thickness was found maximum in fifth decade of life. The decline in skinfold thickness in advanced age can be due to decrease in subcutaneous fat as a result of reduced energy intake, or it could be due to fat redistribution in favor of internal fat.

Skinfold thickness measurements on both the trunk region and extremities were found more among females than males depicting more subcutaneous fat and hence body fat content than males. Though males are usually heavier than females as assessed from weight, skinfold thickness measures showed that females have more body fat content than their male counterparts at all stages of life, which also implies that males are more muscular and have heavier bone structure than females.

Waisthip ratio, which is the ratio of waist circumference to hip circumference, provides an index of the regional distribution of body fat. It is a valuable guide to health risks. The WHO experts have indicated that other anthropometric measurements, especially waist circumference, can be widely used as measures of health along with BMI. It is because they reflect body-fat distribution pattern and could better predict the risk of metabolic disease. The level of general adiposity can be assessed with the help of body mass index and grand mean thickness, which is the measure of subcutaneous fat deposit over the body. There are gender differences in adiposity with females having more fat than males as reported in various population studies.

Check Your Progress 2

3) Explain the gender difference in anthropometric measurements and physique.

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12.3 RELATIONSHIP OF PHYSIQUE WITH ADIPOSITY AND HEALTH

In Human Biology, study on body shape through somatotyping is a long-term tradition. The anthropometric method of somatotype computation by Heath and Carter (1967) has become one of the most employed phenotypical methods. Somatotype characteristics are not constant physical classifications, as anthropometric measurements in specific moments of the individual's growth and development can be affected by various factors such as health status, physical activity or nutrition. Genetic factors also greatly influence the variation in human physique, which is the overall configuration of the entire body. Physique may play an important role in individual's health status and disease outcome.

Relationship between different categories of body mass index and somatotype components were observed. Endomorphy increased with increasing BMI from

lowest to the highest BMI category and the maximum endomorphic value was found among obese category among both males and females. Mesomorphy also found minimum among underweight and increased with increasing BMI from underweight to normal BMI and then to overweight and obese category among both males and females. It showed that endomorphy and mesomorphy increased with increasing BMI among both males and females. But ectomorphy decreased with increasing BMI from lowest to the highest BMI category among both males and females. This shows that BMI is a measure of relative weight whether due to excess fat mass or muscle mass. For this specific limitation BMI should be used with selected skinfold thickness and circumference measurements for a clearer picture of body composition of population under study. Overweight and obesity are linked to high endomorphy and mesomorphy component.

Correlation study between somatotype components and obesity indices such as body mass index (BMI), waist stature ratio (WSR), waist hip ratio (WHR) and grand mean thickness (GMT) of skinfold thicknessess among males and females showed the association between them. There were significant positive correlations of endomorphy and mesomorphy with all the obesity indices but ectomorphy had significant negative correlation with all the obesity indices among both males and females. It showed that endomorphic and mesomorphic components increased with increasing obesity level whereas ectomorphy declined with increase in obesity whether it is general or central obesity.

Correlations between somatotype, specifically mesomorphy and endomorphy, and cardiovascular diseases have been reported. Significant positive correlations of endomorphy and mesomorphy with systolic and diastolic blood pressure was observed among both males and females. But ectomorphy showed significant negative correlation with systolic and diastolic blood pressure signifying that systolic and diastolic BP rise with increased in endomorphic and mesomorphic components but it declined with increased in ectomorphy. Correlation coefficient showed relationship of somatotype components with systolic and diastolic blood pressure to be strongest when compared with other physiological variables. Physique was found to be associated with cardiovascular and metabolic functions. Elevated endomorphy and mesomorphy has positive association with blood pressure and blood sugar level (Mungreiphy, 2010).

Blood pressure and in particular hypertension is a complex trait which may arise through a varied range of pathological mechanism. There are several environmental variables that have been identified to be associated with blood pressure. These variables include excessive adiposity, physical activity levels, dietary pattern, intake of sodium, smoking habit and alcohol in take etc. (Ward, 1990).

The relationship between physique and chronic medical conditions has been investigated extensively. Physiological processes regulating the development of physique can also play a role in specifying the ability of a person to resist infective factors (Malinovsky, 2000). Physique is also correlated to several noninfectious diseases, including diabetes mellitus, cardiovascular disease and cancer. Both elevated an upper body fat distribution as well as total body fatness appear to be an independent causal factor of non insulin-dependent diabetes mellitus. Some studies suggest that higher mesomorphy and endomorphy also influence endometrial, cervical and breast cancer risk. Elevated total body fatness is independently associated with gall bladder disease, and ectomorphy may be causally related peptic ulcer (Stephen, 1998).

Muscle mass may have significant impact on risk of cardiovascular diseases in addition to adipose mass. Various studies have shown that skeletal muscle strength is inversely correlated with the occurrence of cardiovascular diseases. There is growing indication implying that muscle tissue is an important organ affecting human metabolism and thus can directly influence risk of metabolic diseases (Tomas et al., 2004).

12.4 ETHNIC DIFFERENCES IN HUMAN PHYSIQUE

Ethnicity is a complex construct, which incorporates both cultural phenomena and biological characteristics. Ethnic or racial disparity in physique and body composition analyses are of concern to anthropologist, sport scientists and human biologist because these attributes influence health status, fitness level, strength, and performance. There are wide range of ethnic variations in physical traits which includes physique, body sizes, facial features, skin colors, hair colors and textures etc. Besides gene, environmental factors influence ethnic variation in physique and other biological features. Natural environmental forces operate on all the living forms, including human populations in any given habitat. Essential interaction with these environmental forces affects the survival and reproduction of its members. Long-term adaptation of human population groups to differing environments can cause variations in physique and other biological characteristics.

India is a multiethnic country and there are ethnic differences in physique, body composition, adiposity, and health outcome among different population groups. The National Family Health Survey which is a large-scale, multi-round survey conducted all over India showed diversity in socioeconomic status, health, biological and physiological parameters. Scheduled tribe and cast population, and especially tribal groups of northeastern part of India had lower mean BMI than the overall India population. Population groups with lower socioeconomic status have lower mean BMI as reflected from urban and rural comparison data.

Studies conducted to understand India's diversity in terms of biological and socio-cultural backgrounds showed variation in diverse populations. Different ethnic groups of India comprising of Indo-Aryan population from North India, Mongoloid population from North East India and Dravidian population from South India showed significant differences in body mass index, adiposity and cardio-respiratory health. There are genetic and environmental factors that influence the differences.

