PRACTICAL MANUAL

ignou
THE PEOPLE'S
UNIVERSITY

PRACTICAL MANUAL*

Contents

Learning Objectives

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

- understand the practical aspects of cardiovascular and respiratory functions;
- visualise various functions such as blood pressure, heart rate, pulse rate; and
- learn about Haemoglobin estimation and Treadmill test.

1.0 INTRODUCTION

Physiological anthropology is connected to physical anthropology and is concerned with the uniqueness that relates to biology. It focuses to elucidate human physiological features, in a wide sense. Seen in this viewpoint, physiological anthropology belongs to the basic natural sciences. It flourishes on living organisms that vary in many different ways. Living organisms, in the process of evolution, have differentiated in many different directions up to the current day. And within the same species, as individual specimens or in groups, they have come to have widely varying functional, morphological and behavioral characteristics which only physiological anthropology takes into account. The second different aspect of physiological anthropology is that the objects of study of physiological anthropology are we ourselves, human beings, who have unique physiological functions compared to other animals in nature. In short, this refers to very highly developed mental abilities and it is impossible when studying human beings in a comprehensive

*Contributor: Prof. Rashmi Sinha and Ms. Kaneeka Joshi, PhD Scholar, Discipline of Anthropology, School of Social Sciences, Indira Gandhi National Open University, New Delhi.

way to overlook the existence of these distinctive abilities.

Physiological anthropology is an area focused on the understanding of human nature and behavior in reference to their environment based on physiological mechanisms. These biological roles which are based on behavioral physiological mechanisms have a constructive effect for the living being resulting as being a form of "adaptation".

1.1 CARDIOVASCULAR FUNCTIONS

Some adaptations might lead to frequent complaints pertaining to body problems, basically physiological in nature such as low or high blood pressure, obesity etc. Such problems have become very common. Blood pressure can be defined as the pressure exerted by blood on the arterial wall. What happens is that with each ventricular beat i.e. when left ventricle contracts, blood enter the aorta which is already filled with blood. As more and more blood enters the aorta, the blood flow exerts pressure on the elastic arterial wall. This pressure is called 'blood pressure'. Most people have had their blood pressure checked at some point of time, either due to curiosity or on a visit to clinician for some discomfort, isn't it? You must have seen that it is simple and quite painless procedure, yet gives vital information about our heart and the condition of the blood vessels.

Now, what is measured while taking blood pressure? Well it is the maximum pressure (systolic) and the lowest pressure (diastolic) made by the beating of the heart that is measured. The question what is the maximum or systolic pressure and what is the minimum or diastolic pressure? The systolic pressure is the maximum pressure in an artery at the moment when the heart is beating and pumping blood through the body. The diastolic pressure is the lowest pressure in an artery in the moments between beats when the heart is resting. Both the systolic and diastolic pressure measurements are important – if either one is raised i.e., more than the standard value one is said to have high blood pressure or hypertension. How do you measure the blood pressure? Sphygmomanometer is the answer (Uzogara, 2016; Shenoy and Jagdemba, 2011; Fontela et al., 2017).

1.1.1 Blood Pressure

Source: https://www.fotosearch.com/photos-images/

Measuring Blood Pressure

Source: https://www.fotosearch.com/photos-images/

These days' electronic measuring devices are commonly found to be used by people at their home to measure blood pressure (since mercury is being phased out because of its hazardous nature). They are found to be accurate enough for routine clinical use, more user friendly and are relatively inexpensive. The chances of errors in blood pressure measurement that human beings can generate are reduced.

Ambulatory blood pressure monitoring (ABPM) entails measuring the blood pressure for 24 hours during the daily routine and even during sleep. In this, the device measures the blood pressure at regular intervals. The readings are recorded on a chip in the device and give a detailed picture of blood pressure variation in a normal environment. Ambulatory blood pressure monitoring is advised when high blood pressure is resistant, that is no reaction to drug treatment—three or more drugs or help in the identification of high blood pressure related to anxiety in the clinical setting, known as 'white coat hypertension' or when the blood pressure is showing a typical variation or probably when symptoms suggest the possibility of low blood pressure due to over treatment (McArdle et al., 2007).

1.1.2 Heart Rate

If you know how to measure your heart rate or pulse, it facilitates in learning about your own level of fitness and detects potential medical problems that should be brought to the attention of your physician in case of an irregular reading. What is Heart Rate? As the name suggests it is number of times heart beats in a minute measured by feeling your pulse. It is the rhythmic expansion and contraction (or throbbing) of an artery as blood is forced through it by the regular contractions of the heart. It is a measure of how hard your heart is working by feeling the pulse.

Measuring Heart Beat

Source: https://www.fotosearch.com/photos-images/

Source**:** https://www.fotosearch.com/photos-images/

Heart rate is defined as the number of ventricular beats per minute. The heart rate can be recorded at any point on the body at which an artery is close to the surface and a palpitation can be experienced. The most common places to measure heart rate using the palpation method is at the wrist (radial artery) and the neck (carotid artery). Elbow (brachial artery) and the groin (femoral artery) are also sometimes used. Always remember to use your fingers to take a pulse, not your thumb. This is particularly when recording someone else's pulse, because sometimes you feel your own pulse through your thumb. How do you record the heart rate?

