STATE LEVEL WORKSHOP ON

HUMAN EXPERIMENTS IN PHYSIOLOGY

Setting up innovative experiments with minimal equipment and expenditure

28th and 29th January 2000

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and

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For limited circulation. Please contact individual authors for further details on the experiments and on the subject material.

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WORKSHOP SCHEDULE

DAY 1: JANUARY 28, 2000	
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11: 00 – 11: 20	Workshop Background and specific aims of the Workshop. Dr. Mario Vaz
11: 20 – 11: 30	Short Tea Break
11: 30 – 12: 45	SESSION 1 (Central Nervous System)
12: 45 – 1: 45	Lunch
1: 45 – 3: 00	SESSION 2 (Respiration and Cardio-vascular system)
3: 00 – 3: 15	Tea
3: 15 – 4: 30	SESSION 3 (Body Composition / Skeletal Muscle Function)
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9: 00 – 10: 15	SESSION 4 (Special Senses)
10: 15 – 10: 45	SESSION 5 (Miscellaneous experiments)
10: 45 – 11: 00	Tea
11.00 – 12: 00	Interactive Session with Participants. Prof. Rani Gupta
12: 00 – 12: 30	SUMMING UP. Dr. Mario Vaz
12:30	Lunch

For details of the contents of Sessions 1 to 5, please refer to the 'Contents' page

The organisational and technical work carried out by various members of the Department of Physiology in relation to the conduct of the workshop is gratefully acknowledged.

Funds	Prof. Rani Gupta and Dr. Sathyaprabha
Correspondence	Prof. Sandhya Avadhany
Registration and Opening Ceremony	Dr. Sathyaprabha
Accommodation and Catering	Dr. Tony Raj and Dr. Sathyaprabha
Audio-visual arrangements	Dr. KN Maruthy
Workshop programming, Programme manual, Minutes of the workshop	Dr. Mario Vaz

The help given by Drs. GV Veena, B Caszo, S Sucharita and D Nazareth in various activities of the workshop and during various stages of the development of the experiments is gratefully acknowledged.

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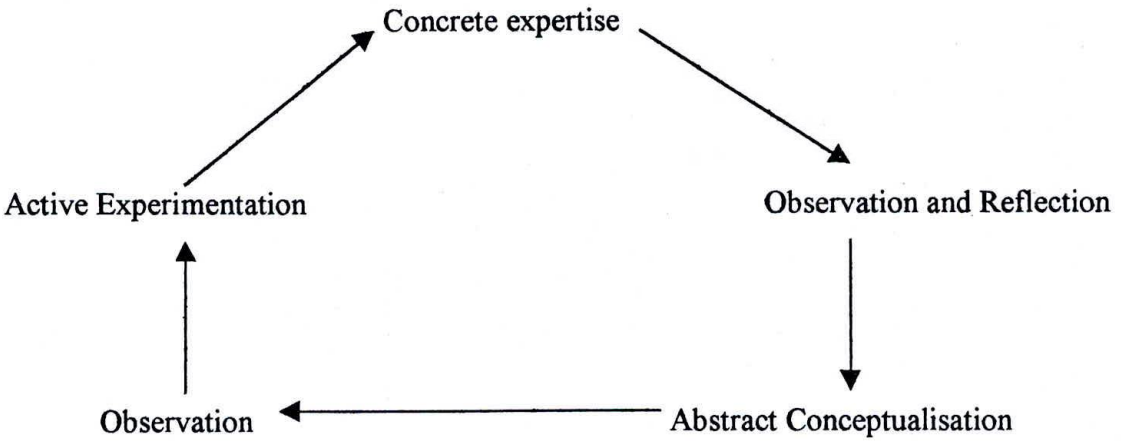
THE ROLE OF PHYSIOLOGY PRACTICALS IN THE MEDICAL CURRICULUM: A BACKGROUND PAPER

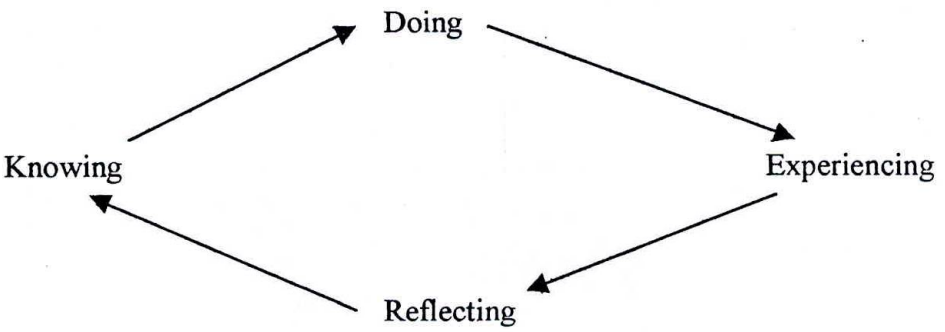
Practicals in the context of Andragogy (Adult Learning)

Adults learn in very different ways from children. Malcolm Knowles in his book "The Adult Learner. A neglected species" highlights the issue. He points out that all great teachers in history, were all teachers of adults, not children. Because their experience was with adults, they had a very different concept of the learning / teaching process then that which has come to dominate formal education. They, for instance perceived learning to be a process of active enquiry, not passive reception of transmitted content. Accordingly, they invented techniques for actively engaging learners in enquiry. This fits in with the notion that enquiry into "experience" is the richest resource for an adult's learning.

It is in this context that practicals fulfill a very special place in adult learning. Practicals, if properly structured, challenge the learner to engage in active enquiry and in a process of reflection, the ultimate aim of which is to achieve concrete expertise as indicated below in Schon's Experiential Learning Cycle. Experiential methodology aims at putting action and enquiry into a purposive cycle.



A perhaps simpler way of expressing this is given below:



In order to be truly analytical, a permissive environment is necessary, where the individual can freely express ideas.

Learning outcomes of a practical.

A practical in Physiology can have a large number of learning outcomes. The list given below is not exhaustive.

- A practical may help to demonstrate an otherwise apparently abstract concept.
- It may allow for an extension of knowledge that a student has gained through reading and reflection.
- It may reinforce basic theoretical knowledge.
- It may provide opportunities for integration of knowledge across systems.
- It may allow students to understand the concepts of study design.
- It may allow a student to interpret data, both in the context of an individual experiment and when data is collated from multiple experiments.
- In relation to the above, it provides an opportunity for students to learn the essentials of biostatistics.
- A practical may help students understand the concept of biological variability
- A practical may allow a student to understand the basic issues of instrumentation
- It may allow the student to develop skills in specific clinically relevant measurements e.g measurement of blood pressure

Can Physiology Practicals Enhance The Capabilities Of Students To Become More Effective Medical Practitioners?

In order to be relevant to the medical curriculum, a Human Physiology course must be targeted to enhancing the capabilities of the product of the medical system, in the first instance, the general practitioner. Unfortunately, this has received rather less than its appropriate attention.

Many medical schools have attempted to focus on the ultimate development of the medical practitioner rather than assigning an overwhelming importance to each individual subject curriculum. This has resulted in a greater synergy, with more integration and a greater emphasis on early clinical experiences. The new Dundee medical curriculum is a case in point, and is driven by the very appealing doctrine that the "whole is greater than the sum of its parts". Given below are some possibilities that a Human Physiology Practical Course can achieve in this regard:

TARGET	METHODOLOGY TO ACHIEVE TARGET
• Enhance the skills of students to perform 'clinical' measurements	• Develop practicals where these measurements can be repetitively applied eg. blood pressure, pulse, respiratory rate etc.
• Enhance the skills of the student at 'problem-solving'	• Introduce more 'analytical' experiments. • Encourage students to explain the unexpected. • Avoid providing the 'expected' result at the start of the experiment. • Introduce clinical problems based on the experiment
• Enhance the ability of the student to practice 'evidence-based' medicine (see below for details)	• Introduce elements of 'study design' into the practicals • Introduce biostatistics into the analytical component of experiments
• Enhance the inter-personal and communication skills of the student	• Emphasise the importance of clear and comprehensible instructions to the subjects of a human experiment. • Include communication skills as part of the evaluative process in the practical examination

Two elements that have been included above are that of 'Problem-solving' and 'Evidence-based Medicine' which will be discussed in greater detail.

Problem-based learning (PBL): is an instructional innovation in medical education first adopted by the McMaster University in the mid-1960's. PBL is decribed as a method characterised by the use of patient problems as a context for students to learn problem-solving skills and acquire knowledge about the basic and clinical sciences. Barrow's articulated four major educational goals of PBL.

- Structuring of knowledge for use in clinical contexts
- The development of clinical reasoning processes that include hypothesis generation, inquiry, data analysis, problem synthesis, and decision-making
- The development of self directed learning skills deemed critical for doctors to to cope with an expanding knowledge base and unusual or unique problems in practice.
- To enhance the intrinsic motivation for learning.

Clearly, Physiology practicals provide an obvious place where some of the skills for problem-based learning can be learned and applied. Clinical problems structured around the practicals can help motivate students to learn, and encourage students to seek solutions on their own, thus promoting self-directed learning.

Evidence-based Medicine: is the conscientious, explicit and judicious use of current best evidence in making decisions about the care of individual patients. This is increasingly important as ever more treatment strategies and drugs appear at seemingly shorter intervals of time. The practice of Evidence-based medicine means integrating individual clinical expertise with the best available external clinical evidence from systematic research. The latter requires an understanding of study design and biostatistics, given the largely probabilistic nature of clinical outcomes. Physiology practicals offer the opportunity for students to learn the elements of study design and to apply statistics to data that they have generated.

Why Human Experiments?

The introduction of human practicals leads to less 'dehumanisation' during the pre-clinical years of the medical curriculum. Human experiments also allow students to develop inter-personal and communication skills, provided these are emphaised during the learning process. Our own data suggests that students enjoy human experiments much more than animal experiments, in part, because the data is generated on themselves. Despite the limitations on the types of experiments that can be conducted with human volunteers, there can never-the-less be good learning outcomes, if the experiments are planned carefully. Human experiments also afford the opportunity for students to be exposed to the ethical implications of human experimentation.

A window on the current workshop

This workshop attempts to introduce innovative human experiments that can be implemented with minimal cost and equipment. The experiments covered in the manual are not a comprehensive list. They do however provide a starting point, to which we can add and innovate further.

In this workshop, some experiments have involved the construction of simple instruments at very low cost. These experiments have extended the scope of the practicals (e.g. Visual Reaction Time in Session 1, Maximal expiratory pressures in Session 2, Audiometry in Session 4). Other experiments have sought to standardise current methods to allow for a greater interpretation of results (e.g. Tests of Sympathetic and Parasympathetic Nervous Function in Session 2). Some experiments present novel but simple ways of demonstrating theoretical concepts (Purkinje Sanson Images, Travelling wave, Colour Mixing in Session 4). There are some experiments that have been linked to clinical problem-solving exercises (Anthropometric Assessment, Assessment of Habitual Physical Activity in Session 3). There has also been an attempt to introduce practical exercises in systems that to a large extent have been ignored thus far in Human Physiology Practical courses (Assessment of Renal Function, Assessment of Satiety in Session 5).

The workshop is not only the effort of the individual speakers but of all the members of the Department of Physiology who have contributed in many diverse ways.

References:

Knowles M. The Adult Learner. A neglected species. 4th Edition. Gulf Publishing Co; Houston, 1990.

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SESSION 1

Central Nervous System

QUANTIFYING TWO POINT DISCRIMINATION

Introduction:

The skin is endowed with areas or spots, which are either sensitive or insensitive to touch. This depends on whether or not there is a sensory receptor at the Spot which has been touched. If the receptor is touched-the sensation of touch is elicited. Respective sensations are elicited by hot & cold stimuli. (Fig 1)

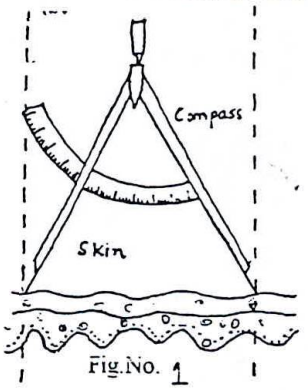


Fig.No. 1

In areas where these receptors are close together –the least distance between 2 points which can be identified as 2 separate points is less-as compared to areas where receptors are widely separated (Fig 2).

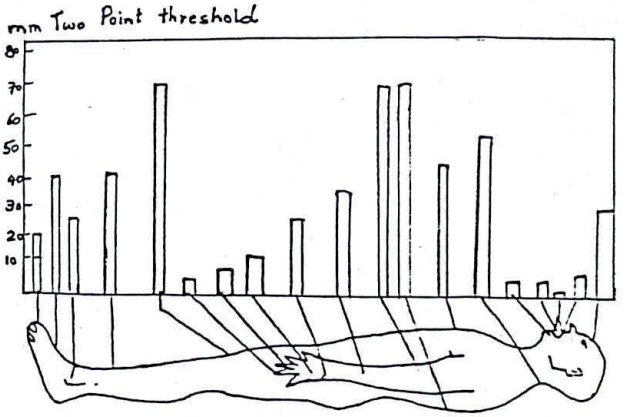


Fig.No. 2

The property that could reflect on the results is the receptive field of a neuron i.e. the area of the skin supplied by a sensory neuron. The factors affecting 2 point discrimination are: -

1. Integrity of the pathway of touch sensation.
2. Cortical functions(sensation and perception)

For routine clinical testing the skin is touched lightly with cotton wool and the patient is asked about the kind of sensation felt and location of the stimulus. Spatial resolution is evaluated by recognition of numbers or letters written on the skin in various sizes with a blunt probe or fingers. Sense of vibration is tested using tuning fork.

Receptors are classified as follows: -

1. Exteroceptors – those in contact with the environment.
2. Enteroceptors – eg. chemoreceptors
3. Teleceptors – eg. Rods & cones for vision, hair cells.

All these receptors convert a specific stimulus into an impulse-they therefore function as transducers.

Clinical Significance:-

Sensory information from the skin projects to the sensory cortex. The representation of a peripheral area in the sensory cortex is determined, by the density of the cutaneous receptors eg. The face, hands, finger etc. have greater representation than the back or the thighs. (Fig no. 3)

This experiment has clinical application in the testing of peripheral nerves.
The normal values for 2 point discrimination are- fingertips (2-5mm), palms and soles (2-6mm), dorsum of hands and feet (6-8mm), back(60-70mm).

I Aim:-

1. To measure the minimum distance between 2 points (in mm) that can be appreciated as 2 separate points on the right & left thumb.
2. To compare it with that of on the forearm and back.

II Requirements: -

1. A pair of dividers or Weber's compass.
2. A ruler.

Fig. No. 3.

III Procedure: -

1. Choose an appropriate area.
2. Blindfold the subject.
3. Set the dividers to some separation and touch the skin simultaneously with both points of the divider.
4. Re-test after varying the separation of points, starting from the lowest to the highest separation distance.
5. Record the minimum separation distance, which the subject identifies as 2 points.
6. Take the recordings from your classmates (at least 10).

IV Observations: -

	Thumb mm		**Forearm mm**		**Back mm**	
	R	**L**	**R**	**L**	**R**	**L**
1						
2						
3						

Mean SD=

V Questions & Discussion:-

1. Define receptors and classify them? Define receptive field?
2. Draw a flow diagram of the pathway of sensation of touch.
3. What is the law of projection?
4. What is the doctrine of specific nerve energies?
5. Which clinical conditions can this test be applied?

VI Reference:-

1. Practical Physiology (Vol II)- Apte
2. Human Physiology- Robert Schmidt (2^{nd} ed.)
3. SOURCE BOOK OF PRACTICAL EXPERIMENTS IN PHYSIOLOGY REQUIRING MINIMAL EQUIPMENT, PREPARED BY IUPS.