Body mass index, grand mean thickness and fat percentage indices were used to evaluate general body fat deposition in the studies. Results showed that Indo-Aryan population from North India had the highest general body fat accumulation as compared to the other two populations. However, central adiposity as assessed from waist–hip ratio, waist–height ratio and conicity index was found to be significantly higher among the Mongoloid population from North East India indicating a relatively more androidal pattern of fat deposition in the population. Most of the inter-population variation in adiposity was significant but there were not much ethnic differences in blood pressure showing differential relationship of fatness and physiological function in different ethnic groups. Respiratory functions differed significantly between the ethnic groups. Mongoloid population residing in hilly region of North East India had better respiratory efficiency than

the other populations. The differences in variations of respiratory functions were statistically significant among the different ethnic groups. The three ethnic groups showed noticeable differences in adiposity and cardiorespiratory health. Ethnicity, body dimension and cardio-respiratory health are interrelated (Mungreiphy et al.,2012).

Studies show that there are biological differences in the overall physique and body composition in diverse populations in different countries. Literature review on the differences and similarities between Blacks and White population groups relative to body dimensions, fat patterning and fat-free body mass assessments showed that in general, Black populations have a greater bone mineral density and body protein content than the White population groups, resulting in a greater fat-free body density. Moreover, there are racial differences in the length of the limbs relative to the trunk and the distribution of subcutaneous fat in different population.

Various studies clearly show that there are significant differences in the fat-free body of the blacks and whites. It has been shown from in *vivo* and cadaver analyses that blacks have a greater bone mineral content and bone mineral density than do whites. These racial disparities could considerably affect measures of body density and percentage body fat. One might contend that for a given body mass index; blacks might have less adiposity because of their greater predisposition toward mesomorphy. Therefore, surveys which use body mass index, might overestimate the prevalence of overweight and obesity in black populations. Since most equations that predict relative body fat were developed from mostly white populations, biological difference that exist between the races in body composition indicators has practical significance. If these inherent racial differences are overlooked, methodical miscalculation can result in the incorrect assessment of relative body fat of black populations, and hence of overweight and obesity (Wagner and Heyward, 2000).

There are steady differences between Black and White populations in variables linked to bone mineralization, with Black population exceeding the Whites. The lean body mass of Blacks may be of greater density in comparison to the White population. Overall morphological variation among populations is perhaps associated with performance rather than a factor of performance.(Himes, 1988)

Owing to the increasing evidence that the relationships between Body Mass Index, percentage of body fat, and body fat distribution vary across populations and consequently, the health risks surge below the cut-off point of overweight (25 kg/m^2) in some population, there was a deliberation for developing different body mass index (BMI) cut-off points for different ethnic groups. Scientific evidence indicates that Asian populations have different relationships between BMI, percentage of body fat, and health risks as compared to the European populations. The consultation established that the proportion of Asian people with a high risk of cardiovascular disease and Type 2 diabetes is substantial at BMIs lower than the WHO cut-off point for overweight. In Asian population, the risk associated with diabetes and cardiovascular diseases occur at lower levels of BMI when compared with the White population because of variation is attributed to body fat distribution. The WHO also encouraged a lower ceiling of normal BMI value in Asian Indians. In order to promote weight control and healthy lifestyles, the International Obesity Task Force, the World Health Organization and the International Association for the Study of Obesity proposed

lower cut-off points for overweight as BMI = 23.0 kg/m^{2}and obesity as BMI = 25.0 kg/m^2 in Asian and Pacific Island populations (WHO, 2000).Ethnicity influence the variations of body shape, size, proportion and health outcome. It also shapes the association of body type and functions in various population.

Check Your Progress 3

4) Elaborate on the ethnic differences in human physique and health consequences.

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12.5 SUMMARY

Ethnicity is an intricate construct of secure biology as well as cultural, language, behavior, and belief system. Different ethnic groups across the globe exhibit different physique, body dimension, function, performance and health outcomes. Both genetic and environmental factors are responsible for the variations in different ethnic and gender groups.

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12.7 ANSWERS TO CHECK YOUR PROGRESS

1) Human Physique refers to an individual's body form. It is the configuration of the whole body rather than its particular features. Human Physique can be observed easily, and it is helpful in understanding variation in physiques among individuals in the same or different populations.

2) Human physique can be evaluated by a method known as Somatotyping, which is a physique classification system of quantified expression. It is the description of body type on the bases of three component parts, namely ectomorphy, mesomorphy and endomorphy. Ectomorphy refers to relative slenderness, mesomorphy refers to relative musculo-skeletal robustness and endomorphy refers to relative fatness of physique.

3) There are gender differences in body size and shape throughout life starting from first trimester of the prenatal stages of human growth and development. Males are larger and more muscular, with longer and heavier body as compared to females. Males also have larger lean body weight than females. Even during early stage in life when sexual dimorphism is not much visible, boys are noticeably larger than girls of the same age. There are differential rate of growth and development in boys and girls of the same population. Gender differences in weight gain have also been observed. Refer to section 12.2

4) Ethnicity is a complex construct, which incorporates both cultural phenomena and biological characteristics. Ethnic or racial disparity in physique and body composition analyses are of concern to anthropologist, sport scientists and human biologist because these attributes influence health status, fitness level, strength, and performance. There are wide range of ethnic variations in physical traits which includes physique, body sizes, facial features, skin colors, hair colors and textures etc. Refer to section 12.4

PRACTICAL MANUAL

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PRACTICAL MANUAL

Contents

Learning Objectives

After going through the practical manual you will be able to:

- understand the practical aspect of somatometric measurements;
- visualize various measurements used by anthropologists for determining obesity; and
- define anthropometric indices for assessing nutritional status at right place.

1.0 INTRODUCTION

Somatometry is the metric study of living human body. This science of measurement of human body also holds immense significance in racial classification, evolutionary studies and in designing of clothes and equipment. This section will facilitate you with concise description of standard techniques, positions and methods for taking somatometric measurements. Somatometric measurements are defined on the basis of various anatomical landmarks and are useful in describing the morphology of man.

Somatometry (measurement of the dimensions of body) involve different types of instruments for taking measurement, as you learnt in your course Introduction

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to Biological Anthropology depending upon its nature. Anthropometric measurements use growth references and standards for determining the growth, nutritional status and welfare of children and adolescents. The anthropometric measures such as Z-score and percentiles have been widely used to assess the nutritional status of an individual and his/her growth. In this section, we have also covered nutritional status assessment through anthropometric indices and dietary practices. Nutritional status is the total of the anthropometric indices of an individual which are influenced by consumption of nutrients. All this information is obtained by physical, biochemical and dietary practices which depends on the quality and the quantity of food consumed and the individual's physical health. The nutritional status of an adolescent has an important implication on his/her health, in developing of chronic diseases and holds importance in breaking the sequence of malnutrition. Dietary pattern that is a crucial factor to determine the nutritional factor, is the general outline of the food and nutrient intake and utilization which is characterized on the basis of common eating habits. And, the analysis of dietary patterns provides a more all-inclusive imprint of the food intake habits or practices within a population.