Manual Method

Carotid Pulse (neck)- In this case when heart rate is taken at the neck, the first two fingers on either side of the neck are positioned, and the number of beats for a minute is then counted.

Radial Pulse (wrist)- Radial pulse rate involves index and middle fingers together to be placed on the opposite wrist, about 1/2 inch on the inside of the joint, in line with the index finger. As soon as pulse is felt, number of beats felt within a one-minute period is counted.

Monitor Method

A heart rate monitor is often used to get a more precise heart rate measurement. This holds significance particularly during exercise where the motion of exercise often makes it hard to get a clear measurement using the manual method. This heart rate monitor is especially useful when recording heart rate changes over short time periods. At times heart rate monitors require a little body sweat between the chest strap and the skin for best conduction of the signal. In such cases, care should be taken that there is a good connection between the chest strap and the chest, and some water or other fluid can be added to enhance the conductivity too.

Heart rate monitor

Source: www.chicagonow.com

60-90 is counted in the normal range. It fluctuates a lot depending on factors like activity level and stress level. Nevertheless, if beat is consistently above 90, it needs medical attention. This condition of high heart rate is termed as tachycardia (increased heart rate). It has been observed that in many athletes the pulse rate is in the range of 40-60 depending upon their fitness level. However, a lower pulse rate is considered to be good. But if the heart rate is too low, it is termed as bradycardia and can be a dangerous situation combined together with low blood pressure. A person would feel weakness,

loss of energy and fainting. It warrants for medical attention. (Arnold et al., 2008)

There can be a situation when the pattern of beats are irregular (i.e. a beat is missed) on a consistent basis, such cases necessitate medical attention. There are many factors that influence heart rate like emotions, climatic temperatures, posture (sitting, standing, lying down), and body size (if the person is overweight for size, the heart will have to work harder to supply energy to your body). It is always good to experience a decrease in resting heart rate as one of the benefits of increased fitness due to exercise. This is because heart is a muscle and will respond just like any skeletal muscle in that it will become stronger through conditioning. If the heart muscles are stronger, then heart rate will decrease. In fact, heart will be putting out less effort to pump the same amount of blood.

What should be your heart rate? Are you not curious to know?

Take 220 and subtract your age. For example, if you are 36 years old, subtract 36 from 220 (220-36=184). This means that your maximum physiological limit as to how fast your heart should beat is 184 beats per minute. Now see what should be yours.

1.1.3 Pulse rate

Your pulse can be felt at the wrist, neck, groin or top of the foot-areas where the artery is close to the skin. Most commonly, people measure their pulse in their wrist. This is called the radial pulse. How to measure your Pulse?

Measuring Pulse Rate

***Source*:** https://www.fotosearch.com/photos-images/

The first time that you try to take your pulse it may be a little difficult proposition. Place the index and middle fingers of your right hand on the thumb side of your left wrist until you feel your pulse throbbing under your fingers. Using the second hand on your watch starting the first beat at zero, count how many times your pulse beats in fifteen seconds.

1.2 RESPIRATORY FUNCTION

Human beings are composed of different types of organs that work together in coordination with each other. There are 11 different systems that exist in the body that helps maintain all the vital physiological body functions. Amongst the eleven organ systems, respiratory system is one of them.

Respiratory System

It is one of the main body systems that helps during the process of respiration. The major function of this system is the gaseous exchange between the environment and organism. This is performed with the help of several types of organs. The organs that comprise the respiratory structure are mainly divided into the following segments:

- Major Organs– mouth, nose, pharynx, larynx, lungs, bronchi, and trachea.
- Respiratory Tract (Upper)– nasal cavity, nose, sinuses, trachea, and larynx. Sinuses include frontal, sphenoid, ethmoid, and maxillary.
- Respiratory Tract (Lower)– alveoli, lungs, bronchioles i.e. airways and bronchi.