VII Problems for assessment:- (20 marks)

1. Test the 2-point discrimination in areas of distribution over C7 or L3, 4,5 or the trigeminal nerve.
2. Compare the 2-point discrimination on the fingers, forearm & back of the given subject.

VIII Evaluation: -

1. Instruction to the subject, closing the eyes. (2)
2. Testing for both the sides for comparison. (2)
3. Testing in areas confined to the dermatomes. (2)
4. Tabulation of results (6)
5. Discussion (8)

DEMONSTRATION OF DYNAMIC PROPERTY OF THERMAL RECEPTORS
(Demonstration of 3 - bowl experiment)

Introduction:

It is known that there are specific warm and cold points on the human skin. These spots when touched will produce warm and cold sensations only i.e. they are specific. There is a range of temperature within which there is neither the sensation of heat or cold. This is the neutral zone and thermal stimuli are constant. The upper and lower limit of the neutral zone is 36 C-30 C. Permanent or static sensation of warmth is produced by temperatures ranging from 36 C-45 C and that of cold by temperatures less than 30 C. The sensation of pain induced by cold is felt by temperatures less than 17 C. The properties of these thermal receptors are as follows:-

1.They are specific for heat or cold and insensitive to non thermal stimuli.
2.They are carried by nerves belonging to group IIIa and group IVc of Lloyd's classification of nerve fibers
3.The receptor discharge increases as rate of change of temperature increases.
4.The sensation perceived by the person while the temperature is changing and depends upon:-

a) Initial temperature
b) Rate of change
c) Size of skin area exposed

This is the dynamic property of thermal receptors.

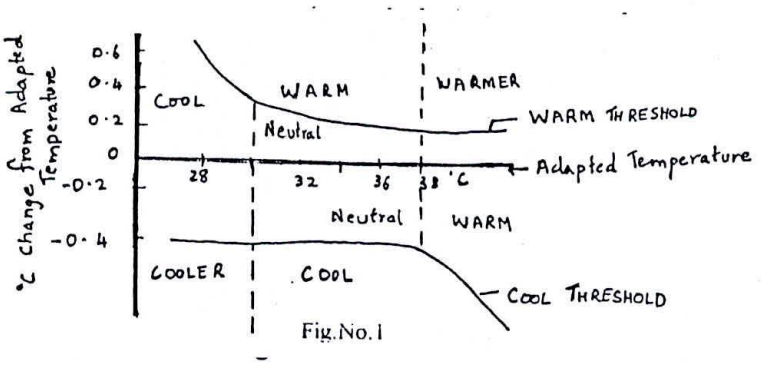


Fig.No.1

Eg. At 28 C the threshold for warmth is high and for cold sensation is low.At 38 C threshold for warmth is low and that for cold is high.

This experiment demonstrates the dynamic properties of receptors sensitive to heat or cold.

I Aims & Objectives: To study the dynamic property of temperature receptors.

II Requirements: 1) A team of three volunteers of which one is the subject, one to mix hot & cold water and one to read the thermometer.
2) Three flat bowls large enough for immersing both hands of the subject. Each bowl filled with water at 20,30,40 C respectively.
3) Thermometers (3 nos.)

III Procedure:
1) The 3 bowls are filled with water at 20,30&40 C respectively.
2) The subject puts his \ her left hand in the bowl with water at 20 C and right hand in the bowl with water at 40 C and reports the sensation felt in each hand.
3) After 30 sec, both hands are removed from the bowls and put into the bowl with water at 30 C.
4) The subject reports the sensation felt in the right and left hands immediately after immersion and after 1 minute after immersion.

	STATIC (initial)	DYNAMIC (immediate)	1 minute after immersion.
L	Cold	Warm	Both same
R	Warm	Cold	

V Conclusion: The change to a given temperature can produce sensations of either warm or cold depending upon the initial temperature (Pg.203 Schmidt's Human Physiology). We have to distinguish between static & dynamic sensitivity of thermal sense. While being in water of 30 C the cold receptors of left hand will be inhibited while those of right hand will be activated. This is due to the fact that these receptors not only indicate stationary temperature but they are also sensitive to rate of change of temperature.

VI Discussion: 1) List the properties of receptors
2) Draw the pathway of temperature sensations.
3) What is neutral zone of temperature? How does it differ from the thermoneutral zone.
4) What is adaptation of receptors?

VII References: 1) Source book of Practical Experiments in Physiology requiring Minimal equipment prepared by IUPS
2) Schmidt's Human Physiology.

MEASUREMENT OF VISUAL REACTION TIME

Introduction:

Survival requires quick reactions. Split second decision's in responding to stimuli can be life saving, for example a faster reaction can make a difference between life and death in certain professions such as fire fighting, aviation, airforce etc. The reaction time is a physiological parameter, which belongs to one of the cognitive function in humans and spans the realms of psychologists. **It is the time interval between application of stimuli and the response elicited to it**.This includes the time taken for an impulse to reach the sensory area of the brain via the sensory tracts , from there to motor areas are of the same and opposite side , and to the anterior horn cells of the spinal cord involved in the response.

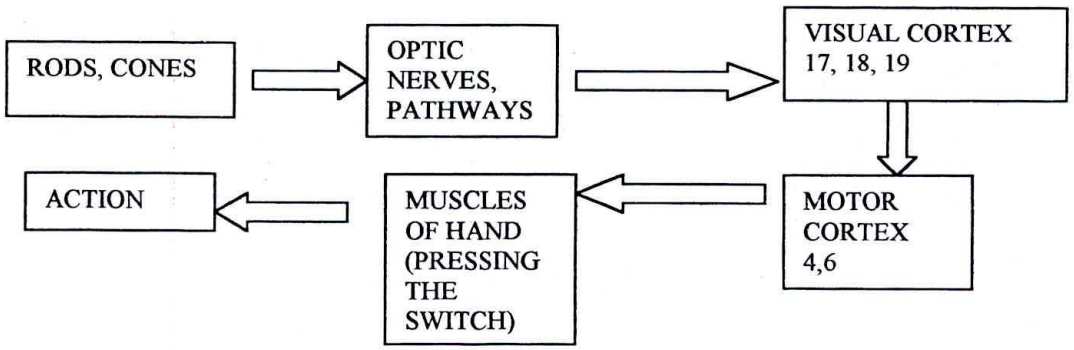
There are three types of reaction times - simple, recognition and choice.

In **simple** reaction time experiments there is only one stimuli and one response e.g X at location, spot the dot and reaction to sound, all the above measure simple reaction time.

In **recognition** time experiments, there are some stimuli that should be responded to (Memory set) and others that should get no response (distractors set). There is still only one correct response Symbol and tone recognition are both recognition experiments. In **choice** reaction time, the user must give a response that corresponds to the stimuli, such as pressing the letter on the keyboard when the letter appears on the computer screen .

The role of reaction time under physiological conditions is protective and this experiment is designed to study it in a group of normal subjects

Flow diagram:



Factors influencing reaction time :

Besides the variation caused by the type of stimuli, stimulus intensity, there are many factors affecting reaction

Arousal: One of the most investigated factors includes muscle tension. Reaction time is fastest in the intermediate level of arousal, and deteriorates when the subject is either too relaxed or too tense .

Age: The reaction time shortens from childhood unto the age of 30, then increases slowly until the age of 50 and 60, and lengthens faster as the person reaches the age of 70 and beyond . One of the studies reported that the value for teenagers 187 m sec, (visual) and 158 m sec (auditory)

Gender: In almost all age groups, males have a faster reaction time than females, and which cannot be over come by practice .Males have responses to light as220 ms and 190 ms for sound, and females had response times as 260 and 200 msec, respectively.

Direct vs. peripheral vision: Visual stimuli perceived by different portions of the eye produce different reaction times .The fastest reaction time comes when a stimuli is seen by cones (when subject is looking at stimuli). If the stimuli is picked by rods (around the edge of the eye) the reaction is slower.

Fatigue: The reaction time gets slower when the subject is fatigued. The deterioriation is due to fatigue is more marked when the reaction time is more complicated than when it is simple. Mental fatigue, especially sleepiness has the greatest effect. Distraction increases the time of fatigue.

Exercise: Physically fit subjects have faster reaction times and reaction times were fastest when subjects exercised sufficiently to produce a heart rate of 115 beats per minute or more.

Intelligence: Serious mental retardation produces slower and more variable reaction times. Among people of normal intelligence, there is a slight tendency for more intelligent people to have faster reaction times, but there is not much variation between people of similar intelligence.

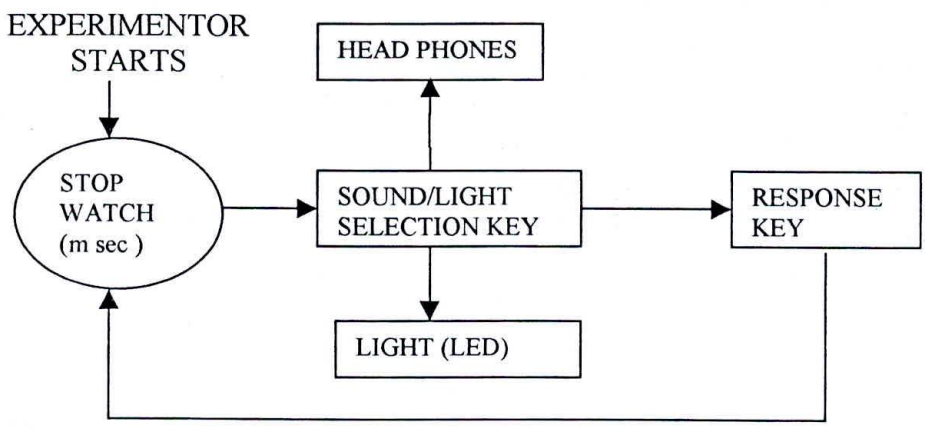
Aims and objectives: -

1. Measure the visual reaction time in a given subject.
2. Compare it to that of a group of subjects and obtain summary statistics - mean & SD

Materials required: -

1. Assembled reaction timer (made from locally available low cost parts like stop watch, 3V battery, 1 LED and 2 switches, Headphone.

Block diagram :



Procedure: -

Instruct the subject to look away from the stop watch and sit comfortably in chair with switch in hand The experimenter presses the switch and light and stop watch starts The subject should press the switch as soon as he see the light glow As soon as he presses the switch the stop watch will stop .Take the reading in m sec . Repeat the experiment thrice and take the average.

Results: -

Visual				**Mean**	**Range**
No. of Subjects	Start	Finish	Diff (m sec)		

Auditory Reaction time:

Is measured in the same way by changing the position of the switch to the sound, the subject gets an auditory stimuli, in a form of click. He / She responds by pressing the response key. The 3 readings are taken in msec. and an average of 3 readings is taken as the result.

Auditory				Mean	Range
No. of subjects	Start	Finish	Diff (m sec)		

Questions for discussion :

1) Name the various components of the reflex arc. Draw a flow diagram of visual reaction time
2) Discuss the factors modifying the reaction time.
3) Give three possible areas or application of this experiment,

Assesment:-

1. Instruction to the subject 2
2. Position of the subject (away from the stop watch) 2
3. Viva 8
4. Visual 4
5. Auditory 4

REACTION TIME - A LAB ACTIVITY (ALTERNATIVE METHOD)

The activity, Reaction Time, described below is a means of gathering data on a group of students.

Student Grouping: groups of 3 (4 if needed) students

Materials: each group will need 1 piece of tape (masking, electrical, or any other type which can be removed easily); metric ruler; meter stick; paper and pencil for recording data.

Object: to determine a student's reaction time by measuring how far an object will fall before the student stops the falling object

Procedure:

1. Groups are to be stationed around the room, against the walls. A piece of tape should be positioned on the wall at a standard height, preferably just above eye-level.

2. In each group, student A holds the ruler against the wall (the top of the ruler should be aligned with the top of the tape). Student B holds his dominant hand with his palm facing wall and approximately 6 inches away (palm should be aligned with the bottom of the ruler). Student C is to record the results.

3. Without prior notification, Student A releases the ruler. Student B stops the fall by placing his hand on the ruler against the wall, Student C measures and records the distance the ruler has fallen.

4. The same procedure should be repeated two more times. At the end of the third 'hit', the arithmetic mean (average) should be calculated and recorded for that student.

5. The students within each groups switch roles and repeat the process until an average dstance has been recorded for all students in the class.

6. Each group should calculate the reaction times of he group members.

   The following formula gives the distance an item falls in a given amount of time

$$S = ut + \frac{1}{2} g t^2$$

   where s = distance (in centimeters)
   t = time (in seconds)
   $g = 980\ cm/sec^2$ (acceleration due to gravity)
   u = Initial velocity = 0

The formula may be rearranged to show the amount of time it takes an object to fall a certain distance.

$$t = \sqrt{\frac{2 \times S}{g}}$$

7. The individual reaction times should be recorded. Then, if desired, the data may be complied for the entire class.

Questions of discussion:

Same as before

ALTERNATIVE METHOD II

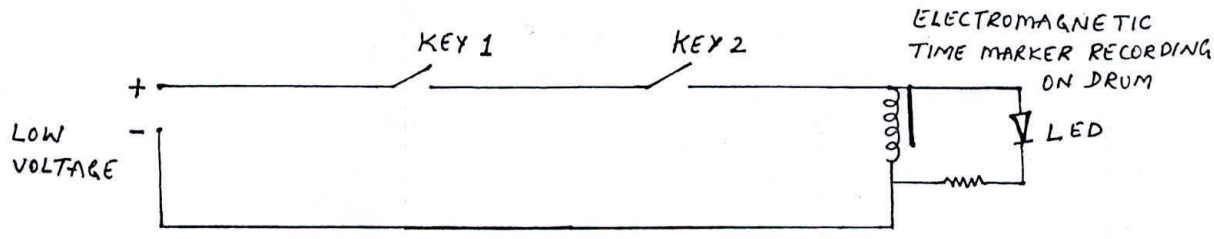
Aim:-

To determine visual reaction time by kymograph method.

Apparatus:-

Kymograph,Electromagnetic time marker,LED,2 simple keys(morse keys), Low voltage source,100 ohms resistance.

Arrangement of apparatus:-



Procedure:-

1) Arrange the apparatus as shown in the diagram above.

2) To start with,the key 1 is in the off state(open) and key 2 is in the on state(closed).

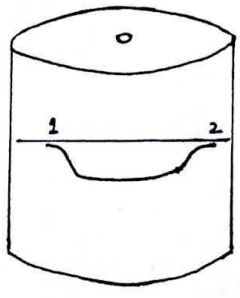
   The baseline is recorded with the drum moving at 320mm/sec.

3) The experimenter then closes key1 and the subject opens key2 after he sees the LED glow.

4) The start and end points are noted and the time interval between them is measured using time tracing by tuning fork (100 H z)

Calculations :

The number of oscillations obtained are counted. This is multiplied by 10 to give reaction time in milli seconds.



SIMPLE TESTS OF MEMORY (Establishing a physiological basis)

All this experiment requires is paper and pen, and an overhead projector.

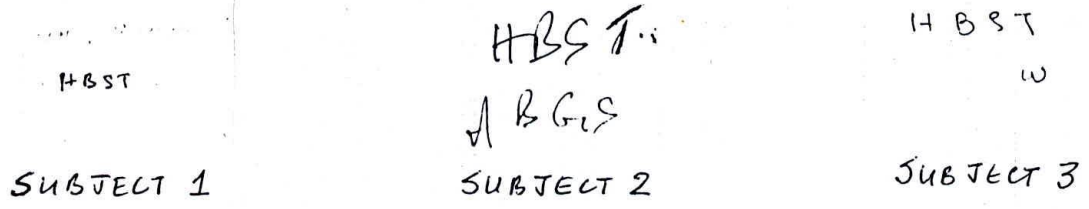
1. A TEST OF ICONIC MEMORY

The iconic store is a discrete visual sensory register. Children often use this part of memory when they write their names using a sparkler during Diwali. The test that we use was devised by George Sperling (1960) when he was a graduate student at Harvard. It involves very briefly displaying (for a fraction of a second) a set of symbols which the subject is then asked to recall. Because of this, the test is sometimes called the "Visual-recall Task".