1.1 GROWTH STATUS: SOMATOMETRY

Somatometry is made of two words 'somato' which means living and 'metric' which refers to measurement, so in simple terms it means measurement of living beings. Therefore, somatometry a division of anthropometry is defined as a systematic technique to measure living body including head and face. Anthropologists have formulated number of measurements for describing the morphology of man. These measurements are not arbitrary and are based on anatomical landmarks and have been in use for hundreds of years. They are useful in comparing various kinds of people living in different geographical regions, i.e., for racial comparisons or to study variations in body types. Physical growth of children is studied on the basis of their body measurements. The nutritional status of young and adults is also assessed with the help of these measurements. It also facilitates in the determination of certain physiological functions like vital capacity, basal metabolic rate, etc. Data generated on the basis of anthropometry surveys of populations has been an asset for designing proper equipment for use in industry and defence purposes, spaceships, garments, etc. The anthropometric surveys also provide norms of the physique of any population and trends of changes in morphological traits. Let us learn how we take body weight or weight, stature commonly called as height, and mid upper arm circumference. You are familiar with landmarks and procedure of some measurements, nevertheless lets go through it again.

Body weight

Weight should be taken by means of standard weighing machine without any zero error with fine accuracy. The weight should be taken with minimum clothes and barefoot. Body weight is measured in kilograms, which gives an idea of body mass.

Instrument used: Weighing machine

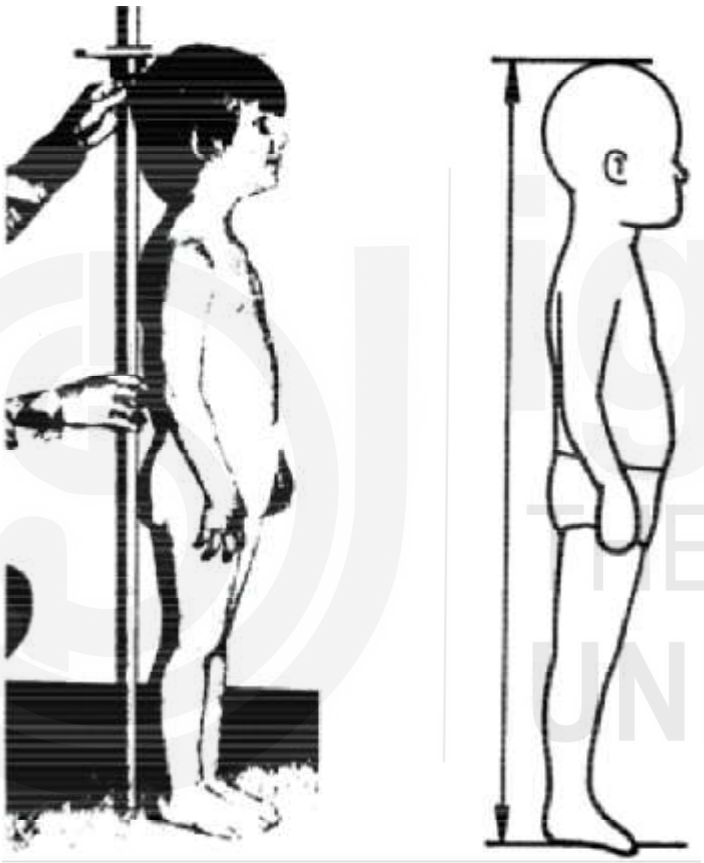
Method: The needle of the weighing scale is adjusted to remove the zero error. The subject stands with equal weight on both the feet. The head of the subject should be forward. The reading on the weighing scale is noted when the needle is stationary.

Precautions

- Take care that the subject is wearing minimum number of clothes.
- Weight should not be taken right after taking meals.
- Make proper adjustment for clothes worn by the subject at the time of taking weight.
- It is recommended that at the time of recording weight of the clothes should also be adjusted.

Stature

Stature (floor-v): It measures the vertical distance from the standing floor to the vertex.



Source: www.ovrt.nist.gov

Vertex (v): It is the highest point on the head when the head is in the Frankfurt-Horizontal (FH) plane, also known as eye-ear plane. Vertex is not an anatomically fixed point and is dependent on the orientation of the head.

Instrument used: Anthropometer

Method: The subject should stand erect, barefoot on a level floor against the wall with her/his back and buttocks touching the wall. The heels should touch the wall and toes are at an angle of 45° to each other. The shoulders should not be raised upwards. The arms should be in standard arm hanging position and the palms of the hands should touch the thighs. The anthropometer is placed on the back of the subject if the vertical wall is not available. The head of the subject must rest without any strain in the eye-ear plane or FH plane, i.e., tragion and the

right orbitale must lie in the same horizontal plane (Refer to the BANC 101 Manual). Now with the position of the subject set, standing on the right side of the subject with anthropometer in the median sagittal plane of the subject and allow moving cross-bar to touch the vertex lightly. Note that the anthropometer is in vertical position.

Precautions

- ✓ The subject is barefoot.
- ✓ The heels, back and buttocks of the subject should touch the wall.
- ✓ The toes are at an angle of 45°.
- ✓ The arms should be in standard arm hanging position.
- ✓ The head of the subject should be in eye-ear plane

In case of adults or child the height is measured up to the nearest millimeter using anthropometer. And, a sliding board made of wood is used for measuring the length of children. Infantometer is used for the measurement of recumbent length in case of children who are less than 2 years of age.

***Mid Upper Arm Circumference (*MUAC)**

The accurate and a reliable way to measure fat-free mass, is the upper arm circumference at the midway between the tip of shoulder and the tip of elbow on the left side of arm. The mid arm point is assessed by measuring the distance from the tip of the shoulder to the elbow and then dividing it by 2.

Instrument used: Flexible steel tape.

Method: The subject is asked to hang the hand freely in standard arm hanging position. The tape is placed horizontally around middle of the upper arm where generally the bicep muscles are most developed and reading is recorded.

Precaution

- ✓ The arms should be hanging freely.
- ✓ The tape should neither be tightly nor loosely held.

Note that the low reading of MUAC represents the loss of muscle mass. For determining the risk of mortality (in children) and individuals having HIV/AIDS, MUAC is the best assessing and screening tool. It is the only anthropometric tool for evaluating the nutritional status in case of pregnant women as well.

Practice 1

Take weight and mid upper arm circumference of five subjects

S.No	Name of the Subject	Weight of the Subject (kg)	Mid Upper Arm Circumference (cms)
1			
2			
3			
4			
5			

1.2 ASSESSMENT OF CHRONOLOGICAL AGE

Chronological age is the number of years represented by revolutions of earth around the sun. It is calculated from the date of birth. In other words, it is the definite number years an individual has lived his/her life in years, months, days or in a combination of all of these factors. For e.g. 16 years, 3 months and 10 days.