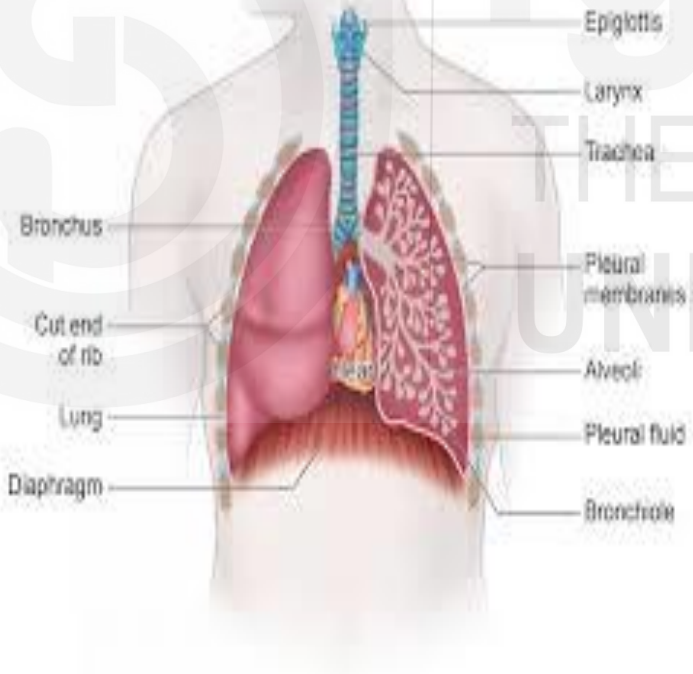


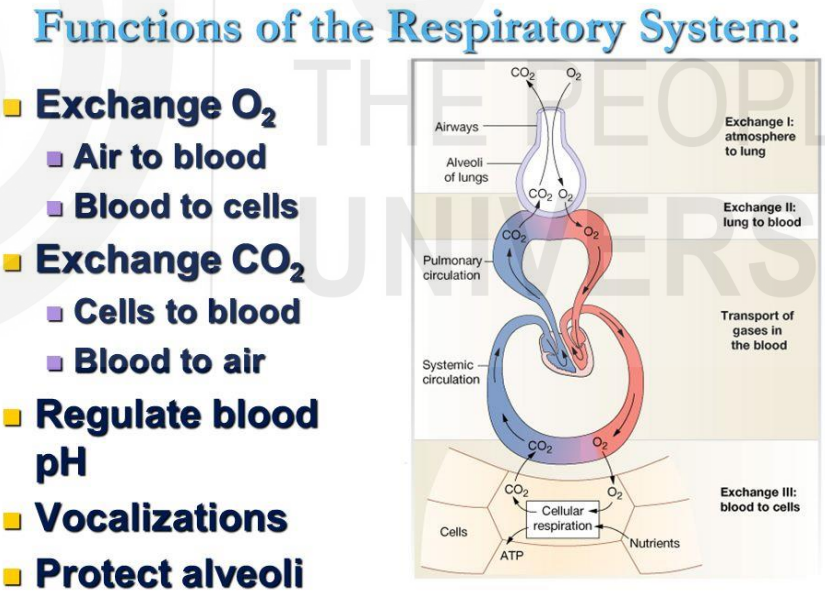
Figure: Human Respiratory System

Source: https://www.brainkart.com/article/Respiratory-functions_33203/

The functions of Respiratory System are:

- Gaseous exchange– In this, the gaseous exchange of carbon dioxide and oxygen takes place between the environment and body which is performed by breathing i.e. via expiration and inspiration. This respiratory structure brings oxygen to the various organs of the body and helps in expelling the CO_2 i.e. carbon dioxide from the body.

- Cleans the air– The respiratory system helps clean the air that we breathe in and it acts as a defense structure. The cavity of the nose is filled with small hairs and helps in cleaning the air by trapping the particles. It also prevents its reach to the lungs.
- Immunological function– The respiratory system is covered or lined by the membrane (mucous) that contains mucosal related tissues of lymphoid which produces lymphocytes. Lymphocytes increase the body's immunity. The airways of epithelial cells secrete IgA i.e. Immunoglobins, defensins, collectins, etc. that help keep the airways free from any kind of infection by acting as antimicrobials.
- Vocalisation– It is the moving of gas, via the pharynx, larynx, and mouth that allows humans to phonate or speak. Gas movement is very important to articulate.
- Controlling Temperature– An increase in breathing helps maintain the temperature of the body and aids in proper body functioning during emergency cases. Moreover, it also maintains the core temperature of the body.
- Removes irritant– Sneezing and coughing are the 2 crucial reflexes to the nerve irritation within the airways or nasal passages. This system increases the rate of expiration, thus dislodging and eliminating the mucous or irritant that is present in the airways.



Functions of Respiratory System

Source: https://masaka.luxiarweddingphoto.com/functions-of-the-respiratory-system/

Factors affecting the functions of the respiratory system

Lungs are considered the most important body organ of the respiratory system and are affected by several factors such as environmental agents that depend on the susceptibility of an individual. The function of the lung acts as a clinical instrument for pulmonary adequacy. Changes in lung function are because of the bodily changes due to acclimatisation, acclimation, or

adaptation. Human beings are one of the most adaptive organisms present on the earth. Environmental changes are overcome by regulating changes in oneself. Adaptation is the main reason behind this as it is a reversible or long-time process. The most important environmental factor that affects respire tory function is ecology.

Type of Respiratory Function

There are 2 ways of measuring respiratory functions i.e. static and dynamic lung function. The former one is, in which the function of the lung is measured without any pressure of time and the latter, are the functions which are measured in respect of time. Let's study the different types of respiratory functions:

1.2.1 Static Lung Respiratory Functions

Tidal Volume– It is also called TV, which is the volume of air during inspiration and expiration. In other words, it is measuring of air volume that is taken in, or out in a single breath. The standard range of TV is 700 to 2000 ml BTPS.

Vital Capacity– called VC. It is the maximum volume of air that is exhaled after the maximum expiration. The standard range is 4000 to 3300ml BTPS.

Minute Ventilation (MV)– It is the volume of air that is expired or inspired in 1 minute at the time of normal respiration. The standard range is 4 to 12 L BTPS.