A typical symbolic display is given below:

H B S T
A H M G
E L W C

While testing this, we used an overhead projector. We instructed the subjects to concentrate on the screen. We told them that they would have to note down what they had seen soon after the projection. In order to minimize the time of projection, we set up the focus of the OHP prior to the experiment. The sheet with the symbolic display was was placed on the OHP and the lighting upped and then reduced as rapidly as possible. An example of what subjects noted is provided below:



In Sperling's original observations, most participants were able to recall only about 4 symbols.

2. HOW MANY ITEMS OF INFORMATION CAN WE HOLD IN SHORT-TERM MEMORY AT ANY ONE TIME?

In order to test this, tell the class that you will read out a set of numbers for them. They will then have to recall this. Read out to the class the following numbers, without specifically emphasising any of them:

10100100010000100100

You will find that most people in the class will be unable to recall the numbers in sequence (the sequence contains 21 digits).

Now ask the class to recall the number as 10, 100, 1000, 10000, 1000, 100
The vast majority of the class will now be able to write the sequence of numbers quite comfortably.

This experiment demonstrates that we can hold only a limited number of items in our immediate or short-term memory stores. George Miller (1956) noted that our short-term capacity for a wide range of items is about 7 ± 2 items.

In the experiment above, what we have essentially done is to reduce 21 items to 6 items by clustering numbers.

3. ACOUSTIC ENCODING IN SHORT TERM MEMORY

When you encode information for temporary storage and use, what kind of code do you use? While this is a very complex issue, this experiment illustrates that part of the encoding process is acoustic.

In order to test this, visually present the following table one column at a time using an OHP, and a paper (make sure its thick enough!) to cover the other column.

MAP	**COW**
CAB	**PIT**
MAD	**DAY**
MAN	**RIG**
CAP	**BUN**

When you are presenting the second column, cover the first. Period of exposure should be just long enough for the experimenter to read out the words (to her/him self i.e quietly). Ask the students to recall the table – first column one then column two.

You will find that on recall, the students write out some words which are acoustically similar to those that have been presented. For instance while testing this experiment some of the words that came out were CAD, RIP, BOW, BIG, RUN, PIG etc.

Despite the fact that the lists were presented visually, errors tended to be based on acoustic confusion.

4. INTERFERENCE AND MEMORY STORAGE

In this experiment we investigate the 'interference theory' of forgetting, according to which forgetting occurs because new information interferes with, and ultimately displaces, old information in short-term memory.

The experiment is very simple. Students are told that they will be presented with a list of words (using the OHP). Tell the students to say the list once to themselves, and then to immediately recall all the words in any order without looking back at them. If you want to prevent cheating, turn off the OHP once you have read the words to yourself.

The list is:

Table, Cloud, Book, Tree, Shirt, Cat, Light, Bench, Chalk, Flower, Watch, Bat, Rug, Soap, Pillow.

You will observe that students tend to remember more words at the beginning and at the end of the lists. An example of what we found on one of our tests is given below:

Table, Cloud, Tree, Cow,

Soap,

The experiment is explained on the following basis. There are two types of 'interference'. Retroactive interference (or retroactive inhibition) is caused by activity occurring after we learn something but before we asked to recall that thing. Proactive interference (or proactive inhibition) occurs when the interfering material occurs before, rather than after, learning of the to-be-remembered material.

In the case of the experiment, the initial words on the list are subject to retroactive inhibition, the words towards the end of the list to proactive inhibition and the words in the middle of the list to both proactive and retroactive inhibition. This is why words in the middle are less recalled.

5. SEMANTIC ENCODING IN LONG-TERM MEMORY STORAGE

In an earlier experiment we have demonstrated the importance of acoustic encoding in short-term memory storage. In this experiment we demonstrate the importance of semantic encoding (i.e. by the meaning of words) in long-term memory storage.

Like short term memory, the process of encoding in long term memory is considerably more complex than what is presented here.

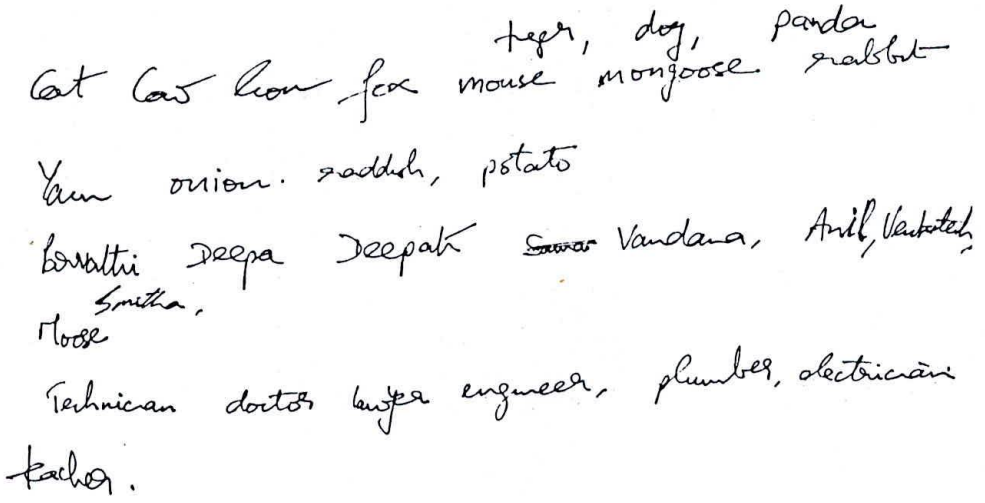
For this experiment, students are presented with a list of 60 words using an OHP. This list consists of 15 vegetables, 15 animals, 15 occupations and 15 names of people. The order of the words is randomised (this is done by putting all 60 words into an envelope and then removing them one at a time after mixing them thoroughly). The students are given

5 minutes to memorise the words. After 5 minutes the OHP is switched off and the students asked to write the words down in any order that they like.

The list that we used on the OHP is given below:

Cat, Cow, Lawyer, Plumber, Yam, Lion, Farmer, Moose, Deepak, Radish, Smitha, Grocer, Brinjal, Tiger, Deepa, Cobbler, Mouse, Parvathi, Gourd, Camel, Mushroom, Potato, Rajiv, Capsicum, Horse, Manager, Architect, Pavithra, Venkatesh, Anil, Vandana, Fox, Savithra, Meera, Dog, Cauliflower, Tailor, Mongoose, Technician, Pumpkin, Doctor, Sanjay, Teacher, Tomato, Rabiit, Carrot, Sheep, Cucumber, Beetroot, Engineer, Vinay, Onion, Deer, Ajit, Gardener, Cabbage, Laxmi, Sweeper, Electrician, Panda.

Given below is one of the responses we achieved during the testing of this experiment.



It is clear that the words have been grouped into appropriate semantic categories.

For further reading on the subject:

- Cognitive Psychology. 2nd Edition. Robert J Sternberg. Harcourt Brace College Publishers; Fort Worth, 1999
- There are several books on Neurophysiology including those by Kandel, Conn and Purves.

SESSION 2

Respiration and Cardiovascular system

TO DEMONSTRATE BREATH HOLDING TIME(BREAKING POINT) UNDER DIFFERENT MANOEUVRES.

The lung is a vital organ in direct contact with the external environment. The important function of lungs is to ventilate the blood. During ventilation, there is constant threat of entry of noxious substance in to lungs. If this threat is met, and for short periods it can be overcome, by breath holding, a mechanisms by which respiration becomes a closed system from which the external environment is excluded. In this sense, breath holding is a subsidiary function of ventilation, often essential to survival, and could be considered as a type of respiratory regulation, available on demand.

The term 'breaking point' is defined as the voluntary termination of breath holding in response to the development of a net ventilatory stimulus too strong to be further resisted by voluntary effort. During breath holding, the alveolar partial pressure of oxygen falls (65-75mmHg) and alveolar partial pressure of carbon dioxide rises (45-50mmHg) providing two obvious reasons for the breaking point.

The term breaking point embodies no particular dimension, it can be expressed in terms of any appropriate parameter under observations, the most commonly used being time and alveolar gas tension . Breaking point depends on number of independent variables. These variables can be classified as 1. Related to lung volumes

2. Related to gas tension & pH

Breath holding time is directly related to the initial lung volume. The relationship between lung volume and breath holding time results from the fact that a restriction in volume, is an independent ventilatory stimulus which interacts with stimuli from hypoxia & hypercapnia, in determining the breaking point. The second group of stimuli which interact to determine the breaking point are chemical and are due to changes in partial pressure of oxygen,carbon di oxide & pH. The variables which interact with lung volumes are determined largely by these conditions:

a)gas composition of inspired breath

b) the metabolic rate

c) level of Co_2 stores and the buffering capacity for Co_2 at the onset of breath holding.

The effect of these condition on breaking point as measured by breath holding time can be appreciated. The duration of breath holding time is more when the breath held at vital capacity, since a larger volume of alveolar gas exists to overcome the changes in the arterial pCO2 and pO2 , compared to breath held at function residual capacity or residual volume. Hyperventilation prior to breath holding reduces, blood and tissue hydrogen ions concentration and pCO2 thereby increasing breath holding time.

During breath holding time the volume of gases in the lungs shrinks, and concentration of carbon dioxide rises and there by partial pressure of carbon dioxide rises. The rate of volume loss from the lung is directly related to the rate of oxygen uptake, hence anything that increases rate of oxygen uptake, such as exercise, will shorten the breath holding time.

Thus the following experiments demonstrate the role of chemoreceptor control of the arterial gas pressure and also draw attention to the dominant role of CO2 in determining the need of breathe.

Reference: Text book

1) Applied respiratory physiology - Authour J F Nunn
2) Lung function - Cotes
3) Physiology of respiration - Julius H Comroe
4) Text book of respiratory medicine - Murray and Nadel
5) Hand book of Physiology - Respiration

STUDENT WORK SHEET:

AIM: 1. To investigate the duration of time for which breath can be held in different manoeuvres.

2. To observe and explain respiratory drive by pCO2 and pO2.

EQUIPMENT :1. Stop watch with indications of seconds.

2. Nose clip.

3. A plastic bag with two liters capacity.

4. A plastic bag with two liters capacity, with 100gms sodalime in a finely perforated container

TEAM: 1. One subject

2. One person to measure the breath holding time.

3. One person to record the observation.

PROCEDURE:

1. The subject rests in a chair for five minutes and breaths room air.

2. The subject is instructed to hold his breath for as long as possible by closing his mouth and nose by the nose clip.

3. When the breath holding becomes intolerable and increase desire to breathe, the subject is asked to remove the noseclip and the duration of breathhold time is measured.

4. The above procedure is done at the end of

a) Quiet inspiration

b) Maximum inspiration

c) Quiet expiration

d) Maximum expiration

e) Rebreathing through a plastic bag for 30-45 seconds.

f) Rebreathing through a plastic bag with sodalime for 30-45sec

SUBJECT SHOULD BE GIVEN 2 - 3 MIN REST BEETWEEN EXPERIMENTS.

OBSERVATION:

I. Measuring breath holding time (Sec) at the end of

PARAMETER	1st trial	2nd trial	Mean
Quiet inspiration			
Max inspiration			
Quiet expiration			
Max expiration			

II. Measuring breath holding time (Sec) at the end of rebreathing

with out soda lime

	Inspiration	Expiration
1st trial		
2nd trial		
Mean		

with soda lime

	Inspiration	Expiration
1st trial		
2nd trial		
Mean		

QUESTION

1. How do you explain the differences in the duration of breath holding time observed.
2. Which is more important drive for respiration , pO2 or pCO2
3. Explain central nervous mechanism which generate the different duration of breath holding time.
4. What is the effect of bilateral local block of vagi and glassopharangel nerve in conscious normal subject on breath holding time.
5. What is the effect of carbohydrate and protein meal on breath holding time.
6. What is the effect of hyperventilation on breath holding time.

TO RECORD MAXIMUM EXPIRATORY PRESSURE WITH MODIFIED BLACK AND HYATT APPARATUS.

INTRODUCTION:

Measurement of maximum expiratory pressure (MEP) and maximum inspiratory pressure (MIP) together provides an index of respiratory muscle strength. The MIP & MEP are more sensitive indicators of respiratory failure, particularly in the patients with neuromuscular diseases. The measurement of MIP requires either a negative pressure gauge or pressure transducer , which adds to the cost of the measurement.The measurement of the MEP on other hand is inexpensive . It can be recorded with help of an aneroid blood pressure gauge attached to a mouth piece of standard dimension.
There are well documented results suggesting that the measurement of MEP alone can be used as a screening test for respiratory muscle strength in situations where MIP can not be recorded.

INDICATIONS :

- For assessment of respiratory muscle strength , where the assessment of skeletal muscle strength is a direct index of nutritional status of an individual.
- To investigate any patients with neuromuscular disease that might involve the respiratory muscles.
- The MEP has been found useful for evaluating the ability of a patient to cough and bring up the secretions. An MEP more than 40 cm H_2O is required for reasonable cough. This is an important assessment in susceptible groups, where the inability to cough effectively predicts the development of atelectasis and respiratory infection.
- To evaluate patients with unexplained dyspnea. It has been documented that a reduced MEP has been associated with dyspnea.

REFERENCE :

Text book - Pulmonary function testing Indication & Interpretations
Edited by Archief Wilson MD PhD.

Journals -

- Black LF, Hyatt RE. Maximal Respiratory pressure normal values & relations to age & sex. Am Rev Respir Dis 1969; 99:696-702.
- Shahebjami. H . Dysponea in obese healthy men . Chest 1998; 114:1373 - 1377
- Maruthy KN, Vaz M . The development and validation of a digital peak respiratory pressure monitor and its characteristics in healthy human subjects. IJJP 1999; 43: 186-192.
- TT Ukyab ,Vaz M. The characteristic & deterninants of maximal expiratory pressure in young, healthy, Indian males. IJJP ; 1999: 43 : 435-442.

STUDENT PRACTICAL SHEET:

Aim: 1) To record the Max.Expiratory pressure
2) To assess the respiratory muscle strength
3) To evaluate the ability of a subject to cough.

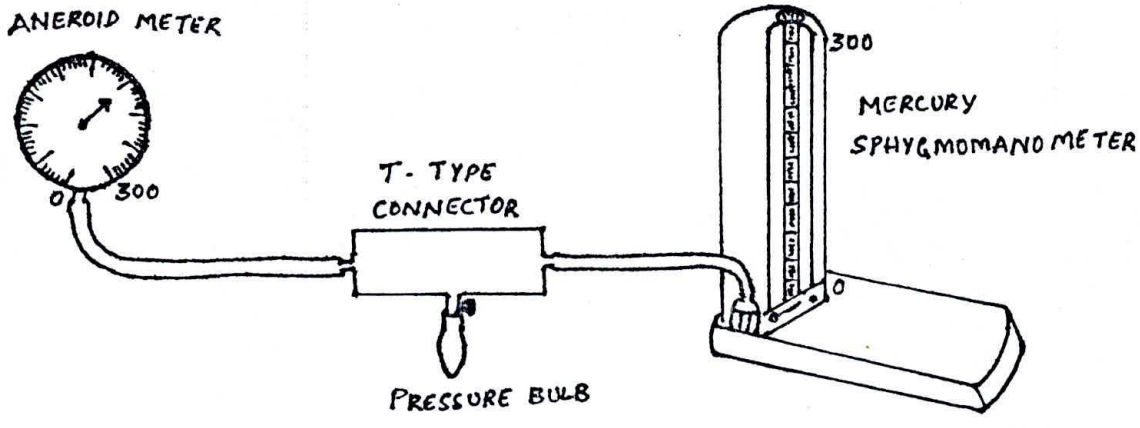
Equipment: 1) Mouth piece, 2) Aneroid meter (0-300mm)

Constructions of mouth piece - According to specifications lied down by Black & Hyatt mouth piece was constructed. It consists of a hallow PVC tube 15 cm length closed by PVC cap at one end with 2 mm hole in centre of cap. The other end was connected to PVC reducer.