Chronological age estimation approach provides the age of an individual in terms of years, months and days. It is mainly used to evaluate the accurate age of an individual with respect of day, month & year. Let's understand this with the help of an example, if an you want to find out the age of an individual born on April 02, 1990 on January 10, 2016, then subtract 10.01.2016 by 02.04.1990.

$$2016.1.10 - 1990.4.2 = 25.7.8$$

Anthropometric measurements use growth references and standards for determining the growth, nutritional status and welfare of children and adolescents. The growth standard indicates that all children are potentially able to achieve a level, whereas a growth reference is the distribution that is used for the purpose of comparison.

The anthropometric measures such as Z-score and percentiles have been widely used to assess the nutritional status of an individual and his/her growth. The parameters of growth are

- Undernutrition that includes underweight, stunting and wasting; and
- Over nutrition involving overweight and obesity.

Z-scores (-2 and +2) and Percentiles (5^{th}, 85^{th}, 95^{th}, 97^{th}, 99^{th} percentiles) are used to categorize various health conditions. Moreover, sex-age specific anthropometric measures cut points are also evaluated using these factors.

As per WHO, use of growth chart i.e., growth reference on the basis of Z-scores assesses the nutritional status and growth of an children and growth charts are prepared on the basis of data generated.

1.2.1 Percentiles

The percentile of populations falls below the variable's value. Rank scale is used and it is more understandable. It also indicates the expected prevalence.

Limitations:

- Values are lumped to the lowest or highest percentiles
- This factor does not suit, in case of assessing longitudinal growth status and
- It is not comparable across different anthropometries.

The following table represents the percentile-Z-score conversion values

0.2^{nd}	-3
2.3^{rd}	-2
2.5^{th}	-1.96

5th	-1.64
15th	-1.04
16th	-1
50th (median)	0
84th	+1
85th	+1.04
95th	+1.64
97.5th	+1.96
97.7th	+2
99.8th	+3

Source - Wang and Chen 2012

Additionally, percentile also defines the population's expected percentage that should be above or below the table. Different age-sex specific percentiles are also used to evaluate the growth of children and their nutritional status on the basis of anthropometric measures and other health conditions as well such as low or high blood pressure.

An interesting information, Z-score and percentiles are convertible to each other. For e.g. Z-scores of 2 and -2 matches to the 97.7th and 2.3rd percentiles while the 85th and 5th percentile correspond to Z-scores of 1.04 and -1.65 respectively (Wang and Chen 2012).

1.2.2 Z-Scores

It is defined as the number of standard deviations away from the mean, when the distribution is in a normal process. The scale is continuous from -" to ". The main advantage of this factor is that it :

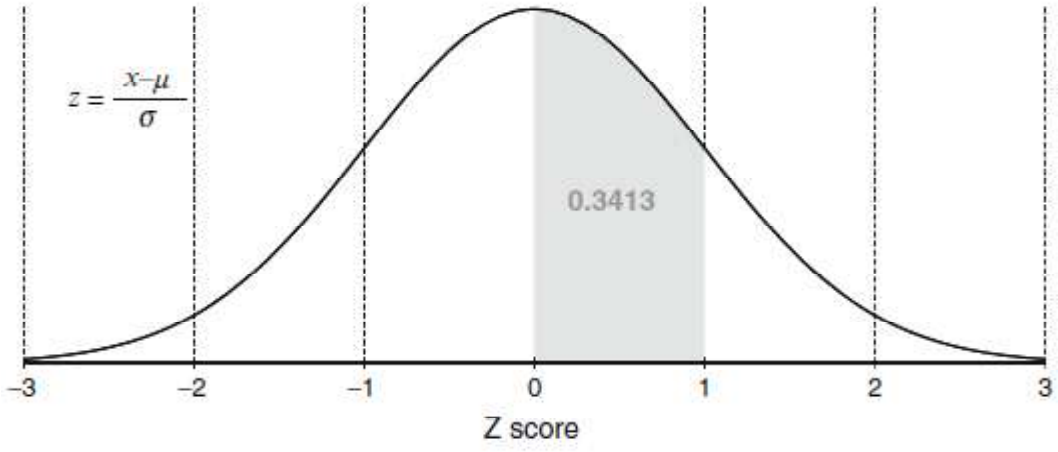
- allows comparison between sexes and ages;
- also helps in quantifying the extreme values; and
- is good for evaluating the growth status in longitudinal changes.

One of the major drawbacks of this factor is that it is difficult to perceive than percentiles, especially for the public.

Z-scores are calculated on the basis of distribution of reference population; thus, it reflects as the reference distribution. The reference population can be taken by mean and the standard deviation (SD). Z-scores are also comparable across age, sex and also is a measure of dimensionless quantity. Z-score group can be subjected to a summary of statistics such mean and SD, and both can be studied as continuous variable. As discussed above, the main limitation of this process that they are easy to explain to the public eye and also limited in clinical settings.

They are also called as standard scores, where the z-score transformation is considered to be useful when comparing the relative values of different measures such as height vs. BMI from distribution of different standard deviations or means.

The following graph illustrates Z-score and the corresponding cumulative probability and percentile



Source: Wang and Chen 2012

The transformed values of Z-score distribution will have a zero mean value or a standard deviation value of 1. This conversion process is called as normalizing or standardizing.

1.2.3 Height-for-age

This is the index that is used for evaluating stunting that is the presence of chronic malnutrition in children. Children who are stunted have poor physical and intellectual performance, thus the less work output leads to less productivity at the individual level and poor socio-economic status at the community/society level. If there is a presence of stunting in a child for provided population, shows that the children are suffering from the chronic malnutrition, thus affecting their linear growth.

Stunting is a child's low height-for-age when compared to the standard child having from the same age group or same age. Child who is suffering from stunting is found to have the lower mental and the physical productivity capacity.

1.2.4 Weight-for-age

Weight-for-age is an index that is used for monitoring the growth for the purpose of assessing and evaluating the status of underweight children. By carrying out the community-based nutrition (CBN) activities every year, an analyst can assess the weight-for-age of all children who are less than 2 years of age. This index determines the body size and also reflects the levels of food intake and it is also assessing the acute and short-term under-nutrition.

$$\text{Weight for age} = \frac{\text{Weight of the child}}{\text{Weight of the reference child of the same age}} \times 100$$

Did you realize how important these concepts in the study of human growth and development are? Let's learn about others to have more insight about it.

1.2.5 BMI for Age

Body Mass Index (BMI) – This is measured when the weight of an individual (in kg) is divided by the height of same individual in meters squared.

$$BMI = \frac{\text{Weight (kg)}}{\text{Height (meters)}^2}$$

BMI is considered as a good indicator of undernutrition in relation to a chronic energy deficiency (CED) and is a non-invasive and inexpensive approach that is used for wide scale surveys for the assessment of malnutrition (WHO 2004).