Apart from these three, other static functions are:

- Residual Volume– It is commonly called RV, which is well-defined as the volume of air that is residual in the lungs at the last of maximum expiration. The standard range of residual volume is 1000 to 700 ml BTPS.
- Expiratory Reserve Volume i.e. ERV– It is the maximum volume of air that is exhaled from the last tidal expiration. The standard range of ERV is 800 to 600 BTPS.
- Inspired Reserve Volume i.e. IRV– It is the maximum volume of air that is inhaled from the last tidal inspiration. The standard range of IRV is 2800 to 2400 ml BTPS.
- Respiratory Rate i.e. RR– RR is the number of breathing in a minute. The standard range is 12 to 14 breathe for a minute.
- Inspiratory Capacity– IC is the maximum volume of air that is inhaled after the normal expiration. The standard range is 3200 – 2700 ml BTPS.
- Total Lung Capacity (TLC)– It is the maximum volume of air that lungs would be able to attain. The standard range of TLC is 5000 to 4000 ml BTPS.

- Functional Residual Capacity (FRC)– It is the volume of air residual in the lungs at the last of usual respiration. The standard range o FRC is 1800 to 1300 ml BTPS.

1.2.2 Dynamic Lung Respiratory Functions

This dynamic function is measured with respect to time and helps in carrying out different types of changes in lung functions with the change in its activity. Following are the various types of dynamic lung functions:

- Forced Vital Capacity (FVC)– It is the maximum volume of air that is exhaled as rapidly as possible after the maximum inspiration.
- Forced Expiratory Volume in one second (FEV)– It is described as the maximum volume of air that is exhaled because of force in the 1st second after the maximum inhalation.
- Maximum Voluntary Ventilation (MVV)– It is a large amount of air that is breathed in one minute by breathing as fast and deep as possible.

As we all know, air pollution has a number of harmful effects on the human body. The lungs perform various immunological mechanisms. These mechanisms are majorly effective in protecting the whole organism from several physiological functions.

It is specifically for lung defenses and it takes part in inflammatory systems that act as a defense mechanism. Air pollution effect reduces proper lung functioning. One of the major reasons for this decrease causes several types of restrictive and obstructive lung diseases.

There are number of diseases/illnesses caused by the emission of harmful biological and chemical constituents in the working industries. This causes respiratory issues and also increases the problems related to the cardio-respiratory system. And, these kinds of diseases majorly fall under the category of occupational hazards and causes occupational problems.

1.3 HAEMOGLOBIN ESTIMATION

Haemoglobin is a protein used by red blood cells to distribute oxygen further to other tissues and cells in the body. It constitutes of *heme*, which comprises iron atoms plus the red pigment, porphyrin (responsible for giving the blood its red colour) and globin a chain of amino acids. Haemoglobin, which is a complex protein-iron compound in the blood, has an important function to carry oxygen to the cells from the lungs and carbon dioxide away from the cells to the lungs. Each erythrocyte contains about 200 to 300 molecules of hemoglobin, and then every molecule of hemoglobin consists of four groups of *heme*, and each group of *heme* has potential carry one molecule of oxygen. Hemoglobin molecule comprises four globin polypeptide chains composed of amino acids, with each polypeptide chain composed of 141 to146 amino acids. The absence, replacement, or addition of only one amino acid alters the characteristics of the hemoglobin. Different kinds of hemoglobin are recognized by their specific arrangement of polypeptide chains. Mostly alpha and beta chains are found with gamma and delta being found less often.

When there is an atmosphere of high oxygen concentration, such as in the lungs, hemoglobin has the characteristics to the bind with oxygen to form oxyhemoglobin and in an atmosphere of low oxygen concentration, such as in the peripheral tissues of the body, oxygen is substituted by carbon dioxide to form carboxyhemoglobin. Hemoglobin releases the carboxyhemoglobin in the lungs for excretion and picks up more oxygen for transport to the cells. The normal concentrations of hemoglobin in the blood are 12 to 16g/dL (grams per deciliter) in women and13.5 to18g/dL in men.

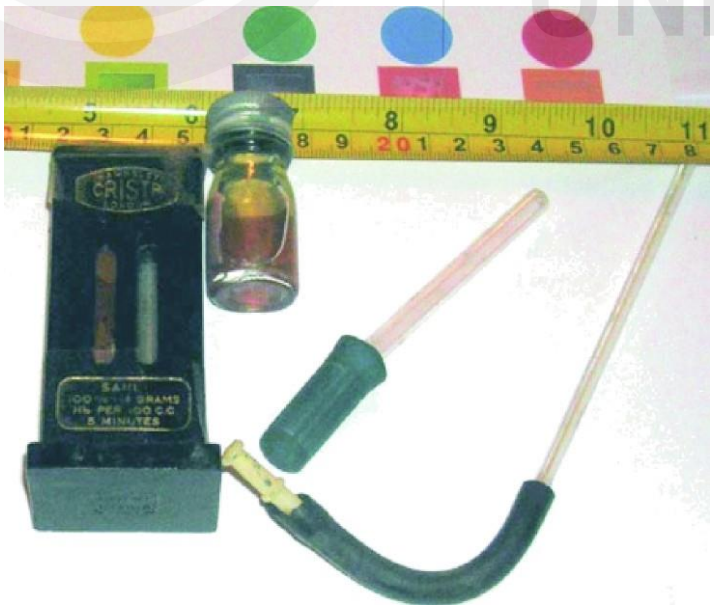
Hemoglobin Estimation

Hemoglobin estimation measures the amount of this substance in a specific volume of blood. It also indicates the amount of intracellular iron. Being an important indicator of anemia, hemoglobin estimation is also used in blood transfusions.