The thickness of PVC tube was 2 mm with internal diameter 3 cm. The bottom of the tube was connected to a 3 way stopcock and linked to aneroid meter.

Calibration of Instrument:

With help of a mercury manometer the aneroid meter is calibrated. Mercury manometer and an aneroid meter were connected to the sphygmomanometer pressure bulb Via 'T' type connector using a pressure tube.



Then the bulb is compressed to increase the pressure in the mercury manometer in steps to 10 mm Hg upto 300 mm mercury. The corresponding pressure changes in aneroid meter were noted.

Team: 1) A Subject
2) Observer

Procedure:

1. The subject is made to stand . He is asked to take deep inspiration to total lung capacity and instructed to blow out in the mouth piece and sustain the pressure atleast for one second.

2.Three such readings taken with an interval of 2-3minutes and the highest of the reading is considered.

Pressure(mm Hg)

First attempt
Second attempt
Third attempt

Results - _____ mm Hg

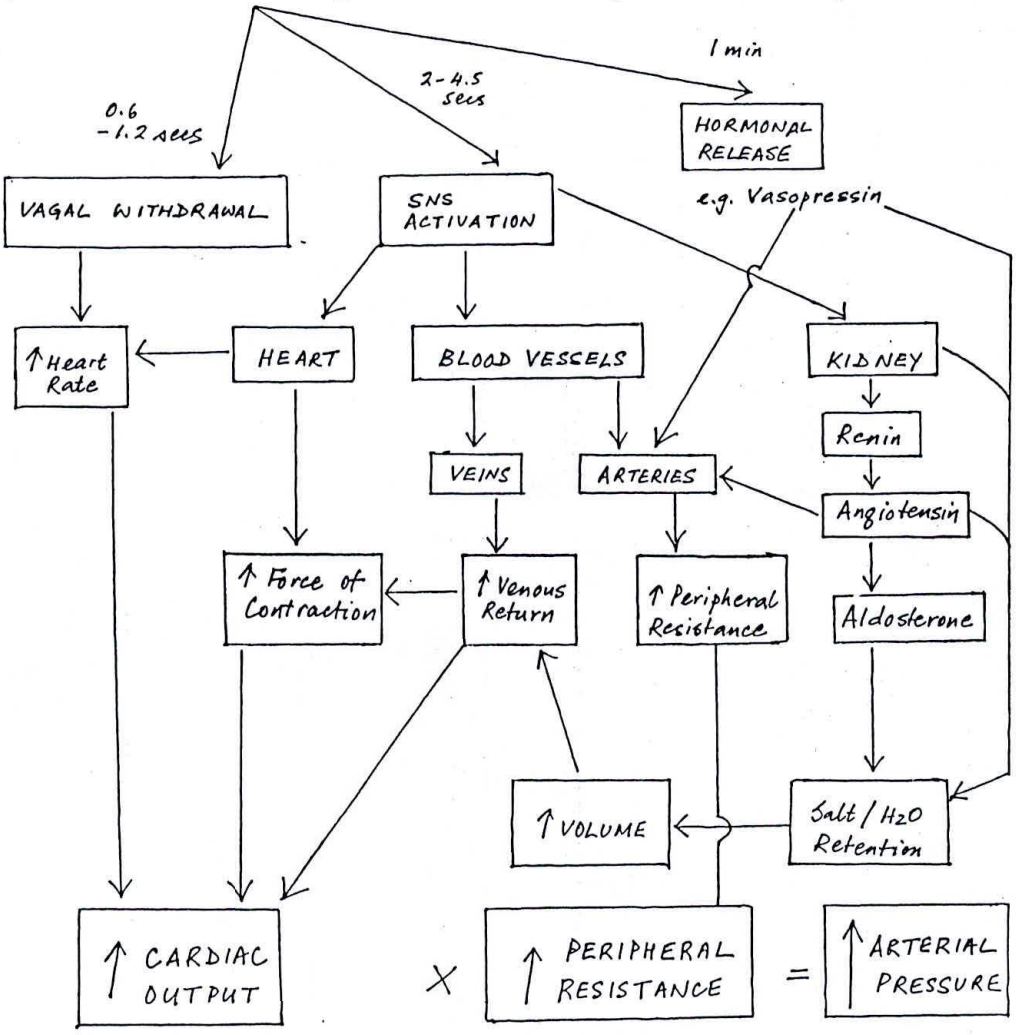
QUESTION:

1. Name the muscle of expiration.
2. Explain the central mechanisms of expiration.
3. Name conditions in which Max. Exp. Pressure is decreased.
4. Describe cough reflex.

A STUDY OF THE ROLE OF THE SYMPATHETIC NERVOUS SYSTEM IN CARDIOVASCULAR REFLEXES

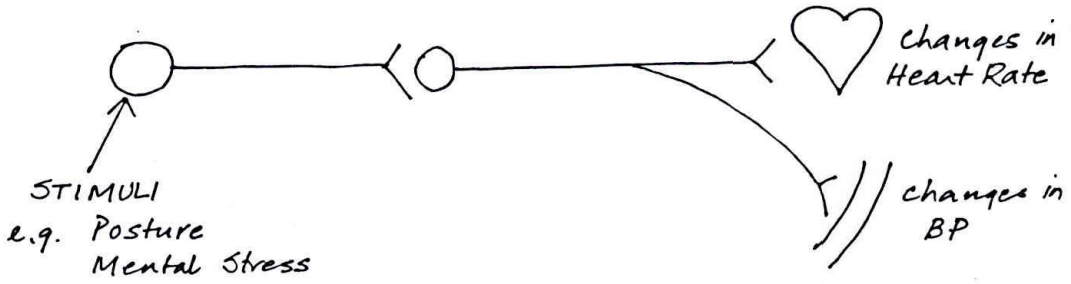
BACKGROUND:

The sympathetic nervous system is a part of the autonomic nervous system. During acute alterations in blood pressure, both the sympathetic and parasympathetic nervous systems form part of the efferent systems that attempts to restore the blood pressure to normal. Depicted below is a flow diagram that outlines responses to an abrupt fall in BP.

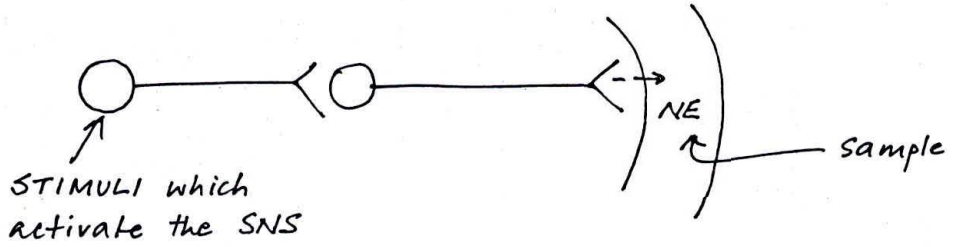


The response time of the parasympathetic nervous system to any change in BP is faster than that of the sympathetic nervous system.

There are three traditional ways of assessing sympathetic nervous activity in man:

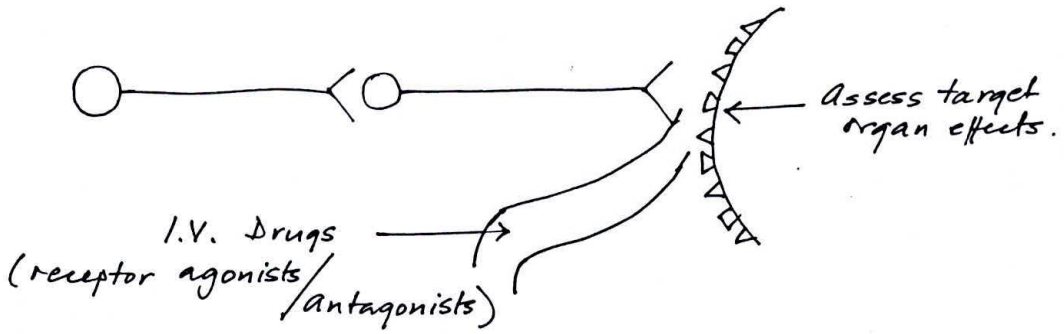


- **Physiological methods**: the principle here, is to use certain stimuli, which are known to activate the sympathetic nervous system and then record the effects of that activation. This is the basis of the experiments used in this practical. In order to increase applicability, it would be preferable to use those effects, which can be easily measured. Most physiological tests use blood pressure and heart rate as the measured physiological effects.



- **Biochemical methods**: in this case, stimuli are used to activate the sympathetic nervous system and then the level of the neurotransmitter (noradrenaline) is measured in plasma. Resting circulating plasma noradrenaline levels are between 100 and 300 pg/ml. Since these concentrations are very low, special analytical equipment is necessary to measure the neurotransmitter. One of the techniques used to measure plasma noradrenaline is High Pressure Liquid Chromatography (HPLC) with electro-chemical detection (ECD). The disadvantages of using elevations in plasma noradrenaline as an indicator of sympathetic nervous activation is related to the following factors:
    1. the site of sampling: venous samples may be affected to a large extent by the tissues that the vein drains. Thus, if the ante-cubital vein is used, the concentration of noradrenaline in plasma will be determined considerably more by sympathetic nervous activity in the forearm than for instance, sympathetic nervous activity in the heart.

2. Plasma noradrenaline represents the balance of two processes: spillover of noradrenaline from the nerve endings and clearance of noradrenaline from the plasma.
3. It is not possible to assess the relative contributions of different organs to the increment in plasma noradrenaline. This is important, since the sympathetic nervous system is not like a global "on / off" phenomenon. Thus, some of the organs may exhibit an increase in sympathetic nervous activity to a particular stimulus, while others do not.



Pharmacological methods: these methods require the administration of sympathetic nervous agonists / blockers. The effects of these drugs are documented. In the process, the sympathetic nervous pathways are by-passed and inferences can be made on the basis of target organ responses. Thus, if target organ responses to a given dose of an agonist are enhanced, one of the possible conclusions is that the receptors are up-regulated, and this may be due to reduced sympathetic nervous activity.

NEWER METHODS OF ASSESSING THE SYMPATHETIC NERVOUS SYSTEM.

- **Radio-tracer [^{3}H] derived noradrenline regional kinetics**. This technique developed by Murray Esler at Melbourne, Australia involves the administration of tracer quantities of radio-labelled noradrenaline. After steady-state has been achieved, simultaneous arterial and venous samples are obtained and Fick's principle applied to obtain the "spillover rate" of noradrenaline. Regional venous samples are obtained from the internal jugular vein, coronary sinus, hepatic vein and renal vein using central venous catheterisation. This allows for the estimation of sympathetic nervous activity from the brain, heart, hepato-mesenteric bed and kidneys respectively. Although invasive, it is the only technique in man which allows for the determination of regional sympathetic nervous activity in multiple organs.

- **Microneurography.** This technique was popularised by Gunnar Wallin of Sweden and involves the insertion of fine tungsten electrodes into the sympathetic nerve fibres of mixed peripheral nerves e.g. the common peroneal nerve. It is the only technique in man which allows for a direct recording of sympathetic nervous activity. There are several tests which can be done to ensure that the recordings of nerve activity are indeed autonomic. These include checking for synchrony with heart rate and looking

for changes with stimuli known to activate the sympathetic nervous system. Side effects with the procedure are rare, although a small percentage of subjects complain of parasthesias for a few days after the procedure.

- **Spectral analysis of heart rate and blood pressure rhythms.** Heart rate and blood pressure have been known to rhythmically cyclical since the early part of this century. The clinical relevance of heart rate variability was first recognised by Hon and Lee in 1965. In 1981, Axelrod introduced a mathematical analysis of heart rate fluctuations (power spectral analysis) to evaluate beat to beat cardiovascular control. A study of heart rate rhythms reveals important information on sympatho-vagal balance to the heart, while the study of blood pressure rhythms allows for the assessment of vasomotor sympathetic nervous activity. This technique has become very popular because it is non invasive, but there is still debate on how best to interpret the data.

INTERPRETATION OF DATA FROM STANDARD AUTONOMIC TESTS (modified from Bannister R ed. Autonomic Failure. Oxford Medical Publications 2nd Edition, 1988)

Test	Interpretation and normal values
• Sustained isometric contraction	Lack of tachcardia suggests dysfunction of sympathetic efferent fibres to the heart. A rise of less than 10 mmHg diastolic BP is considered abnormal and representative of dysfunction of sympathetic efferent constrictor fibres to capacity and resistance vessels.
• Cold pressor test	Causes increase in BP and tacycardia and is a test of the sympathetic efferent pathway, both to the heart and blood vessels. The data is sometimes difficult to interpret because the stimulus can be painful and sensitivity to pain may differ in different individuals.
• Postural Stress	The normal response is an increase in diastolic BP by about 10%, with little or no change in systolic BP. The steady state heart rate increase after 1 min amounts to about 10 beats / min. A postural fall in systolic BP of 11-29 mm Hg is considered borderline and more than 30 mm Hg abnormal
• Mental Stress	Interpretation same as for ice-cold pressor test. Recent studies have shown that mental stress particularly enhances cardiac sympathetic nervous activity.

KEY POINTS:

- The sympathetic nervous system plays an important role in the regulation of blood pressure
- The role of the sympathetic nervous system can be assessed with established bedside clinical tests using blood pressure and heart rate as the measured parameters.
- Autonomic nervous activity (including sympathetic nervous activity) may be altered in both physiological states (e.g. aging) as well as in disease (e.g. diabetes, hypertension)

FURTHER READING

- Autonomic Failure. A textbook of Clinical Disorders of the Autonomic Nervous System. Ed. Sir Roger Bannister. Oxford Medical Publications.
- Parati G et al. Spectral analysis of blood pressure and heart rate variability in evaluating cardiovascular regulation. A critical appraisal. Hypertension 1995; 25: 1276-1286.
- Vallbo AB et al. Somatosensory, Proprioceptive, and Sympathetic Activity in Human Peripheral Nerves. Physiological Reviews 1979; 59: 919-957.
- Esler M et al. Overflow of catecholamine neurotransmitters to the circulation: source, fate, and functions. Physiological Reviews 1990; 70: 963-985.

STUDENT PRACTICAL SHEET:

AIM:

To document the role of the sympathetic nervous system in cardiovascular reflexes. Specifically to document and interpret the heart rate and blood pressure changes to:

a) Sustained isometric contraction
b) Cold pressor test
c) Postural stress (lying to standing)
d) Mental stress

MATERIALS REQUIRED FOR THE PRACTICAL

- Sphygmomanometer for recording blood pressure
- Sphygmomanometer for isometric contraction (procedure outlined below). In place of this a handgrip dynamometer can be used if available
- Basin, ice and thermometer
- Bed for the study of postural stress
- Tables for the mental stress test

PRINCIPLE:

Certain stimuli are known to activate the sympathetic nervous efferents to the heart and blood vessels. Activations of these fibres result in changes in easily measurable physiological parameters such as heart rate and blood pressure. By documenting the changes in these parameters the state of sympathetic nervous activation can be inferred.

METHODS:

Before proceeding with this experiment, it is mandatory that you should be fully capable of recording heart rate and blood pressure.