Table: BMI cut-off values for the assessment of malnutrition status

Malnutrition Status	BMI
CED Grade III	BMI < 16.00 Kg/m^2
CED Grade II	BMI 16.00 Kg/m^2 – 16.99 Kg/m^2
CED Grade I	BMI 16.00 Kg/m^2 – 16.99 Kg/m^2
Normal	BMI 18.50 Kg/m^2 – 24.99 Kg/m^2
Overweight	BMI 25.00 Kg/m^2 – 24.99 Kg/m^2
Obese	BMI $\geq$ 30.00 Kg/m^2

Source: WHO, 2004

Practice 2

Take stature and weight of five subjects and calculate their BMI.

Sl. No.	Name of the Subject	Weight of the Subject (Kg)	Stature (cms)	BMI Kg/ m^2
1				
2				
3				
4				
5				

1.3 OBESITY ASSESSMENT

Overweight and obesity have reached a level of epidemic in various countries and possess number of serious health and socio-economic consequences. Moreover, obesity has negative consequences related to psychological, medical and quality of life, it has drained all the health resources and also decreases the life expectancy. In various developing countries, there are different type of weight associated diseases such as obesity, overweight and underweight coexists simultaneously in different components of their populations (Uzogara, 2016) (Fontela,et al 2017).

There are various methods which helps determine obesity such as body mass index (BMI), skin fold caliper which are used to evaluate the body fat percentage. All these methods are simple and effective.

1.3.1 General – Body Mass Index

As mentioned above, BMI is measured when the weight of an individual (in kg) is divided by the height of same individual in meters squared. In case of adults, BMI estimates the clinical diseases such as type 2 diabetes, however, its prediction for children and adolescents is not that much. BMI is a global index that measures the nutritional status of an individual and is used to categorize individuals both on the basis of overweight/obesity and eating disorders in combination with the psychological standards. The drawback of BMI is that it does not differentiate the fat and lean masses.

$$\text{BMI} = \frac{\text{Weight (kg)}}{\text{Height (meters)}^2}$$

For information BMI $\geq$30 indicates obesity and BMI $\geq$40 indicates morbid obesity, hence we need to be very careful. High value of BMI is indicative of high potential risk of getting diabetes, heart diseases and premature death.

1.3.2 Body Fat %

Body Fat % is the total mass of fat of human or other living divided by total body mass and then multiplied by 100.

1.3.3 Conicity Index

It is the simple anthropometric measure that is used to determine the central obesity (Shenoy & Jagadamba 2017)

$$\text{CI} = \frac{\text{waist circumference (m)}}{0.109\sqrt{\frac{weight\,(kg)}{height\,(m)}}}$$

1.3.4 Body Adiposity Indices

Let's have a look at commonly used Body Adiposity Indices. BMI is used quite commonly.

Waist Circumference –Waist circumference measures the minimum circumference of the torso which is the level of normal waist. This central fatness is of great importance in assessing deep adipose tissue.

Instrument: Flexible Steel Tape

Method: The subject stands erect with the weight uniformly balanced on both the feet that are placed about 25-30 cms apart from each other. While measuring, mark the level of the lowest rib (margin) and the iliac crest in the mid axillary line. Pass the measuring tape the waist in the horizontal direction in midway between the margins of lowest rib and iliac crest. Measure the circumference in cm up to the nearest mm., ideally the investigator that he/she should sit on a stool in front of the participant.

Precautions:

- ✓ The tape should neither be tightly nor loosely held
- ✓ Stand up straight with body relaxed
- ✓ Keep your feet together

Waist-Hip-Ratio (WHR)

Waist-Hip Ratio (WHR) is defined as the ratio of the circumference of the waist to the circumference of hip. It is commonly used technique for defining body fat distribution. In other words it is a useful measure for assessing the abdominal obesity and has very limited accuracy.

$$\text{Waist-Hip Ratio (WHR)} = \frac{\text{Waist Circumference (in cm)}}{\text{Hip Circumference (in cm)}}$$

Waist-Hip ratio is found to be a good indicator of stroke and ischemic heart disease. WHR value > 0.90 in males, WHR value > 0.80 in females are considered to high risk of diseases such as diabetes.

In adults, the ratio of waist hip is independently related with the risk of morbidity after performing adjustments for relative weight, such that the use of body shape and relative weight at the same time provides a good prediction about the morbidity risk.

Instrument: Flexible Steel Tape

Waist Circumference – Waist circumference measures the minimum circumference of the torso which is the level of normal waist as mentioned above.

Hip Circumference (HC) - This is the distance round the hip measured through the largest part of the buttock's region using a tape.

Method: The subject stands straight and breathe out. Flexible tape is used to measure the distance around minimum waist, just above the belly button. Similarly for hip circumference, the tape is placed horizontally over the buttock's region. The circumference is measured at the point for obtaining the maximum circumference.

Precautions

- ✓ The feet should touch each other
- ✓ Weight of the body should fall equally on both the feet
- ✓ The tape should neither be tightly nor loosely held
- ✓ Stand up straight with body relaxed
- ✓ Keep both feet together
- ✓ Both circumferences must be measured on standing subjects at the end of a gentle expiration.

Minimum Upper Arm Circumference

Refer to earlier section (P-174).

1.3.5 Regional Adiposity Indices

Waist Circumference (WC)

Waist Circumference –Waist circumference measures the central fatness that is an indicative of lipid profile or insulin resistance than total fat.

Waist Circumference	Adiposity Status
WC $\geq$ 35 inches for women	Obesity
WC $\geq$ 31.5 inches for Asian Women	Obesity
WC $\leq$ 35 inches for women	Overweight
WC $\geq$ 40 inches for men	Obese
WC $\geq$ 35.5 inches for Asian men	Obesity
WC $\leq$ 40 inches for men	Overweight

Source: WHO 2008

Waist-Hip-Ratio (WHR)

Refer to earlier section.

Waist-to-Height Ratio (WHtR)

It is measured when WC divided by Ht i.e., height. All are measured in same units. This is a simplest method than BMI (Fontela, 2017, Uzogara, 2016). We have learnt in the earlier section about waist circumference and stature/Height.

Reference to understand is

WHtR > 0.5 for men or women indicates obesity

WHtR < 0.5 for men or women indicates healthy weight

Practice 3

Calculate WC of five subjects and identify their adiposity status.