Methods of Estimation

One of the basic techniques for estimating hemoglobin calorimetrically, is with a haemometer.

The Sahli haemometer method utilises the conversion of haemoglobin into acid haematin which has a brown colour in solution. The principle of the instrument is that Haemoglobin present in a sample of blood is changed into acid hematin by adding N/l0 HCl to the blood and its haemoglobin content is ascertained by matching the solution against non-fading glass having a standard colour. The intensity of the colour is associated to the quantity of haemoglobin in the blood sample. The purpose of adding water is to dilute the brown solution until it matches that of a standard. The more haemoglobin, the more water required to arrive at the matching colour. Haemoglobin values are recorded at the meniscus of the brown solution (Kharkar and Ratnaparbha, 2013).



Sahli's Haemoglobinometer

Source: www.health.ade1aide.edu

Sahli's Haemoglobinometer consists of:

- Comparator box possess
- Special diluting tube
- Haemoglobin pipette
- Glass stirrer
- A bottle containing N/10 HCL

Standards for estimation

Normal range varies with altitude.

Male - 8.1 to 11.2 mmol/L (13 to 18 gm/dL)

Female - 7.4 to 9.9 mmo1/L (12 to 16 gm/dL)

Child - 7.1 to 8.4 mmol/L (11.5 to 13.5 gm/dL)

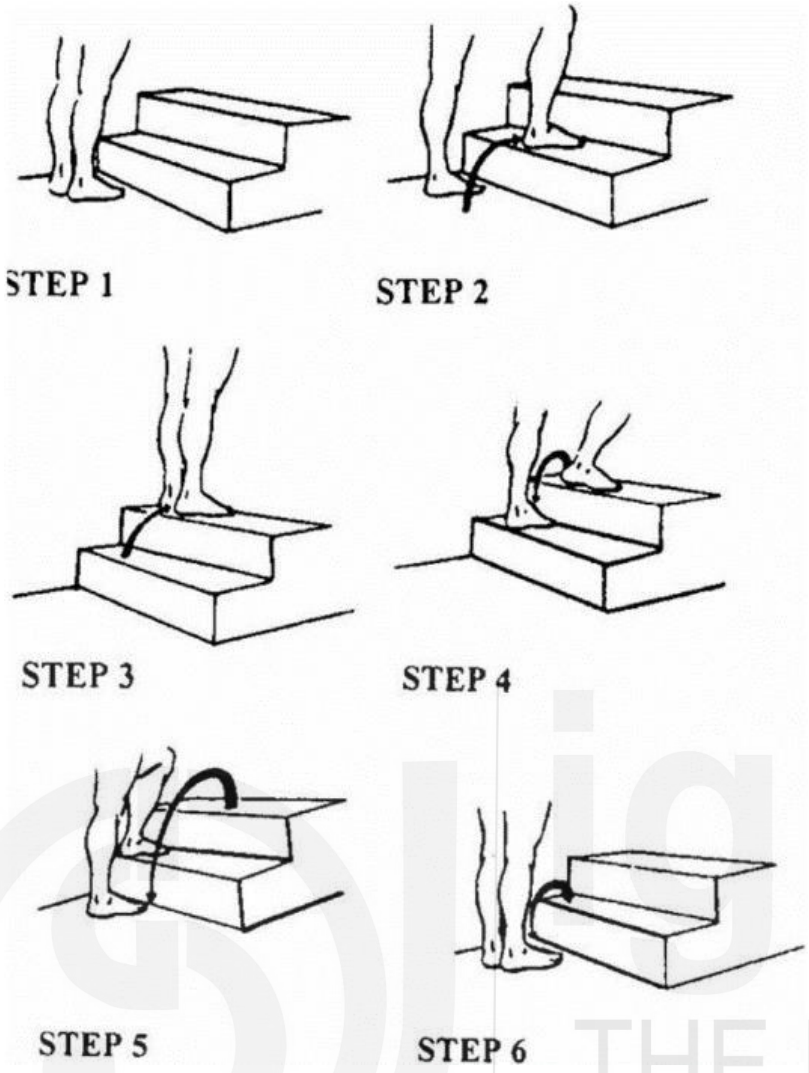
Newborns - 10.5 to 13.7 mmol/L (17 to 22 gm/d1)

1.4 STEP TEST

The step test is specifically designed to measure the aerobic fitness of an individual. Participants are allowed to step up and step down, and on and off (an aerobic type step) for about 3 minutes to increase the rate of heart and to analyse the recovery rate of heart during 60 sec (minute) instantly following the exercise of step test. The main reason of coronary artery diseases (CAD) is inactivity. Consequently, exercise decreases the risk of death from a heart attack. There are various benefits of exercise such as lowers high blood pressure, lowering of triglycerides, improves circulation, increase in good cholesterol and aids in managing/controlling weight.