1. Heart rate and Blood Pressure responses to sustained isometric contraction.

- record baseline heart rate and blood pressure, after the subject has been sitting comfortably and quietly for 5 mins
- roll the uninflated BP cuff tightly. If necessary, secure with an elastic band.
- elevate the BP to a pressure of ~ 40 mmHg
- Ask the subject to compress the cuff maximally. Note the point to which the pressure rises.
- Subtract the recorded pressure from 40
- Ask the subject to maintain a pressure of 40 + 1/3 the difference of the recorded pressure and 40, for 3 mins.
- Record the heart rate and blood pressure during the latter part of the 3rd min, prior to the release of handgrip.

2. Ice-cold Pressor test

- record baseline heart rate and blood pressure

- place the left hand upto the wrist in a basin of ice cold water, maintained by ice cubes at 4 °C, for 90 secs.
- record heart rate and blood pressure prior to removing the hand from cold water.

3. Postural stress

-record baseline heart rate and blood pressure after 5 min of lying down quietly.
- ask the subject to stand up
- record the heart rate and BP after 1 and 2 min of standing.

4. Mental stress

- record the baseline heart rate and blood pressure
- ask the subject to perform sequential subtractions from the tables provided.
(please keep up the pressure to get the students to perform the subtractions as rapidly as possible).
- record the heart rate and blood pressure after 3 minutes of arithmetic.

RESULTS:

PROCEDURE	**Baseline data**		**Activation**	
	Heart rate	BP	Heart rate	BP
• Sustained isometric contraction				
• Ice-cold pressor				
• Postural stress			1 Min	
			2 Min	
• Mental Stress				

Interpret the data in relation to the normative data provided in the table earlier.

CLINICAL PROBLEM:

Mr K Sidappa is an 80 yr old retired military officer. He comes to you with the complaint that of late he has had repeated fainting episodes, especially when he stands for a long period of time. He also feels dizzy when he first gets out of bed in the morning and sometimes feels faint when he gets up from the table after a heavy meal.

Normal Physiology:

- List the mechanisms by which blood pressure is maintained when an individual changes posture from lying down to upright?

Patho-physiology:

- What do you think is the reason for Mr. Sadappa's problems? What additional history would you like to take in addition to what has been provided to you?

Health Education:

- What behavioural advice would you give Mr. Sidappa which would help to alleviate Mr. Sidappa's symptoms a) when he gets up from bed
  b) after a heavy meal

Applied Biochemistry:

- *When Mr Sidappa comes to you, he says he has been advised to do an estimation of his fasting plasma catecholamines (noradrenaline and adrenaline).* Is this estimation likely to help in the diagnosis? Explain.

QUESTION BASED ON INDEPENDENT READING

What are the ways in which the Parasympathetic nervous system can be assessed in man? Can plasma acetylcholine be used as an index of parasympathetic nervous function? Discuss.

PRACTICAL EXAMINATION QUESTION:

The student is asked to perform any one of the tests outlined above

1. In the presence of the examiner, describe the procedure that you followed while conducting the test. (Examiner at this stage may ask the student to demonstrate how pulse or BP was recorded)	5 marks
2. What is the physiological basis of the test	5 marks
3. Comment on the values that you have obtained in relation to standard norms	5 marks
4. Bench Viva of the examiner (discretionary questions)	5 marks

GUIDELINES FOR THE MEASUREMENT OF RESTING BLOOD PRESSURE

(The Medical Journal of Australia 1994; Volume 160: Supplement 21)

- **Patient should be seated and relaxed. Additional information may be obtained by supine and standing readings. This is especially important in the elderly and diabetics, as both groups are prone to postural hypotension.**
- **The bare arm should be supported and positioned at heart level.**
- **A cuff of suitable size should be evenly applied to the exposed upper arm, with the bladder of the cuff positioned over the brachial artery. The bladder length should be atleast 80% and width atleast 40%, of the circumference of the arm.**
- **The cuff should be snugly wrapped around the upper arm and inflated to 30 mmHg above the pressure at which the radial pulse disappears.**
- **The cuff should be deflated at a rate no greater than 2 mmHg / beat.**
- **If initial readings are high, several further readings should be taken after after 5 mins of rest.**
- **On each occasion two or more readings should be averaged. If the first two readings differ by more than 6 mm Hg systolic or 4 mm Hg diastolic, further readings should be taken.**
- **For the diastolic reading, the disappearance of sound (phase V Korotkoff) should be used. Muffling of sound (phase IV Korotkoff) should be used if sound continues towards zero.**
- **For adequate standardisation, caffeine ingestion and smoking should be avoided for two hours before blood pressure measurement.**

MENTAL STRESS TABLES

- The subject is asked to subtract numbers sequentially from a given number.
- You can start off using a simple set eg. subtracting 'three', but should then move on to other more difficult subtractions. (The purpose is to get the subject stressed!)
- Start anywhere on the tables given below and move to another subtraction at any time. It is not necessary to start at the top of the table.
- Ask the subject to perform the subtractions as rapidly as possible. Keep goading the subject to perform faster and indulge in some things which will distract the subject e.g. drumming a pencil on the table.

3	**7**	**9**	**11**	**13**	**17**
298	348	476	583	692	756
295	341	467	572	679	739
292	334	458	561	666	722
289	327	449	550	653	705
286	320	440	539	640	688
283	313	431	528	627	671
280	306	422	517	614	654
277	299	413	506	601	637
274	292	404	495	588	620
271	285	395	484	575	603
268	278	386	473	562	586
265	271	377	462	549	569
262	264	368	451	536	552
259	257	359	440	523	535
256	250	350	429	510	518
253	243	341	418	497	501
250	236	332	407	484	484
247	229	323	396	471	467
244	222	314	385	458	450
241	215	305	374	445	433
238	208	296	363	432	416

EXTENDING THE DEMONSTRATION OF ECG

(CLINICAL TESTS OF PARASYMPATHETIC NERVOUS ACTIVITY)

The ECG is one of suggested demonstrations in the curriculum. In addition to demonstrating the placement of the leads for a standard 12 lead ECG, and displaying the changes in the pattern of the ECG with different leads, it is also possible to demonstrate the correct procedures for assessing parasympathetic nervous system (PNS) activity.

Alterations in parasympathetic nervous activity are fairly common in clinical practice. They are, for instance, seen in long standing diabetes and in the elderly. The response time of the parasympathetic nervous system is very rapid (less than a second). This means that heart rate measurements by palpation of the pulse are particularly unsuitable for assessing the PNS. Unlike the sympathetic nervous system, which can be assessed biochemically, by the plasma levels of noradrenaline, plasma acetylcholine levels are not a viable method since acetylcholine is very rapidly degraded by choline-esterase.

The methods described below are all well described standard methods of assessing cardiac parasympathetic nervous activity. All methods involve the use of maneuvers which result in vagal withdrawal and a consequent rise in heart rate.

1. TIMED DEEP BREATHING:

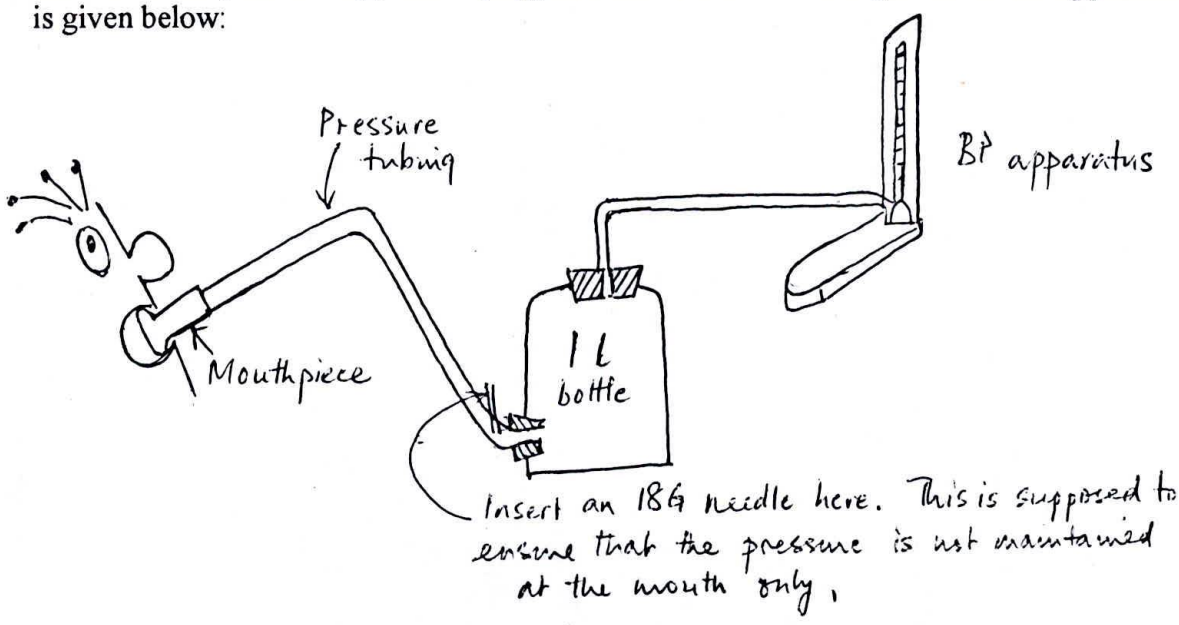
This is an attempt to quantitate sinus arrythmia. The subject is asked to breathe in and out as deeply as possible for 6 respiratory cycles. Inspiration and expiration are for 5 secs. each. (i.e. 10 secs for a respiratory cycle or 1 min for the entire test).

2. IMMEDIATE HEART RATE RESPONSE TO STANDING:

In this test the subject is required to lie supine quietly for about 5 minutes. The ECG is recorded for 10 secs at the end of the 5 minutes. The subject is then asked to stand up as quickly as he can. The heart rate is recorded continuously for 30 secs after standing up.

3. VALSALVA MANOEUVRE:

For this test you require a mouthpiece, some pressure tubing, a 1 litre bottle with a top and side outlet, a nose-clip, and a sphygmomanometer. The arrangement of the apparatus is given below:



Record a 10 sec strip of ECG after the subject has been sitting quietly for about 5 secs. Ask the subject to take a maximal inspiration, apply the nose-clip and then ask the subject to blow hard into the mouthpiece so as to maintain a pressure of 40 mm Hg in the manometer for 10 secs. Record the ECG continuously for the period that the subject is blowing out and for 20 secs afterwards.

4. QUALITATIVE TESTS OF PARASYMPATHETIC NERVOUS ACTIVITY

There are a few tests that can be performed here. But these tests are not sensitive in cases of mild parasympathetic autoneuropathy.

a) ask the subject to squeeze your fingers maximalls. Record the ECG for 10 secs prior to the maneuvre and for about 10 secs during what corresponds to a maximal voluntary contraction.
b) Ask the subject to cough maximally, Record the ECG for 10 secs prior to and 10 secs after the cough.

Interpretation of the Data:

• **Timed deep breathing**	This is interpreted on the basis of the maximum heart rate variation between inspiration and expiration from among the 6 respiratory cycles. A variation of 15 beats or more is normal, 11-15 is borderline and 10 beats or less is abnormal.
• **Heart rate response to standing**	There is an immediate heart rate rise on standing which is due to vagal withdrawal. For this analysis, the shortest RR interval around the 15^{th} beat after standing is calculated (msecs) and so to the longest RR interval around the 30^{th} beat. These intervals are expressed as the 30:15 ratio. A ratio of 1.04 or more is considered normal, 1.01 to 1.03 is borderline and 1.00 or less is abnormal
• **Valsalva Manoeuvre**	There is a tacycardia during the maneuvre followed by a bradycardia. The ratio of the longest RR interval shortly after the manoeuvre, (within 20 beats) to the shortest RR interval during the manoeuvre is measured. A ratio of 1.21 or more is normal, 1.20 or less is considered abnormal.
• **Response to cough and handgrip**	An increase in heart rate in response to these tests is attributed to vagal withdrawal. There is no response in autonomic failure.

References:

- Autonomic Failure. Ed R Bannister. Oxford Medical Publications. Oxford, 1988.
- Levin AB. A simple test of cardiac function based upon the heart rate changes induced by the Valsalva Maneuver. Am J Cardiol 1966; 18: 90-99

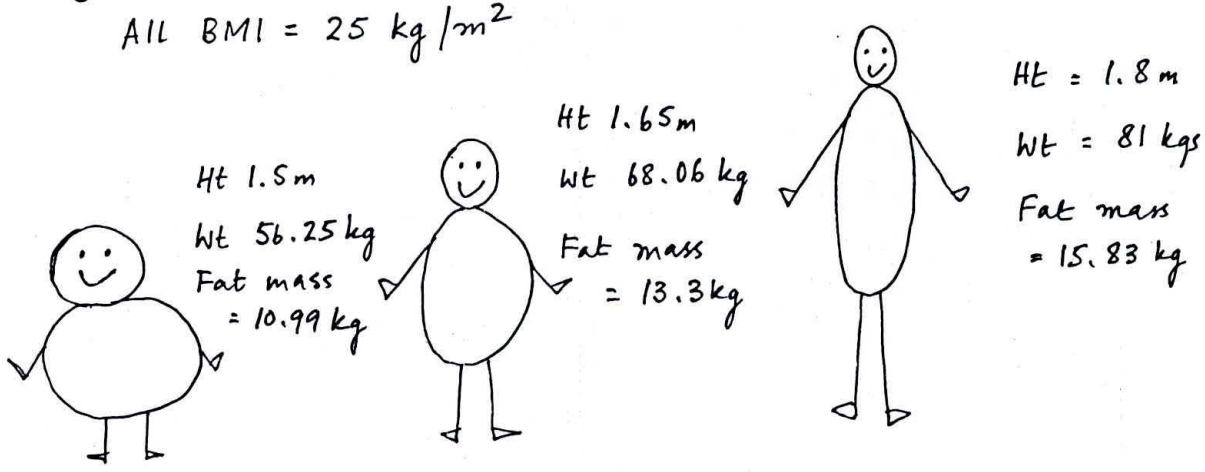
SESSION 3

Body Composition and Skeletal Muscle Function

ANTHROPOMETRIC ASSESSMENT IN ADULTS:

Anthropometric assessment fulfills several objectives, the most important of which is the delineation of nutritional status. The parameters that are used, differ depending on the age of the individual.

The weight of the individual provides an important measure by which sequential assessments can be made. Thus, a recent weight loss of 10% or more is a significant predictor of morbidity in hospitalised patients. There is, however, a problem when weight is used as an indicator of nutritional status during 'one-time' assessments, especially when a prior weight history is not obtained with any certainty. In these situations it is useful to compare the weight of the individual with some standard norm. Some of these norms are included in reference tables such as the Metropolitan Tables (*). An alternative is to use a composite index which incorporates both height and weight. This has led to the use of indices called Body Mass Indices (BMI). There are many ways in which to compute Body Mass Index, and each has its own proponents. However, the most widely used index is Quetlet's Index computed as weight / height^2 (kg/m^2). In a large population, BMI is used as surrogate of body fatness. For the individual, however, it is important to recognise that BMI does not represent fat mass, as is illustrated in the diagram below:

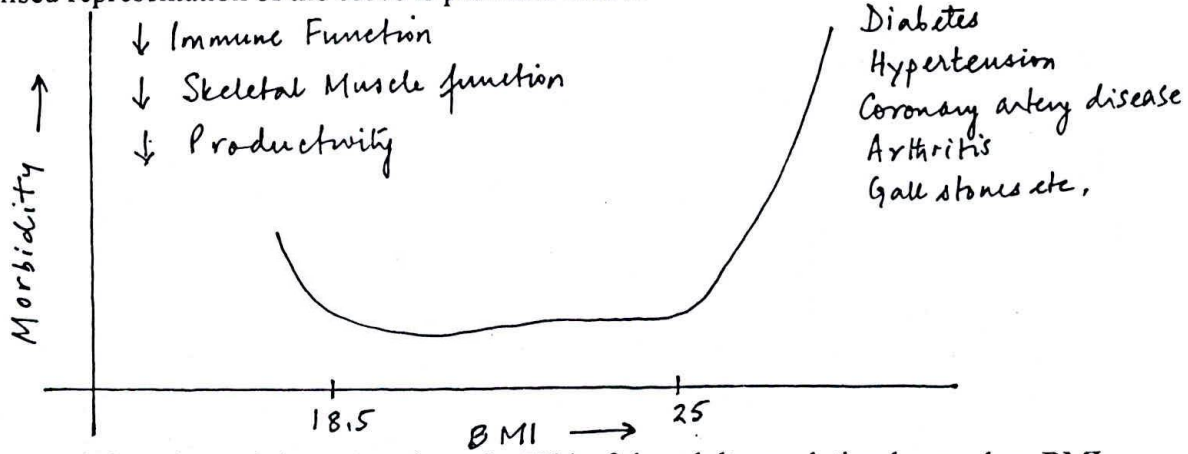


Thus there are three individuals with identical BMI's, but very different masses of fat in their bodies.