S.No	Name of the Subject	Waist Circumference (cms)	Adiposity Status
1			
2			
3			
4			
5			

1.4 ESTIMATION OF BODY COMPOSITON

Body composition is the percentage of fat and non-fat mass present in your body. Body that has a desirable lower percentage of body fat is referred as healthy body composition and a higher percentage of non-fat mass includes organs, muscles and bones. There are many approaches to assess body composition like densitometry, ultrasound, bioelectric impedance, anthropometry, CAT scanning, etc. As the name suggests some of the methods are invasive, expensive and time

consuming, whereas anthropometry is non-invasive, affordable and subject friendly.

Anthropometric measurements and indices are also used such as weight, height, skinfold thickness, diameter, length and circumference that involves mathematical components. All these indices are the main components in estimating body segments (Lee et al, 2015).

Let us understand some of them.

1.4.1 Fat Percentage and Muscle Mass with Skinfold Thickness

Body composition and growth are the key aspects of health in populations. These factors can be assessed by measuring the fat percentage and the muscle mass. Skin fold thickness methods have been used to determine the subcutaneous fat. As discussed above, our body is mainly composed of two types of fat: Body fat, and Non-fat mass.

Body fat is found in muscle tissue, under the subcutaneous fat deposit or skin, and are also present around the visceral fat i.e., organs. These are the essential fats that helps protect body's internal organs, stores energy that act as fuel and also normalizes body hormones which are important for our body. Whereas, Non-fat mass areas (also called as lean tissues) include muscle, organs, tissues, water and bone. These tissues are metabolically active as they help burn calories while body fat cannot do that.

Body fat percentage is used to estimate the total body fat on the basis of specific measurements and there are several ways to estimate it such as bio-electric impedance and Skinfold measurements. A skinfold caliper is used for the determination of skinfold thickness through which a prediction can be made of total body fat mass.

Harpenden Caliper
Source: www.harpendenskinfoldcaliper.com

Four skinfolds are generally used for determining total body fat:

Biceps Skinfold- It measures the skinfold thickness at the front of the upper arm at the level marked for taking the upper arm circumference. The landmark is

when the skinfold is picked up with your thumb and index finger directly above the centre of cubical fossa.

Instrument: Skinfold caliper

Method: The subject stands with the arms hanging freely on the sides of the body. The vertical fold with your thumb and index finger one centimeter above the upper arm circumference is lifted. The jaws of the caliber are placed on the folds and the reading in mm is recorded. The reading is noted when needle is at standstill approximately seconds of applying caliper.

Precautions

- ✓ Take care not to prolong the time of the application of the caliper to the skin because prolonging causes the displacement of the fat, hence erroneous reading.
- ✓ The hold of the pinch above the skinfold should not be loosened while taking the measurements.
- ✓ With the caliper, if the subject feels pain, this happens when muscle is also pinched along with subcutaneous fat.

Triceps Skinfold: It is measured in the midline of the posterior surface of the arm, over the triceps muscle in vertical direction at a point half way on the line connecting the lateral projection of acromion process of the scapula and interior margin of the olecranon process of the ulna

Instrument: Skinfold' caliper

Method: The subject is asked to stand erect with arms in standard arm hanging position. Remember this is the skinfold thickness measured over the triceps in the middle of the posterior aspect of the arm at the level of the upper arm circumference or the biceps skinfold, in the line with the olecranon process. The skinfold over the triceps muscle of the right arm, one cm above and one cm below the marked point on of the upper arm midway between the acromion process and the superior border of the radius in line with the olecranon process is picked. Keep the jaws of the calipers at the marked level and note the value. The folds should be parallel to the long axis of the arm.

Source: www.KinanthrEometric_Asses.pdf

Precautions

- ✓ The arms should be hanging loosely and freely at the side of the subject.
- ✓ The caliper should be placed parallel to the mid-circumference line.
- ✓ While taking the measurement the pressure of the caliper should be released slowly.
- ✓ The reading should be taken in 4 seconds and the reading recorded to the nearest 4> millimeter

Subscapular skinfold – It is measured as the fold inferior to the inferior angle of scapula, at natural cleavage. The subscapular skinfold is lifted at 45 degrees to the horizontal plane.

Source: www.KinanthrEometric_Asses.pdf

Instrument: Skinfold caliper

Method: The subject stands erect with shoulders relaxed so that the upper extremity is hanging loosely. Standing behind the subject, palpate the vertebral border of the scapula with fingertip running down laterally until the inferior angle is identified. If the subject is obese, the subject is asked to fold hand at the back, this way it it is easier to pick the fold. The subscapular skinfold thickness is measured below the inferior angle of the scapula. Using thumb and index finger, skinfold lightly below the most inferior angle of the right scapula is picked. The skinfold usually is slightly inclined' pointing downward and laterally in the natural cleavage of the skin. The jaws of the calipers are applied at the marked level and note the reading.

Precautions

- ✓ The subject should stand comfortably erect with loosely hanging upper extremity.
- ✓ The caliper should be placed parallel to the mid-circumference line.
- ✓ While taking the measurement the pressure of the caliper should be released slowly.
- ✓ The reading should be taken in 4 seconds and the reading recorded to the nearest millimeter
- ✓ For all these measurements, subject is required to sit or stand in an upright position.

It is quite interesting to note that for all these measurements, subject is required to sit or stand in an upright position.

Practice 4

What precautions are required for taking biceps skinfold?

Mid Upper Arm Circumference (MUAC), the accurate and a reliable way to measure fat-free mass, is the upper arm circumference at the midway between the tip of shoulder and the tip of elbow on the left side of arm. The mid arm point is assessed by measuring the distance from the tip of the shoulder to the elbow and then dividing it by 2.

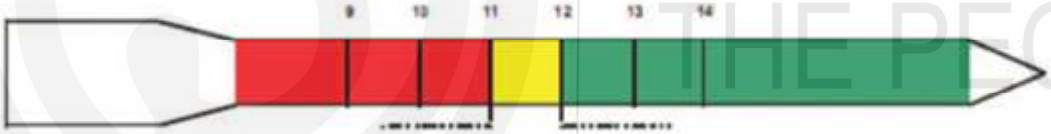
What to do in case you want to screen large number of populations? MUAC helps in the screening of large number of individuals (majorly at the community level) for community – based nutrition involvements such as Outpatient Therapeutic Programs (OTP) or during the emergent situations/circumstances or supplementary feeding programs. This anthropometric screening tool is also used for children, pregnant women for SAM i.e., severe acute malnutrition and MAM i.e., Moderate acute malnutrition.

MUAC Measurement in Children – To measure the MUAC of children, a special tape is used that has 3 colors: red, yellow and green. Each color indicates different nutritional status.