Steps to Perform Step Test

- Participant should sign the Fitness Testing Release and Consent.
- Follow the guidelines mentioned above i.e. Contraindications for stopping the step test.
- Before starting the test, inform the participant about the importance of sitting down rapidly at the completion of the test. The participant is asked to remain quiet and still for about 1 minute so an accurate rate of heart can be measured from his/her wrist.
- Instruct the subject on stepping to the monochrome beat using the same lead leg in a set rhythm i.e. UP, UP, DOWN, DOWN during each four-step cycle.
- Set the monochrome for about 95 steps (24 beats) per minute.



Measurements for Step Test

Source:https://www.researchgate.net/figure/Step-Test-and-Exercise-Prescription-STEP-protocol

- Participant should always position facing step and allow his/her to pick up the metronome beat by marching in a right place. Start the stopwatch when the participant begins to step UP, UP, DOWN, DOWN rhythm. Always check that they are maintaining the metronome rhythm and correct it, if required. You can speed up, slow down, listen to the beat carefully, etc.
- During the test, inform the subject about the time as it passes i.e. 2 min, 1 min or 30 sec remaining. Remind them to sit down quickly at the completion of the test when 30 seconds remaining and wait for recording the heart rate.
- When the subject sits down, quickly place your fingers, and not thumb resolutely on the radial artery. Check the rhythm and begin counting 5 sec after the completion of test.
- Measure the number of heart beats for 1 minute. The count of 1 minute reflects the recovery rate of heart. (Cooney et al., 2016; Norton et al., 1996)

Contraindications for testing and guidelines for stopping the Step Test:

- High BP: diastolic pressure > 100mm Hg or Systolic Pressure > 160 mm Hg.
- Beginning of angina or angina like symptoms.
- Subjects request to stop the test.
- Verbal or physical appearance of severe fatigue.
- Indications of poor perfusion: confusion, nausea, cold, clammy skin, pallor, cyanosis.

1.4 TREADMILL TEST

Exercise testing is a type of cardiovascular stress examination that utilizes exercise with ECG i.e. electrocardiography and monitoring of blood pressure. This type of stress examination is generally done with exercise conventions by using a bicycle or treadmill. Patients who are not able to exercise may benefit from the management of a pharmacological agent which stimulates heart activity during exercises.

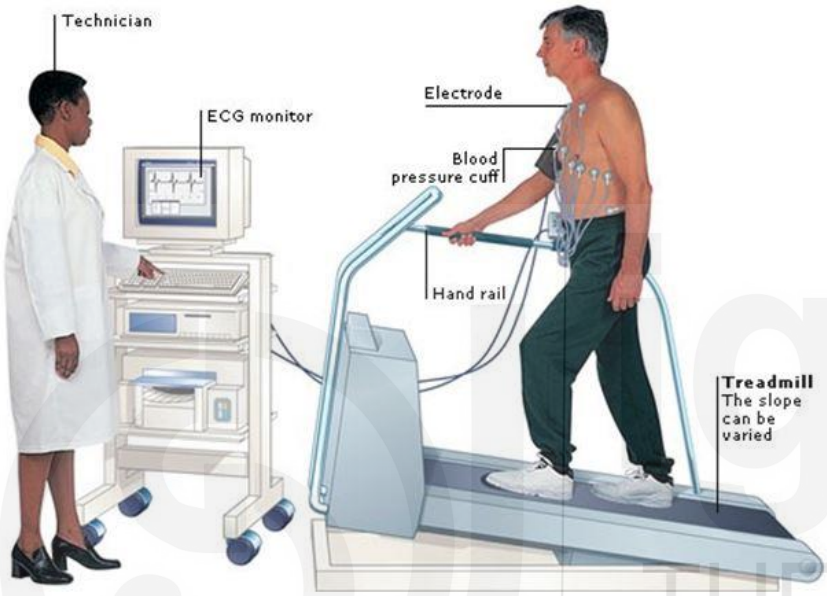
Exercise is related to the sympathetic stimulation and the modifications in the tone of the coronary vasomotor that affect the blood flow of a coronary system. As per various researches, coronaries are dilated at the time of exercise. The dilation results in the release of vasoactive components from the endothelium because of the increased consumption of myocardial oxygen, passive relaxation because of the increased arterial pressure, and limitation that is endothelium mediated constrictor effects of catecholamine.

Indications for testing and guidelines for stopping the Treadmill Test:

- Acute pain in the chest in patients (excluding the acute coronary syndrome i.e. ACS).
- Symptoms involving myocardial ischemia.
- CAD with worsening symptoms.
- Heart failures/ cardiomyopathy.
- Valvular heart disease to determine the capacity of exercise and requirement for surgical interference.