In adults, the desirable range of BMI is 18.5 to 25. The Table below provides a classification of individuals based on their BMI.

BMI Range	Category
< 18.5	Underweight / Undernourished
18.5 – 24.9	Normal range
25 – 29.9	Overweight / Pre-obese
30 – 34.9	Obese, Class I (moderate)
35 – 39.9	Obese, Class II (severe)
>= 40	Obese , Class III (very severe)

Thus, by calculating BMI, a basic assessment of nutritional status can be achieved. The cut-offs for the above classification have been based on an understanding of the relationship between BMI and morbidity. When plotted, this assumes a 'J' curve. A stylised representation of the curve is provided below.



In India, it is estimated that approximately 50% of the adult population have a low BMI. A comparison with the distribution of BMI's in other countries is provided below:

Percentage of population	**Low BMI (<18.5)**	**High BMI (>25)**
0-10%	USA, France, Brazil	India, China
10-20%	China, Ghana	Ghana
20-30%	Haiti	Morocco
>30%	India, Ethiopia	Brazil, France, USA

In populations, a BMI less than 18.5, has been used to categorise individuals as being Chronically energy deficient (CED). The recognition that morbidity increased as BMI became lower, led to the grading of chronic energy deficiency using the following cutoffs:

BMI	< 16	16.0 –16.9	17.0 – 18.5
CED Grade	III	II	I

In order to reduce the error of misclassifying individuals as undernourished, the incorporation of mid-arm circumference into the assessment has been suggested. The cutoffs are given below:

MEN: 24 cm
WOMEN: 23 cm

In assessing the body composition of an individual, the number of compartments that the body can be divided into depends on the techniques that are available. A simple two-compartment model that divides the body into fat and fat-free mass may be obtained using age and gender specific regression equations that incorporate the BMI of the individual. One such equation is that of Deurenberg , which is used in the practical. An important caveat in the use of these equations is that equations tend to be race specific

and apply best to the population from which they have been generated. In addition, a very crude approximation of muscle mass can be obtained as 50% of the fat-free mass.

Factors that may affect fat and fat-free mass include the following:

- Gender: for the same body mass index, females have a higher proportion of fat than males.
- Age: Aging is associated with a loss in muscle mass (sarcopenia) and an increase in percent body fat.
- Race: for the same BMI, Indians have a higher percent body fat than Tibetans.
- Food intake: the energy (calorie) intake, as well as the distribution of the calories in terms of the macronutrients (fat:carbohydrate:protein).
- Physical activity/ athletic training: would result in a reduction in fat mass
- Drugs / Stimulants: These include drugs like anabolic steroids, growth hormone, and stimulants which activate the sympathetic nervous system (caffeine, nicotine) and which therefore result in lipolysis.
- Disease: in cancers and AIDS (aquired immune deficiency syndrome), there is reduction in all body stores, including fat and fat-free mass. There is a reduction in BMI and individuals may have a particularly low percent fat, depending on the duration and severity of the disease.

In certain diseases, it is not the total amount of fat, but rather the distribution of fat which determines the risk of developing disease. Thus, abdominal visceral fat is a better determinant of the risk of developing diabetes, hypertension and coronary artery disease than total body fat. Intra-abdominal fat can only be effectively measured using computed tomography (CT). Recent attempts to measure intra-abdominal fat using ultrasonography have been promising, but are incompletely validated. Both these measurements are equipment intensive and expensive. As an alternative, simple anthropometric measures like waist-circumference and waist-hip ratio have been used as surrogates of intra-abdominal fat, since there is a high correlation between these measurements and actual estimates of CT derived intra-abdominal fat. The cut-offs for normality of these indices have been determined and are provided below:

Sex-specific waist circumferences that denote increased risk of metabolic complications associated with obesity (data derived from Caucasians)

	Risk of obesity-related metabolic complications	
	Increased	Substantially increased
Men	> 94 cm (~37 inches)	> 102 cm (~40 inches)
Women	> 80 cm (~32 inches)	> 88 cm (~35 inches)

For waist-hip ratio, the point of high risk is > 1.0 in men and > 0.85 in women. These cut-offs however, need to be validated for different racial groups.

Although the waist-hip ratio has been the traditional index of central adiposity, recent studies have indicated that waist circumference alone may be a better indicator of intra-abdominal fat and risk of obesity-related complications.

KEY POINTS

- BMI allows for the assessment of obesity and undernutrition. This is important because the relationship between morbidity and BMI is 'J' shaped, with increased morbidity both at low and at high BMI's.
- BMI can also be used for monitoring the nutritional status of individuals over time.
- The measurement of mid-arm circumference adds to the assessment of nutritional status.
- A basic understanding of fat and fat-free body compartments can be obtained using simple anthropometric measures.
- The quantity of intra-abdominal fat is an important determinant of diseases like diabetes, coronary artery disease and hypertension. Waist circumference / waist-hip ratio can be used as surrogate measures of intra-abdominal fat.

FURTHER READING

- Obesity. Preventing and managing the global epidemic. WHO / NUT / NCD / 98.1. WHO, Geneva, 1998
- Body Mass Index. A measure of chronic energy deficiency in adults. PS Shetty, WPT James, FAO and Food and Nutrition Paper 56. FAO, Rome, 1994
- Management of severe malnutrition: a manual for physicians and other senior health workers. WHO, Geneva, 1999
- Anthropometric Standardization Reference Manual. TG Lohman, AF Roche, R Martorell eds. Human Kinetic Books, Champaign, Illinois, 1988
- You will also get good insights from reputable books in Nutrition such as:
    a) Davidson and Passmore. Human Nutrition and Dietetics
    b) Shils and Young. Textbook of Nutrition
- Some standard textbooks of medicine also have chapters on Nutrition which would be worthwhile reading

STUDENT PRACTICAL SHEET:

AIM:

a) To determine your body composition using standard anthropometric measures and simple regression equations.
b) To evaluate your nutritional status using anthropometric indices by comparison with standard norms
c) To compare the body composition of the males and females in your practical batch

MATERIALS REQUIRED FOR THE PRACTICAL
• Measuring tape to be stuck to the wall for measurement of height
• Measuring tape to measure mid arm circumference and waist-hip ratio
• Weighing scale for body weight

METHODS:

Height: can be measured very simply by pasting a measuring tape to a wall. The subject is barefoot, the arms hang freely by the side, the heels of the feet are together with the medial borders of the feet at an angle of 60 degrees. The scapula and the buttocks must be in contact with the measuring wall. The head is held in the Frankfort plane (with the tragus of the ear and the lateral angle of the eye in a horizontal line). Height is recorded to the nearest 0.1 cm after the subject inhales fully and maintains the erect position without altering the load on the heels.

Weight: the subject is measured in standard indoor clothing (without shoes). Care must be taken to ensure that the scale is 'zeroed' before taking any weight. Weighing scales should be calibrated at regular intervals using standard weights.

Mid upper arm circumference: is recorded at the mid-point of the arm. The mid-point of the arm is identified as the point between the lateral border of the acromion and the inferior border of the olecranon, with the elbow flexed to 90 degrees.

Waist circumference: the subject stands erect with the abdomen relaxed and the arms at the sides. The circumference is recorded as the narrowest part of the abdomen between the ribs and the iliac crest. The measurement is taken to the nearest 0.1 cm at the end of a normal expiration, without the tape compressing the skin.

Hip circumference: This is measured at the point of maximum circumference.

RESULTS

Individual data:

Height:_____(cm) Weight:_____(kg)

Body Mass Index:_____(kg/m^2)

Mid upper arm circumference:_____(cms)

Waist circumference:_____(cms), Hip circumference_____(cm)

Waist-hip ratio:_____.

Percent fat:_____%

PERCENT FAT = (1.2 x BMI) + (0.23 x Age) – (10.8 x Sex) – 5.4
Where for sex, Males =1 and Females = 0
Age is in years
Deurenberg, Br J Nutr 1991; 65: 105-114

Fat mass:_____(kg) [(weight/100) x Percent fat]

Fat Free mass _____(kg) [weight – fat mass]

Muscle mass: _____(kg) (50% of fat free mass)

Comment on your anthropometric measures. How does it compare with acceptable standards?

Batch Data:

FEMALES							MALES						
Wt	Ht	BMI	%fat	Fat	FFM	Mus	Wt	Ht	BMI	%fat	Fat	FFM	Mus

Compute the average for each column in the last row. Comment on the gender differences that you have observed. What is the basis of these gender differences?

CLINICAL PROBLEM

A 33 yr old male business executive, 1.7 m tall and weighing 90 kg. walks into your out-patient clinic. He expresses a desire to lose weight. He tells you that among other things, he is addicted to potato chips and has one 100 g packet every evening when he returns home from work. He spends his evenings watching television.

You may need the following information for the problem:
BMI = weight / height^2 (kg / m^2)
Percent fat = (1.2xBMI) + (0.23x Age) – (10.8x Sex) – 5.4 (for males sex=1)
1 gm of fat = 9 kcals

Computational questions

1. How many kgs. overweight is the man?

2. *You advise him to refrain from eating potato chips every day (275 kcals/100gms), and also ask him to exercise daily (30 mins brisk walking, roughly equivalent to an energy expenditure of 160 kcals). Assuming that the entire weight reduction is in body fat (which is unlikely to be true), what reduction in fat mass can he expect to achieve over a two week period?*

Applied / Clinical question
What risks of obesity will you highlight to the patient

On examining the patient you determine that the BP is 140 / 96 mmHg. You do not start him on treatment but advise him a low salt diet. The patient tells you that he has heard that there is a health clinic near the city which guarantees a reduction of body weight to the ideal in 2 months.

Patho-physiological question
What is the basis of hypertension in obesity?

Educating the patient

1. What are the hazards of rapid weight reduction in obesity?

2. What are reasonable guidelines for the management of obesity?

One month later, the patient reports to the out-patient clinic for follow up. A medical student attached to your clinic measures his weight and finds it to be 90.2 kg. The patient insists that he has very vigorously followed your advice. In addition, he claims that he has reduced his salt intake by more than half during thesame period. His BP is still 140 / 96 mmHg.

1. What is your response to the assertion of the patient that he has been following your advice?

2. Is it possible that his BP can remain unchanged despite the reduction in salt intake?

QUESTION BASED ON INDEPENDENT READING:

List three methods which may be used to determine the fat and fat-free mass of a subject. Briefly outline the principle involved in each method.

PRACTICAL EXAMINATION QUESTION:

1. In the presence of the examiner, perform an anthropometric examination of the subject provided.	5 marks
2. Calculate the BMI, Percent fat, fat-free mass and muscle mass of the subject	5 marks
3. Comment on the values that you have obtained in relation to standard norms	5 marks
4. Bench Viva of the examiner (discretionary questions)	5 marks

SKELETAL MUSCLE STRENGTH: ITS DETERMINANTS AND PHYSIOLOGICAL VARIATIONS

BACKGROUND

Use of assessing skeletal muscle strength

The determination of skeletal muscle strength has many uses in the field of exercise and sport physiology. It allows for the monitoring of resistance training protocols which are primarily aimed at increasing muscle bulk and muscle strength. In addition the determination of skeletal muscle strength is often used as a functional index of nutritional status. In undernutrition there is a reduction in all body stores including skeletal muscle mass. There is also a shift in skeletal muscle fibre composition, with a relative preservation of slow oxidative muscle fibres. Both these factors result in a reduction in muscle strength with undernutrition. It is important to estimate muscle strength in clinical conditions as a functional index of undernutrion, since a diminshed muscle strength increases the likelihood of complications in hospital.

Methods of assessment

There are several methods of assessing skeletal muscle strength based on the muscle group that has to be tested. However, very broadly, these methods can be classified into two groups:

a) Electrical methods: in principle this method requires the electrical stimulation of a muscle group through a superficial nerve. The frequency and intensity of stimulation can be controlled by the experimenter. The advantages of this method are that it is independent of the motivation of the subject and allows for the recording of true and repeatable measures of muscle strength. The disadvantage is that it requires specific equipment, and is not easily performed at the bedside of the patient.
b) Voluntary methods: in this case the subject/patient is asked to maximally contract a specific muscle group and the strength is recorded with a devise known as a dynamometer. The advantage of this technique is that it is relatively easy to perform, and that there are many small, portable dynamometers commercially available. The disadvantage is that since it is voluntary, it requires the co-operation of the subject. In our hands, the within subject variability of repeat testing of muscle strength using a dynamometer is between 5 and 7%. The most widespread dynamometer used to assess muscle strength is the handgrip dynamometer, and the measure recorded is often referred to as handgrip strength.

Factors affecting muscle strength

1. Muscle size: Generally, bigger muscles are stronger than smaller muscles. There is a large range in the reported values for muscle strength/unit muscle cross-sectional area. This may be due to the varying methodologies that are used to assess cross sectional area. Muscle cross-sectional area can be assessed anthropometrically. Bu

this allows for the estimation of total muscle cross-sectional area at a particular level, and not for the estimation of the cross- sectional area of the specific muscle groups involved. A better method is to use cross-sectional computed tomography. This is, however, prohibitively expensive.

2. Synchrony of motor units: increases in muscle strength are observed during resistance training schedules well before any increases in muscle mass. While one possibility is that subclinical hypertrophy has indeed occurred, another explanation for this phenomenon has been put forth based on electromyographic (EMG) findings. Researchers have found that within 6 weeks of starting a strengthening program, untrained subjects demonstrate increased synchrony of motor unit firing in their exercised muscles, something that is already present in trained weightlifters. (Normally, motor units fire asynchronously).
3. Muscle fibre distribution: Type II fibres (fast fatigable) are larger in size and contribute to the increase in muscle mass in individuals who undertake resistance training schedules. Thus weightlifters have a greater proportion of type II fibres in their exercised muscles.
4. Age of the individual: Normative data derived from the study of large numbers of individuals indicate that muscle strength increases till about the age of 20yrs. From 20 to about 40 yrs there is a plateau in muscle strength, followed by a steady decline thereafter. The decrease in muscle strength with aging is largely due to sarcopenia (a loss of muscle mass) and is prevented by resistance training.
5. Gender of the individual: Body size may partly explain the lower muscle strength of women in absolute terms. When muscle strength is expressed relative to body size, (body weight or lean body mass) upper body strength continues to be lower in women, while there are no gender differences with this correction for lower body strength. Our own studies have shown that handgrip strength in untrained Indian women is lower than that in untrained males with comparable ages. This is true when handgrip strength is expressed both in absolute terms as well as when corrected for forearm muscle area. The differences beteen the genders may in aprt, be attributable to skeletal muscle fibre distribution differences; males have a higher proportion of type II fibres than females.
6. Prior physical activity patterns: For muscle strength, prior resistance training schedules are of particular importance since these exercises result in the development of a larger proportion of type II muscle fibres in skeletal muscle.
7. Psychological/behavioural factors: Researchers have suggested that our maximal efforts are normally inhibited (presumably by cerebral mechanisms), and that under appropriate circumstances these inhibitions are inhibited (disinhibition), resulting in a fuller expression of our inherent muscular potential. This hypothesis, though intriguing remains to be validated. Other evidence suggests that as the "skill" in performing a task increases, the expressed maximal contraction also increases. Thus, subjects who were isometrically trained for five weeks produced an average gain of of 20% in the maximal voluntary contraction MVC) of these muscles, although there was no corresponding increase in how strongly these muscles contracted to electrical stimulation. This observation implied that the increase in strength was due to subjects learning "how to contract" rather than due to any intrinsic change in the force generating capacity of the muscles.