Red: Severe acute malnutrition

Yellow: Moderate acute malnutrition

Green: normal nutritional status



MUAC Measuring Tape

Source: Unicef Technical Bulleting No. 13

There are some specific cut-off values which are used for the screening purposes in the community-based interventions for SAM and MAM using MUAC

Target Groups	MUAC	Malnutrition
Children - < 5 years	11-11.9	Moderate acute malnutrition (MAM)
	<11 cm	Severe acute malnutrition (SAM)
Pregnant women/adults	17-21 cm	Moderate Malnutrition
	18-21 cm (with current loss in weight)	Moderate Malnutrition
	<17 cm	Severe Malnutrition
	<18 cm (with current loss in weight)	Severe Malnutrition

***Source*:** WHO, 2009

1.4.2 Bioelectric Impedance

This approach is used in the measurement of body composition and in the assessments of healthcare system. The fundamental principles and the wide variety of methods in case of bioelectric impedance are used to interpret the obtained information. A large spectrum of utilization of bio-impedance is in healthcare system and facilities such as prediction of disease and the monitoring and keeping the status of all your body vitals. Biological tissues possess electrical properties which are categorized on the basis of electricity source which are:

- Active response - In case of bio-electricity, active response occurs when the biological tissue aggravates the electricity from ionic activities inside the cells in the form of ECG i.e., electrocardiograph signal from the heart and EEG i.e.; Electroencephalograph signals from the brain.

- Passive response - It arises when the simulation of biological tissues starts through an external source of electric current.

The biological impedance and the bioimpedance is the ability of a biological tissue to obstruct the electric current. Number of studies have been conducted on the analysis of bio impedance and related to its applications in assessing the composition of body and estimating the clinical conditions. This is due to its intrusiveness, the low cost and portability of bioimpedance analysis. The bioimpedance is measured from the entire body and its segments individually through the use of single and multiple frequencies, and analysis of bioimpedance spectrograph.

Application of Bioimpedance analysis

Let's have a look at significance of bioimpedance analysis. In healthcare facilities, bioimpedance helps in estimating the body sections to evaluate and monitor the consistent changes in nutritional status in in-patients and also observing the risk related to their nutritional status in out-patients. Various techniques such as BMI, skin fold and weight measurement in water are used for assessing the body composition. All these methods are used to estimate the fat mass and fat free mass, thus bioimpedance analysis can predict the total number of body fluids that is considered very useful for the prognosis of diseases/illnesses (Khalil, S et al, 2014).

1.5 NUTRITIONAL ASSESSMENT

In the above section, you learned majorly about nutritional assessment using the somatometry approach. This section discusses about the different methods of evaluating the nutritional status using dietary patterns and anthropometric indices.

Nutrition is considered as an important concept for preventive healthcare. An ideal nutrition level is the amount of food intake that promotes a good health. The nutritional level of individuals is interrelated to the status of diseases/illnesses and health. However, the calorie intake in excess amount leads to obesity whereas a small intake of calories results in the decrease of essential nutrients. All these changes results in biochemical alterations and eventually to clinical signs and symptoms. The requirements of nutritional intake are influenced by number of factors such as age, gender, physical activity, drugs, physiological status and

alcohol consumption. Nutritional status is considered as the main and important health indicator to determine individual's health.

The main and the direct causes of malnutrition are:

- poor consumption of food and
- regular attack of diseases and infections, thus low defense system.

There are various indirect causes of malnutrition as well, they are:

- Low production
- Lack of awareness
- Less power of purchasing
- Poor sanitation and personal hygiene
- Highly prone to infections and diseases

Remember malnutrition is both undernutrition and over nutrition.

Importance of Assessing Nutritional Status

Assessment of nutritional status is imperative for the purpose of screening and identifying and also for the population that are majorly affected by malnutrition. This concept is found to be very useful in formulation and the development of nutritional involvements and awareness and they also help in evaluating the impact of these program at a community based and individual level.

As per the reports of World Health Organization (WHO), the main objective of assessing nutritional status is the improvement in the human health quality. There are two approaches which can be used for assessing the nutritional status: Direct and Indirect methods.

- Direct Methods: The assessment of nutritional status is conducted using different methods/approaches which are:

  Anthropometry - A

  Biochemical methods – B

  Clinical methods, and - C

  Dietary methods - D

Remember this as 'ABCD'

- Indirect Methods: These methods involve the statistical data that are obtained from the demographic and census data, and from other important sources such as population density and per capita income.

Here we will consider Anthropometry – A and Dietary methods – D. We have already dealt with Anthropometry-A in earlier section. Refer to the section and here will go through very briefly.

1.5.1 Anthropometric Indices

Anthropometry that we discussed earlier, originates from two words: *Anthropo* means human and *metry* means measurement. Anthropometric measurements are used to assess the nutritional status in community by recording growth or

changes in the composition of body. All methods are useful, however, no single method provides a comprehensive view about the nutritional status of the population and thus, it sometimes becomes important to use a mixture of methods. At the time of using combination of approaches, one should always keep in mind the objectives and accessibility of resources (Omage and Omeuemu, 1890-1897).

Anthropometry is an effective, non-invasive and quite inexpensive method that is available to determine the body size, proportions and human body composition. The most important and utilized measurements are:

- Height/Weight
- Weight
- Mid Upper arm circumference (MUAC)
- Head Circumference
- Chest Circumference
- Waist circumference

Most of the measurements have been discussed in the above section. Go through the section carefully for Height/stature, weight, circumferences at mid upper arm and waist. In this section we will learn about Head and Chest circumference.

Head circumference – It is the maximum circumference of the head taken just above brow ridges. It is the measurement of head done along with the supra orbital ridges i.e., the forehead anteriorly and occipital prominence posteriorly. Occipital prominence is the bulging and protruding part on the back part of the human head that you must have noticed.

Instrument used: Flexible steel tape

Method: The subject sits down and the tape is placed around the head above brow ridges and adjusted on the back of the head such that maximum circumference is recorded.

In case of assessing the chronic problems related to nutritional status in children below than 2 years of age, head circumference measurement is helpful because brain grows faster during the initial 2 years of life. But after completing 2 years, the brain's growth becomes more inactive and at that time head circumference is not found to be useful.

Precautions

- v Measurement tape should not be too loose or too tight
- Keep the head straight.
- Tape should be kept horizontal

Chest circumference (CC) – It is the circumference of the chest measured at the level of union of third and fourth sternebrae. The measurement should be taken at the end of normal expiration

Instrument used: Flexible steel tape

Method: The subject should stand erect with tape running around the landmark mentioned above. Care is taken to keep the tape horizontal.

Measuring chest circumference is of great value for determining growth in the 2nd and 3rd years of life.

Precautions

- Measurement tape should not be too loose or too tight
- Tape should be kept horizontal
- Tape should be touching the body.

Indicator is an index or a scale that shows weight-for-age or weight-for-height. When all these scales combined with a particular cut -off values, then in that case it helps determine the nutritional status of a child (whether the child is undernourished or malnourished).

Let's understand this with an example.