This test is mainly performed to assess the effects of exercise on the heart. Exercises help a doctor to detect arrhythmias (abnormal heart rhythms) and also diagnose the absence or presence of CAD i.e. coronary artery disease. This examination involves walking on a treadmill while monitoring the heart's electrical activity. The speed and the incline of the treadmill increase throughout the test. The results indicate that how good your heart is responding to the stress of various levels of exercise. (Norton et al., 1996)

- The medical history should be taken. The blood pressure, ECG (electrocardiogram), and heart rate is also monitored before and after performing the test.
- All the upper body clothing will be removed by the participant and wear a gown that opens from the front side.
- Adhesive electrodes will be connected to the chest to detect ECG. The positions where electrodes are placed will be cleaned using the alcohol and then shaved if required. A slight abrasion might also be of use to make sure a good quality of ECG record.



Steps to Perform Treadmill Test

Source: https://vaishnaviheartcentre.com/treadmill-tmt-test-in-btm-layout-bangalore

- Then, the ECG, heart rate, and blood pressure is recorded.
- After this, participant will be asked to walk on the treadmill. Start with a slow walk and gradually increase the speed at stipulated times. It is important to walk as long as possible due to the effort-dependency of the test.
- The participant will be monitored throughout the test. In case of any problem, the technologist will instruct to stop the test. If the participant experiences any type of symptoms (such as pain in the chest, dizziness, fatigue, and abnormal shortness of breath) during and after the test, it should be informed to the technologist.
- After the completion of the test, the technologist asks the participant to lie down to monitor the blood pressure, ECG, and heart rate for about 3-5 minutes.
- The obtained data can be studied by the cardiologist for further understanding (Vilcant and Zeltser, 2021).

This manual gives a fair idea about the significance of these commonly used tests.

1.6 REFERENCES

Arnold, J.M., Fitchett, D.H., Howlett, JG., Lonn, E.M., & Tardif, J. (2008). Resting heart rate. A Modifiable prognostic indicator of cardiovascular risk and outcome. *Canadian Journal of Cardiology, 24*, 3-8.

Cooney et al. (2013). A simple step test to estimate cardio- respiratory fitness levels of rheumatoid arthritis patients in a clinical setting. *International Journal of Epidemiology, 1-8.*

Fontela, P.C., Winkelmann, E.R., & Viecili, P.B. (2017). Conicity index: An anthropometric measure to be evaluated. *Cardiologia, 36*(5), 365-366

https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=1

https://www.ncbi.nlm.nih.gov/books/NBK499903/

Kharkar, V., & Ratnaparkhe, V. (2013). Hemoglobin estimate methods: A review of clinical, sensor and image processing methods. *International Journal of Engeneering and Technical Research, 2.*

McArdle, W.D., Katch, F.L., & Katch, V.L (2007). *Exercise physiology energy, nutrition and human performance*, 7th ed.

Norton, K.T., Old, S.O., & Craig, N. (1996). Anthropomtry and sports performances. In: K., Norton and T. Old (Ed.). *Antherpometrika: A textbook of body measurement for sports and health cause*. Sydney, Austrailia: UNSW Press, 287-352

Shenoy & Jagdamba. (2017). Influence of central obesity assessed by conicity index on lung age in young adults. *J Clin Diagn Res. 11(4)*

Uzogara, S.G. (2016). Assessment of obesity, presumed and proven causes and prevention strategies: A review. *Medcrave, 5(*1), 199-217

Vilcant, V., & Zeltser, R., (2021). Treadmill stress testing. In: *StatPearls [Internet]*. Treasure Island (FL): StatPearls Publishing. Retrieved from: Link https://www.ncbi.nlm.nih.gov/books/NBK499903/

SUGGESTED READING

UNIT 1 ENERGY INTAKE, METABOLISM AND HOMEOSTATIS

Martini, F.H., Nath, J.L., & Bartholomew, E.F. (2018). *Fundamentals of anatomy & physiology* (11th ed). Pearson.

McArdle, W.D., Katch, F.I., & Katch, V.L. (2015). *Exercise physiology: Nutrition, energy, and human performance* (8th ed.). Wolters Kluwer.

Rodwell, V., Bender, D., Botham, K., Kennelly, P., & Weil, P.A. (2012). *Harper's illustrated biochemistry* (31st ed.). The McGraw Hill.

Widmaier, E.P., Raff, H., & Strang, K.T. (2008). *Vander's human physiology: Mechanism of body function* (11th ed.). The McGraw-Hill.

UNIT 2 EXERCISE PHYSIOLOGY

Barrett, K.E., Barman, S.M., Boitano, S., & Brooks, H,L. (2016). *Ganong's review of medical physiology*(25 ed.). NY: McGraw-Hill Medical.

Hall, J.E. (2015). *Guyton and Hall textbook of medical physiology* (13 ed.). Elsevier Health Sciences.

Plowman, S.A., & Smith, D.L. (2013). *Exercise physiology for health fitness and performance*. Lippincott Williams & Wilkins.

UNIT 3 HAEMODYNAMICS

Boron, W.F., & Bouleap E.I. (2009). *Medical physiology –A cellular and molecular approach* (2nd ed.). Saunders Elsevier.

Hall, J.E., & Guyton, A.C. (2011). *Textbook of medical physiology* (12th ed.). Philadelphia: Saunders Elsevier.

Klabunde, R.E. (2011). *Cardiovascular physiology concepts* (2nd ed.). Lippincott Williams & Wilkins.