8. Nutritional status: Subjects who are chronically undernourished, have a reduced handgrip strength compared to well nourished subjects. This is true even when muscle strength is corrected for differences in forearm muscle area. While the quality of diet may play a part, there is also evidence that there is a reduction in Type II fibres in undernutrition.
9. Other factors: These include things like internal muscle architecture, limb length, and joint structure.

A prediction equation for maximal handgrip strength (non dominant side) generated at the Division of Nutrition, Department of Physiology, St John's Medical College, Bangalore on over 1000 healthy adults of both genders between the ages of 6 and 65 was:

- 25.95 (gender) + 6.43 (Forearm circumference) + 1.46 (gender x forearm circumference) – 0.102 (Forearm circumference)^2 – 67.65.

where: for gender; male =1 and females = 0
forearm circumference is in cms

KEY POINTS:

- Skeletal muscle strength can be assessed very simply using hand dynamometry
- Handgrip strength is important in clinical situations where there is neuro-muscular dysfunction and in the functional assessment of nutritional status
- A caveat to this test is that muscle strength at one site cannot be extrapolated to another site in the body because of muscle fibre distribution differences.

FURTHER READING:

- Textbook of Work Physiology. P-O Astrand, K Rodahl. 3rd Edition. Mc-Graw Hill Book Company: New York, 1986.
- Designing Resistance Training Programmes. SJ Fleck, WJ Kraemer. 2nd Edition. Human Kinetics: Champaign, IL, 1997.
- Skeletal Muscle. Form and Function. AJ McComas. Human Kinetics: Champaign, IL, 1996.

STUDENT PRACTICAL SHEET:

AIM:

a) To determine your skeletal muscle strength
b) To determine whether skeletal muscle strength is greater on the "dominant" side of the body
c) To determine whether there are gender differences in skeletal muscle strength

MATERIALS REQUIRED FOR THE PRACTICAL

- Hand dynamometer*
- Measuring Tape to measure maximal forearm circumference

* If you do not have a handgrip dynamometer an alternative is to use a sphygmomanometer. For this, roll the cuff tight and then apply rubber bands to the cuff. Enough bands should be applied so that they do not break when the cuff is inflated. Inflate the pressure to 50 mmHg and then tighten the valve. In order to measure muscle strength, ask the individual to compress the cuff as tightly as possible. Note the increment in pressure above 50 mm Hg. We have found that using this method, handgrip strengths upto approx. the equivalent of 50 kg force can be recorded. This is not the upper limit of forces that would be recorded in an average classroom, since we have recorded handgrip strengths of upto 60 kg force. This limitation is clearly a disadvantage, but should not affect many students in the class

METHODS / RESULTS:

In order to get some measure of muscle strength we use an instrument called a handgrip dynamometer.

The hand that you normally use for work is called your dominant hand, while the other hand is called the non-dominant hand. Circle which is your dominant side in the table given below.

In order to measure maximal handgrip, adjust the width of the hand dynamometer so that it is comfortable in your hand. Hold the dynamometer by your side and slightly away from your body so that it is not resting against the thigh. Press as hard as you can to a count of three. Then test the other hand. Repeat the cycle three times, keeping about a minute between contractions. Fill in the values obtained by you in the table below:

	1	2	3	Mean	Maximum
Dominant (left / right)					
Non dominant					

- The "mean" refers to the average of the three readings obtained.

- Please note the maximum value under the "maximum" column.

How does your maximal non-dominant handgrip strength compare with that which is predicted for you?

Why do you keep pressing to a count of three?

In this experiment we assessed your muscle strength using a hand dynamometer. The value that you obtained is likely to be related more to the amount of muscle that you have in your forearm, than elsewhere in the body. The best way to assess forearm muscle mass is by cross-sectional computed tomography. However, we can get a rough gauge of forearm muscle mass by simply measuring the maximal forearm circumference. This is done using a simple tape measure.

What do you think are the problems in using maximal forearm circumference as a measure of forearm mass?

Note down your maximal forearm circumference (MFC) on both sides:

dominant :_____cms.
non-dominant :_____cms.

To calculate the strength that you exerted per unit area, first calculate the forearm cross sectional area. In order to do this calculate the radius (r) from the maximal forearm circumference using the equation: Circumference = $2 \Pi r$.
Forearm cross sectional area is then give by: Πr^2

Non-dominant maximum voluntary contraction (kgs) / Forearm area (cm^2)
= _____kg/cm^2

Dominant maximum voluntary contraction (kgs) / Forearm area (cm^2)
= _____kg/cm^2

Is the muscle strength for you more on the dominant side?

In your practical batch, in how many students was handgrip greater:

- In the dominant side:
- In the non-dominant side:

What is your interpretation of these findings and how do you explain them?

In the Table below, enter the values for all your batch mates using the values on the non-dominant side only. After entering the values, calculate the average of each column:

MALES		**FEMALES**	
Maximal handgrip	**Maximal handgrip/area**	**Maximal handgrip**	**Maximal handgrip/area**
Average	**Average**	**Average**	**Average**

What are your conclusions based on the tabulated data of the female and male students of your class? How do you explain your findings?

STATISTICS (BACKGROUND)

DESCRIPTIVE STATISTICS

MEASURES OF CENTRAL TENDENCY

MEAN: is the average of all the values. This is obtained by adding the individual values and dividing this by the number of observations.
MEDIAN: is the middle value, when all the values are arranged either in ascending or descending order. Thus half the values in a data set will be lower than the median and half will be higher. This statistic is useful when data is not normally distributed.
MODE: this is the individual value that occurs most frequently. (This is not used very often)

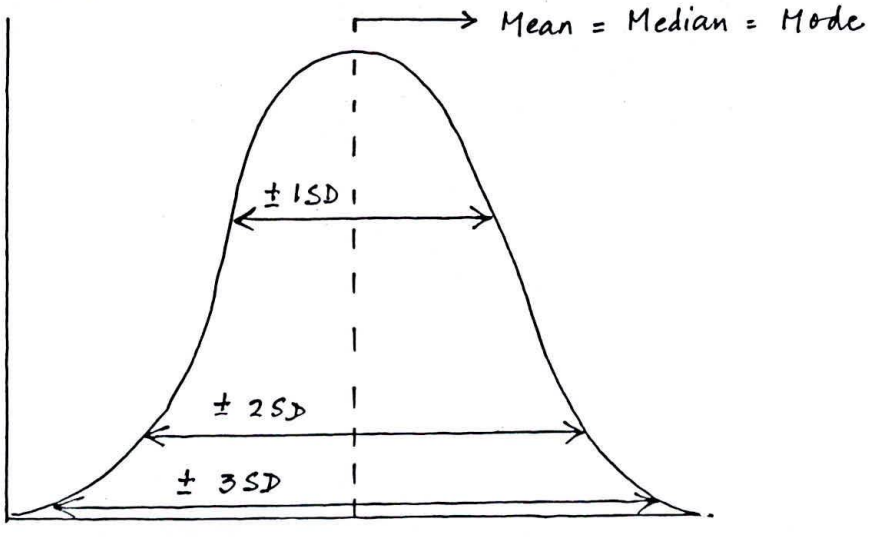
MEASURES OF DISPERSION

RANGE: is the difference between the highest and lowest values in the data set.
STANDARD DEVIATION (SD): you are already familiar with the equation used to calculate standard deviation. (See practical on "Estimation of Haemoglobin") The use of the SD assumes that the data is normally distributed, such that the mean ± 1SD encompasses approximately 68% of the data, mean ± 2SD approximately 95%, and mean ± 3SD approximately 99%.

NORMAL DISTRIBUTION

Is one where:

- The distribution is bell shaped
- The central line going through the distribution represents the mean
- The dispersion of the data can be described by the standard deviation



If a set of data is arranged in ascending or descending order and then divided into equal parts, each part is called a QUANTILE. Special names are used to describe the parts depending on how many parts the data is divided into.

DATA DIVIDED INTO	EACH PART IS CALLED
100 parts	CENTILE
10 parts	DECILE
5 parts	QUINTILE
4 parts	QUARTILE
3 parts	TERTILE

If a set of data is arranged in ascending or descending order then the value in the middle is called the 50^{th} percentile which basically corresponds to the median.

INFERENTIAL STATISTICS

P VALUE

Because many things in biology do not necessarily occur with absolute certainty in a given way, we use probability to describe how likely something is going to happen. Probability in statistics is indicated by a P value or probability value. P-values are expressed in terms of 1 (much like the PCV or Haematocrit). Thus a P value of 0.95 means a probability of 95% and a P value of 0.05% means a probability of 5%.

NULL HYPOTHESIS

In statistics we have a slightly funny way about saying things.

For instance let us say we are interested in knowing whether smokers are more likely to have a heart attack than non smokers.

We start off with the assumption that smokers and non smokers have the same likelihood of having heart attacks. In other words there is no difference between the likelihood of smokers and non smokers having heart attacks. ***This assumption of 'no difference' is called the NULL (no difference) HYPOTHESIS.***
If we do find that there is indeed a difference in the number of heart attacks that smokers have as compared with non smokers, then the NULL hypothesis is clearly wrong. ***In other words we would have rejected the Null Hypothesis.***

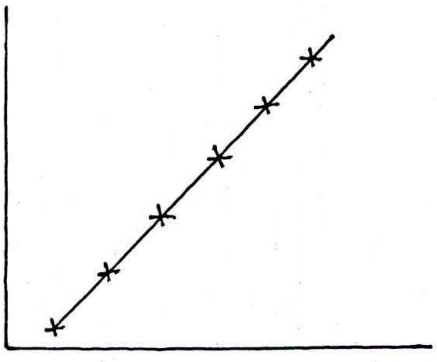
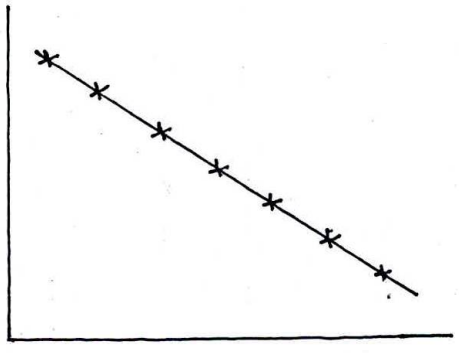
Since in statistics we start off with the Null Hypothesis, when we use P values, these values are also in relation to the Null hypothesis.

Thus,
In the example of the smokers and non-smokers, a P value of 0.05 means that there is a 5% probability that there is no difference in the likelihood of having heart attacks between smokers and non smokers.

Thus,
There is a 95% chance that there is a difference between the smokers and non smokers having a heart attack.
Q.E.D.!

In statistics a P value of 0.05% is considered the minimum value to ascribe statistical significance.

CORRELATION
Is a measure of linear association between two variables.

If one variable increases as the other also increases, it is called a **POSITIVE CORRELATION**. A perfect positive correlation has a correlation coefficient (r value) of + 1.	**If one variable decreases as the other increases, it is called a** NEGATIVE CORRELATION. **A perfect negative correlation has a correlation coefficient of -1**
	

WORKSHEET FOR STATISTICAL ASSESSMENT OF "SKELETAL MUSCLE STRENGTH: ITS DETERMINANTS AND PHYSIOLOGICAL VARIATIONS"

DESCRIPTIVE STATISTICS:

The mean ± SD of the non-dominant MVC: - for the entire class =_____
- for the males only = _____
- for the females only = _____

The diagram below represents a normal distribution:

The distribution of all the MVC's in the class looks something like this:

This is a_____distribution

Comment on the Distribution:

The quartiles for non dominant MVC's in the class are:

_____ to _____: First Quartile
_____ to _____: Second Quartile
_____ to _____: Third Quartile
_____ to _____: Fourth Quartile

The RANGE of MVC's is _____ to _____.

My non dominant MAXIMUM voluntary contraction of _____ kgs.
falls within the_____ quartile
lies above / below the class mean value
lies above / below the mean value for my gender

INFERENTIAL STATISTICS:

The diagrams below depict perfect POSITIVE and NEGATIVE correlations

The correlation (linear association) between body mass index and MVC is r=_____ , P = _____.
This means that there is_____ correlation which is _____ significant.

The correlation between forearm area and MVC is r = _____ and P=_____.
This means that there is a_____correlation which is _____ significant.

Comment:

The table below summarises the comparison between the MVC's of males and females:

	MALES	FEMALES	P VALUE
MVC (kg)			
MVC / forearm area (kg/cm^2)			

This means the difference in MVC between males and females is _____ significant.

This means that the difference in MVC per unit forearm area between males and females is _____ significant.

Comment:

APPLIED PROBLEM:

An 18 year old male student approaches you in your clinic because he is "too thin". He would like to "put on muscle".

Applied Physiology
What advice with regard to exercise will you give him?

He informs you that he has been advised to go on a "high protein" diet as this will help him "put on muscle".

Educating the patient
What advice will you give him?

He also informs you that some of his friends have told him to try anabolic steroids, as this produces results that are fastest and best.

Drugs
What advice will you give him?

QUESTIONS FOR INDEPENDENT READING:

What are the principles that govern 'resistance training'?

What are the tissues that comprise non-muscle, fat-free mass?

PRACTICAL EXAMINATION QUESTION:

1. In the presence of the examiner measure the handgrip strength and maximal forearm circumference on the dominant and non-dominant sides of the given subject.	5 marks
2. How does the non-dominant handgrip strength in the subject compare with the value predicted for him (provide the equation to the student for calculation)	5 marks
3. What are the factors that affect muscle strength	5 marks
4. Discretionary questions	5 marks

EVALUATING HABITUAL PHYSICAL ACTIVITY PATTERNS

BACKGROUND

Importance of assessing habitual physical activity:

Projections for future disease prevalence in India suggest a shift from infectious disease to chronic disease as the primary disease cluster. Of the chronic diseases, circulatory diseases are likely to assume primacy. Even today, circulatory disease in India is not insignificant; almost 800,000 people die each year from coronary artery disease and more than 600,000 from stroke. Physical inactivity is an important risk factor for the development of coronary artery disease, as well as other diseases including hypertension, diabetes, cancers, obesity and osteoporosis . The problem is of particular concern in those countries that have transitional economies. For example, increasing affluence in developing countries has been linked with decreased physical activity and increased obesity, both independent risk factors for coronary heart disease. Thus, behavioural profiles may compound the increased inherent risk of ethnic groups. There is some data, for instance that suggests that Indians have a genetically determined increased risk for coronary artery disease. Physical inactivity would tend to enhance the risk. In order to understand the epidemiology of these diseases, as well as to plan effective interventions, it is therefore necessary to assess physical activity patterns effectively.