A child whose weight for height or weight for age, falls below the specific cut-off values as shown here in the following table.

CC ratio <1 in children (6 months to 5 years)	Under-nutrition
CC ratio > Head Circumference for children (1 year to 5 years)	Protein energy malnutrition

Source: WHO 2006

This table represents whether the child is undernourished or malnourished. All these anthropometric indicators are used for the assessment of nutritional status, to determine the involvement or to enroll children to an involvement program i.e., the treatment package and then to discharge them from a program. If you got to understand how to use all the indicators then, planning an effective intervention will be easy.

Similarly, table below illustrates the use of indicators for individuals and children who are underweight, or suffering from wasting and malnutrition on the basis of weight and height of children relative to their age.

Specific cut offs of BMI in Kg/m^2	Nutritional status
>40.0	Very Obese
30.0-40.0	Obese
25-29.9	Overweight
18.5-24.9	Normal
17-18.49	Mild chronic energy deficiency
16-16.9	Moderate chronic energy deficiency
<16.0	Severe chronic energy deficiency

If an adult is having BMI < 16 $Kg/m^{2,}$ then he/she cannot perform a vigorous physical activity or exercise because of their low energy storage. Moreover, they will be more prone or susceptible to infections/diseases due to their low immunity.

1.5.2 Dietary Methods

It is important to identify the energy and nutrient requirement by studying the changes in body growth and maturation. Nutrition and the dietary practices pose

a major influence on the development of an individual from infancy to old age. As we all know, a sufficient amount of food intake and nutrient (i.e., the basic nutrients such as proteins, fats, vitamins, carbohydrates, and minerals) is important for a normal growth (American Dietetic Association, 2005). Taking inadequate and improper nutrition at any phase of life affects the body adversely. Because of not having sufficient diet, various communities are suffering from several diseases – overnutrition in adults (majorly in old aged individuals), and under-nutrition in infants, children, and in women. Anthropometric assessment is one of the most common approach to determine the nutritional status of a population because of its ease in comparison to other methods, reproducibility, and obtainability of standards on the basis of normal population for the purpose of comparison and forming association between clinical illnesses and abnormal measurements.

Genetic and environmental factors involving the dietary intake influences the height. Stunting reflects the cumulative impact of under nutrition in the past.

To assess the dietary methods for determining the nutritional status, one should always include the analysis of past or current food intakes, or the nutrient consumption by an individual or a group of population. A questionnaire is prepared in which you can ask about the family, (mother or the child) members dietary history like what have eaten over the past 24 hours. Then, after recording all the data, calculate the dietary diversity score (Kapoor et al 2012; Popkin 2002; WHO,1966).

Dietary Diversity- It is measured by the number of food groups which are consumed over a period of 24 hours i.e., reference period. Usually, there are six type of food groups which are required by our body on a daily basis.

Requirement of Nutrients at different stages of life

It is very important to consume healthy food at every stage of life. Most importantly, a pregnant woman should have a good nutritional intake that helps both: the mother and the fetus. The adequate supply of nutrients ensure that the baby grow well in infancy time and after that as well. At the time of pregnancy, a women's requirements for certain nutrients increases in comparison to other and lack of those nutrients in her diet results in the low body weight. In the 2nd and 3rd trimester, pregnant ladies must have a good intake of calories and nutrients (WHO, 2010).

Dietary History

The data about the history of dietary practices can be collected from individual/ or families depending on their requirements. This method is of prime importance as nutritionists has reported that nutrition plays a vital role in the incidence of obesity, heart diseases and diabetes. Dietary surveys, are used in estimating the population and assessments of an individual, which is defined as the planned and a systematic study of the dietary consumption of individuals/population or communities. The methods can be both quantitative and qualitative.

The qualitative method includes the use of the food pyramid as discussed above to predict the requirements of food and its serving and intake, whereas the quantitative method evaluates the amount of energy and particular nutrients required for each food by using the tables of food consumptions. These kinds of

surveys are increasing in the nutritional epidemiology areas, clinical assessment, and population surveillance. Surveys are quite advantageous such as they are not that expensive, comparatively easy and objective.

Types of dietary surveys

- Twenty-four-hour recall
- Weight intake
- Food frequency questionnaire
- Food diary
- Dietary history

Twenty-four-hour recall: In this method, all the food articles are recorded which are consumed during the 24 hours and is used in wide scale nutritional surveys. This method involves the interview or questionnaire where the participant is asked to recall and is required to describe his/her food consumption in detail during the last twenty-four hours.

One of the most widely preferred participant for this method is housewife because she generally knows everything about the dietary practices of her family members. The investigator questions her to remember the type and amount of food intake, how the food is prepared and in what proportion the food is getting distributed to family members. Some of the measuring cylinders in the kitchen such as glasses, cups, spoons and bowls are used to help the participants in recalling the details.

This method has various advantages which are:

- ❖ Inexpensive
- ❖ Quick and easy
- ❖ Depends on short-term memory

The 24-hour recall method should be repeated two to three times where the individual who is being interviewed may be telling the truth is definite or not.

Weighed Intake Method: This method requires the involvement of investigator, when the subject is consuming food and the amounts of food are weighed before, during and after serving. The amount of food is also measured that is not eaten by the subject i.e., left-over food. Then the difference is calculated between the amounts of food that is served and not consumed that gives the amount of food that is actually consumed by the individual. One of the advantages of this method is its intensiveness whereas the disadvantage is that it is time consuming.

Food Frequency Questionnaire: This method is used to collect information about the long-term dietary practices. Individual is allowed to complete the questionnaire by themselves and then the filled form is sent to the investigator. In India, it is generally advisable to fill all the questions by the investigator by interviewing the subjects where the subject is asked about how often he/she consumes special food items. The responses are standardized so that the subject is only required to tick mark the correct answer. The frequency of eating food items is generally calculated as week/fortnight/month. The list of food should not exceed 150 items. The main merit of this approach is that this method is quick and inexpensive and also involves the coverage of more respondents.

Food Diary

Food diary is required to keep the records in a documented form about the dietary practices such as what all food and beverages are being consumed by the subject over a certain period of time. A time period of about 1 week can be used in the diary to predict the dietary intake. The method is reliable as sufficient number of days is covered by each subject. The subjects also take interest in filling up the diary.

The main disadvantage is that individuals are sometimes not able to estimate the quantity of food consumed accurately. The subject concerned can also be illiterate. Moreover, diary making can be a cumbersome process.

Dietary History

In this, the dietary practices are recorded of the participants over a longer period of time. The investigator obtains a retrospective estimate of the food intake using this method. The time duration covered is 3 months to one year. The information is recorded either through interviews and/or questionnaires addressed to the subject. This method is not used in large scale epidemiological surveys.

Practice

What is the importance of nutritional assessment?

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