Martini, F.H., Nath, J., & Bartholomew, E.F. (2018). *Fundamentals of anatomy and physiology* (11th ed.). Pearson.

UNIT 4 PHYSICAL WORKING CAPACITY AND PHYSICAL FITNESS

Author Guide. *ACE's essentials of exercise science for fitness professionals.*

Benson, R., & Connolly, D. (2011). *Heart rate training*. Human Kinetics

Bushman, B. (2011). *ACSM complete guide to fitness health*. Human Kinetics

Sawka, M., & Wenger, C.B. (1988). *Physiological responses to acute exercise-Heat stress.*

UNIT 5 CHRONIC PHYSIOLOGICAL ADAPTATIONS TO EXERCISE TRAINING

Author Guide. *ACE's essentials of exercise science for fitness professionals.*

Benson, R., & Connolly, D. (2011). *Heart rate training*. Human Kinetics.

Bushman, B. (2011). *ACSM complete guide to fitness health*. Human Kinetics.

https://www.cdc.gov/nccdphp/sgr/pdf/chap3.pdf

UNIT 6 EXERCISE AND AGE

Malina, R., Bouchard, C., & Bar-Or, O. (2004). *Growth, maturation and physical Activity* (2nd ed.). Human Kinetics.

McArdle, W.D., Katch, F.I., & Katch, V.L. (2010). *Essentials of exercise physiology* (7th ed.). Lippincott Williams and Wilkins.

McArdle, W.D., Katch, F.I., & Katch, V.L. (2010). *Exercise physiology: Nutrition, energy, and human performance*. Lippincott Williams & Wilkins.

UNIT 7 ANTHROPOMETRY AND CVD AND RESPIRATORY FUNCTIONS

Hale, T. *Exercise physiology: A thematic approach.*

McArdle, W.D., Katch, F.I., & Katch, V.L. (2010). *Exercise physiology: Nutrition, energy, and human performance*. Lippincott Williams & Wilkins.

Shavers, L.G. (1986). *Essentials of exercise physiology.* USA; Macmillan.

UNIT 8 GENDER AND ETHNICITY

Case, R.M. (Ed.). (1985). *Variations in human physiology.* Manchester University Press.

Flynn et al. (2018). *Concepts of fitness and wellness* (2nd ed.). GALILEO, University System of Georgia.

Hale, T. (2003). *Exercise physiology*. England: John Wiley & amp; Sons Inc.

McKinney et al. (2016). The health benefits of physical activity and cardiorespiratory fitness. *BC Medical Journal, vol. 58*(3), 131-13

Nageswari, K.S., & Sharma, R. (2006). *Practical workbook of human physiology*. Jaypee Brothers Medical Publisher.

Shavers, L.G. (1986). *Essentials of exercise physiology.* USA; Macmillan.

UNIT 9 PRINCIPLES OF PHYSICAL CONDITIONING TECHNIQUES

UNIT 10 EFFECT OF LIFESTYLE DYNAMICS

Kelso, A.J. (1970 January 1). *Physical anthropology: An introduction.* Philadelphia, USA: Lippincott,J. B. Lippincott.

Thomas, J.A. (Ed.). (1988 September 30). *Drugs, athletes, and physical performance.* New York City, USA: Springer.

FScanlon, W. (1991 June 30). *Alcoholism and drug abuse in the workplace: Managing care and costs through employee assistance programs* (2nd ed.). WestWestport, CT USA: Kindle Edition, Publisher.

Tyagi, D. (2006 January 1). *Physical anthropology.* New Delhi, India: Anmol Publications Pvt Ltd.

Wu, A.Hb, (2015 June 27). *Performance enhancing drugs and adulterants: The hidden assassin II* . California, USA: Arborwood Glen.

Hrdlicka, A. (2020 October 10). *Physical Anthropology: Its scope and aims; its history and present status in the United States.* Indianapolis, Indiana, USA: Alpha Edition.

UNIT 11 PHYSIQUE, NUTRITION AND PERFORMANCE

Carter, J.L., & Heath, B.H. (1990). *Somatotyping: development and applications*. Vol.5. Cambridge University Press.

Katch, F.I., & McArdle, W.D., (1993). *Introduction to nutrition, exercise, and health* (4th ed.). Philadelphia, Pa: Lea & Febiger.

Malina, R. M. (2007). Body composition in athletes: assessment and estimated fatness. *Clinics in sports medicine*, *26*(1), 37-68.

Shaver, L.G. (1981). *Essentials of exercise physiology*. Ohms Lane, Minneapolis, Minnesota: Burgess Publishing Company.

PRACTICAL MANUAL

Anwaruddin, S., Martin, J.M, Stephens, J.C. and Askari, A.T. (2013). *Cardiovascular and hemodynamics: An introductory guide.* Humana Press.

Inoue, M., Hori, M., Imai, S. and Berne, R.M. (1991). *Regulation of coronary blood flow.* Springe

Mackenzie, B. (2015). *101 Performance evaluation tests.* Green Star Media limited.

Rogers, K. (2011). *The cardiovascular System*. Brintannica Educational Publishing.