Methods of assessment of physical activity:

Physical activity can be assessed by several methods including diaries, time and motion studies, motion sensors, and stable isotope methods. These methods, however, have key disadvantages in terms of cost and cannot easily be applied to large populations. In contrast, questionnaires are easy to administer, cost-effective and applicable for the study of large populations. These advantages make questionnaires particularly attractive as an option in the assessment of physical activity. There are a large number of physical activity questionnaires that have been described in literature, particularly for use in industrialised countries. Many of these questionnaires focus on specific components of physical activity, often leisure time activity, together with some but not necessarily all components of 24 hr energy expenditure. There are several problems that arise in the assessment of physical activity profiles in Asian countries, including India. First, games and sports that are major components of discretionary leisure activities in developed countries may not be true of the adult population in India. This may be due to specific socio-cultural reasons or due to the lack of facilities. Second, household chores which are often not addressed in other questionnaires, may constitute a significant portion of the daily physical activity, especially in non-mechanised households and in housewives and the unemployed. Third, job titles in industrialised and developing countries may have different connotations in terms of the actual activity involved in the job.

In this practical we assess habitual physical activity by using a questionnaire developed at the Division of Nutrition, St John's Medical College. This questionnaire delineates as many activities as possible over a prompted recall of 4 weeks.

KEY POINTS:

- Physical inactivity is an important factor in the development of several chronic diseases of aging including coronary artery disease and osteoporosis
- Habitual physical activity patterns can be assessed by several methods including questionnaires
- Physical Activity Questionnaires are cheap, easy to administer, and can be used widely
- The assessment of physical activity allows for the formulation of appropriate intervention

FURTHER READING

- Blair SN, Kohl HW, Gordon NF, Paffenbarger Jr RS. How much Physical activity is good for health? Annu Rev Publ Health 1992; 13: 99-126.
- Fletcher GF, Balady G, Blair SN, Blumenthal J, Caspersen C, Chaitman B et al. Statement on Exercise: Benefits and Recommendations for physical activity programs for all Americans. Circulation 1996; 94: 857-862.
- Shetty PS, Henry CJK, Black AE, Prentice AM. Energy requirements of adults: an update of basal metabolic rates (BMRs) and physical activity levels (PALs). Eur J Clin Nutr 1996; 50: S11-S23.
- Shephard RJ. Assessment of physical activity and energy needs. Am J Clin Nutr 1989; 50: 1195-1200.
- James WPT, Schofield EC. Human Energy Requirements. A manual for Planners and Nutritionists. Oxford: Oxford Medical Publications, Oxford University Press; 1990 p. 24-26, 133-135.
- WHO. Obesity. Preventing and Managing the global epidemic. Report of a WHO consultation on obesity. Geneva: WHO; 1997 p. 121.
- WHO. Energy and Protein requirements. Report of a Joint FAO/WHO/UNU Expert Consultation. Technical Report Series 724. Geneva: WHO; 1985 p. 78, 178, 186-191.

STUDENT PRACTICAL WORKSHEET:

AIM:

a) To take a physical activity history of the a given subject and record your findings in the physical activity questionnaire
b) To grade the physical activity patterns of the individual in terms of standard norms.
c) To compare the physical activity patterns of males and females in the class

MATERIALS REQUIRED FOR THE PRACTICAL:

- Questionnaire, writing material, calculator

METHODS:

- A sample of the physical activity questionnaire is provided in the following page.
- Remember that physical activity can only be assessed appropriately if a good physical activity recall is obtained.
- The questionnaire relates to activities over the last 1 month only.
- Subjects will report variations in the time spent in various activities. Your job is to obtain an 'average' value that the subject feels is representative of his / her activity.
- Probe deeply; the less the 'residual time', the more reliable will your estimate be of physical activity.
- If the subjects have difficulty recalling various activities, ask them to go through a 'typical' day from the time the get up to the time they sleep.
- Remember subjects tend to overlook sedentary activities and focus on the heavier activities that they have performed in the last few weeks.
- In order to analyse the questionnaire, follow the instructions given later under the heading "Analysis of the questionnaire" and also go through the example provided

NAME: Occupation: Date:
Age: Weight: Height:

1 a) On an average, how many **hours** per day do you spend at work/college:

1 b) Of the hours you spend at work/college how many **hours** do you spend:

standing	sitting	walking	on activities more strenuous than walking

2) On an average, how many **hours** do you sleep in a day:

3) Apart from work/college, how do you spend your time. Fill in the table below:

TYPE OF ACTIVITY		Daily	Weekly			Monthly	
(over the last month)	**Average Duration in minutes**		once	2-4	4-6	once	2-3
Sports / games / exercise							
1.							
2.							
3.							
4.							
5.							
Hobbies involving manual labour (for eg carpentery, gardening..... etc.)							
1.							
2.							
3.							
4.							
5.							
Household chores (for eg. Sweeping, cooking, washing .....etc)							
1.							
2.							
3.							
4.							
5.							
6.							
Sedentary activities (for eg. Reading, watching T.V.....etc.)							
1.							
2.							
3.							
4.							
5.							
Other activities							
1. Eating							
2 .Brushing & Bathing							
3. Dressing							
4. Socializing (talking)							
5. Traveling to and from work							

4)How do you normally travel to and from work/college:

Analysis of the questionnaire:

The analytical procedures used in the assessment of the physical activity questionnaire are discussed below:

1. Physical Activity Level (PAL): This is used as a composite index of physical activity patterns and is calculated as: 24 hr energy expenditure / Basal metabolic rate. 24 hr energy expenditure is calculated as the sum of energy expenditures of all reported activities computed for a single day. This is described in greater detail later. Basal metabolic rate is calculated from age and gender specific regression equations recommended by the WHO, that include height and weight as predictor variables. Cutoffs for PAL's that describe grades of physical activity have been described earlier. These cutoffs are <1.4 = sedentary, 1.55-1.6 =moderately active and >1.75 = heavily active. Thus, lower PAL's indicate more sedentary physical activity profiles.

2. 24 hr energy expenditure: The activities reported for one month are recomputed for 24 hours as the sum of energy expenditure related to sleep, occupational energy expenditure, discretionary leisure time energy expenditure and "residual energy expenditure". In order to calculate energy expenditure for each of these components BMR/min is first computed. For every reported activity a MET (metabolic equivalent) which is essentially a multiple of BMR is applied. For occupational activity, use MET's for various job descriptions in different postures. Thus, higher MET's indicate higher levels of physical activity. "Residual energy expenditure" relates to those periods in a day which are unaccounted for by recall, and for which intensities of activities have to be assumed. This is a common problem in physical activity questionnaires. Since reports from literature suggest that individuals tend to underreport sedentary activities, we employ a uniform MET of 1.4 for all "residual time".

A worked example of a physical activity questionnaire is provided at the end of this section. A collection of common METS is provided as an appendix to this chapter.

Table 1: Regression equations for the calculation of Basal Metabolic Rates (WHO. Energy and Protein Requirements. Technical Report Series 724. 1985)

Weight (W) is in kg and height (H) is in m.

	Age Range (yr)	Equation (BMR in kJ)
Men	10 – 18	69.4W + 322.2H + 2392
	18 – 30	64.4W – 113.0H + 3000
	30 – 60	47.2W + 66.9H + 3769
	> 60	36.8W + 4719.5H – 4481
Women	10 – 18	30.9W + 2016.6H + 907
	18 – 30	55.6W + 1397.4H + 146
	30 – 60	36.4W – 104.6H + 3619
	> 60	38.5W + 2665.2H – 1264

Table 2: MET values for various activities compiled from Compendium values (Ainsworth BE et al. Med Sci Sports Exerc 1993; 25: 71-80)

MET VALUES

OCCUPATIONAL	**MET**
Sleeping	0.9
WORK(Working class)	
Standing	2.0
Sitting	1.5
Walking	3.5
Strenuous work	4.5
(Students)	
Standing	1.8
Sitting	1.8
Walking	3.5
Strenuous work	4.5
HOUSEHOLD CHORES	
Sweeping floors	2.5
Dusting	2.5
Cleaning(light)	2.5
Cleaning house (moderate)	3.5
Cleaning (car, windows, mop,)	4.5
Washing(general)	2.3
Washing clothes, car	4.5
Washing vessels	2.3
Washing clothes (machine)	2.0
Mopping	4.5
Cooking	2.5
Shopping	3.5
Folding clothes, put away	2.0
Child care, pet care (light)	2.5
Household chores, maintenance	2.5
Ironing	2.3
Setting up room, straightening room	2.5
fetching water	3.5
Making bed	2.0
HOBBIES	
Gardening	1.5
Pluming	3.0
Electric repair	3.0
Carpentry	3.0
Home repair	3.0
Painting	2.0
Recreation	1.5

Fishing	4.0
Disco. folk dance	5.5
Dancing(general)	4.5
Automobile repair	3.0
Trekking	6.0
Singing	2.0

EXERCISE

Walking (general)	3.5
Brisk walk	4.0
Cycling	4.0
Pullups, Pushups, Situps	8.0
Home exercise	4.5
Weight lifting(general)	3.0
Weight training(vigorous)	6.0
Treadmill	6.0
Gym, body building	5.5
Yoga, stretching, floor exercise	4.0
Aerobics	6.0
Low impact aerobics	5.0
Climbing Stairs	5.0
Jogging	7.0

SPORTS/GAMES

Badminton	4.5
Basketball	6.0
Billiards	2.5
Boxing	6.0
Cricket	5.0
Football	8.0
Frisbee, Tennicoit	3.0
Golf	4.5
Hockey	8.0
Table tennis	4.0
Lawn tennis	7.0
Volleyball	4.0
Throw ball	3.0
Swimming	6.0

SEDENTARY ACTIVITIES	**MET**
Watching television	1.0
Reading	1.3
Listening to music, prayer, meditating	1.0
Travelling	1.0
Watching movies	1.0

Talking, chatting	1.5
Card playing, board games	1.5
Computer games, games	1.5
Writing (student)	1.8
Reading(student)	1.3
Knitting, sewing	1.5
Music playing	2.0

SELF CARE	**MET**
Bathing	2.0
Eating	1.5
Washing, brushing teeth, put on make up	2.5

MANUAL OCCUPATIONS	**MET**
Tailor - sitting	2.5
Driver (auto, car) – sitting	2.0
Mechanic – standing	4.0
Machine operator	2.5
Painter, polisher - sitting	4.5
Electrician - standing	3.5

PRACTICAL EXAMINATION QUESTION:

1. Fill in the physical activity questionnaire for the subject allotted to you. (examiner should check for completeness, and maybe ask the student to recheck one segment of the questionnaire in the presence of the examiner)	5 marks
2. Compute the 24 hr energy expenditure, daily energy expenditure related to household chores and physical activity level (PAL)	5 marks
3. Interpret the data that you have computed	5 marks
4. Discretionary questions of the examiner (can include among other things benefits of physical activity, diseases linked to physical inactivity and guidelines for desirable physical activity)	5 marks

RESULTS

For the data that you collected on your subject:

Calculated Basal Metabolic Rate (kJ/day):_____

Total 24 hr energy expenditure (kJ/day):_____

Physical activity level (24 hr energy expenditure / Basal Metabolic Rate):_____

Components of 24 hour energy expenditure (all kJ/day):

- Energy expenditure of sleep:_____
- Energy expenditure at work / college:_____
- Energy expenditure of leisure time activities (games/sports):_____
- Energy expenditure of household chores: _____

Intensity of most strenuous activity reported outside of work/college (MET):_____

What is your inference with regard to the reported physical activity pattern of your subject?

Comment on the distribution of 24 hour energy expenditure in the subject allotted to you.

Group Data: Enter the data of your batch in the Table provided below:

FEMALES			MALES		
PAL	EE of household chores	EE of sports and games	PAL	EE of household chores	EE of sports and games

Comment on the gender differences in your batch with regard to the physical activity levels and the distribution of energy expenditure:

APPLIED PROBLEM:

Computational:
A 45 year old business executive comes to your clinic. He is marginally overweight. His height is 1.7 m and his weight is 75.14 kgs. To what extent is he overweight? Draw up an exercise programme (showing your computations) that will allow him to expend an additional 500 kcals per day.

Health Education:
The executive asks you whether the programme that you have given him will also increase his cardio-respiratory fitness. Comment on this.

QUESTION FOR INDEPENDENT READING:
What are the essential guidelines for ensuring cardio-respiratory fitness in individuals who are not athletes?

WORKED OUT EXAMPLE

NAME	Raja
AGE	20
SEX	m
HEIGHT(mts)	1.722
WEIGHT(Kgs)	53.1
BMR(KJ)	4.323

Reported Activities							Calculations			
ACTIVITIES	DUR						MET	Duration	BMR	E.E
								Mins/day	KJ/min	KJ/day
sleeping	7 1/2 hrs						0.9	450	4.323	1750.82
work / college										
standing	2 hours						1.8	120	4.323	933.768
sitting	3 hours						1.8	180	4.323	1400.65
walking	2 1/2 hrs						3.5	150	4.323	2269.58
streneous	1 hour						4.5	60	4.323	1167.21
							WorkTotal	510		5771.21
EXERCISE	daily	Once	weekly 2-4	4-6	Monthly Once	2-3				
Basket Ball			60.00				6.0	25.71	4.32	666.98
Cricket		60.00					5.0	8.57	4.32	185.27
							Ex. Total	34.286		852.25
HOBBIES	daily	once	2-4	4-6	once	2-3				
							Ho. Total	0		0
CHORES	daily	once	2-4	4-6	once	2-3				
Ironing		60.00					2.5	8.57	4.32	92.64
sweeping					60.00		2.3	2.00	4.32	19.89
							Chores T	10.571		112.52
SEDENTARY	daily	once	2-4	4-6	once	2-3				
TV			120.00				1.0	51.43	4.32	222.33
reading		60.00					1.8	8.57	4.32	66.70
OTHER							Sedentary	60.00		289.02
Eating	60.00						1.5	60.00	4.32	389.07
BrushingBathing	30.00						2.0	30.00	4.32	259.38
Dressing	15.00						2.5	15.00	4.32	162.11
Socializing	180.00						1.5	180.00	4.32	1167.21
Travelling towork	30.00						1.0	30.00	4.32	129.69
							Others T	315.00		2107.46
							Grand T	*1379.9*		*10883*

ASSESSMENT OF PHYSICAL FITNESS

BACKGROUND:

Indications for the assessment of physical fitness:

The assessment of whole body (cardio-respiratory) physical fitness is particularly important for athletes and in screening for specific occupations (eg. the armed forces). However, it also has a role in clinical medicine. For instance, it may also be used to detect:

a) The presence and nature of ventilatory limitations to work
b) The presence and nature of cardiovascular limitations to work
c) The maximal tolerable workload and safe levels of daily exercise
d) The extent of disability for rehabilitation purposes
e) O_2 desaturation and appropriate levels of supplemental O_2 therapy

Methods of assessing physical fitness:

For the purposes of testing physical fitness in healthy individuals, the gold standard is the measurement of $VO_{2\,max}$ (Maximal oxygen uptake). This is done by using standard graded-exercise protocols involving either the tread-mill or a bicycle ergometer. These do not, however give the same value. For instance, with the treadmill, individuals may have different walking patterns and different stride lengths which may affect the actual work being done. In addition, subjects who grip the handrails of the treadmill may use their arms to reduce the amount of work being done. VO2 max has been shown to be approximately 7-10% higher on a tread-mill than on a cycle ergometer. These tests, however require special equipment and may be difficult to perform on a large number of people.

"$VO_{2\,max}$ is defined as the highest oxygen uptake that a healthy person can attain during exhaustive (maximal) exercise of approximately 6 minutes duration, when working on a treadmill, bicycle ergometer, steeping bench or performing similar types of exercise activating large muscle groups. The maximum oxygen uptake is also termed aerobic capacity."

In order to offset the cost of traditional tests, alternatives which do require specialised equipment have been developed. These include the step tests, fixed-duration walking/jogging and fixed-distance walking/jogging. Norms for these have been developed. The disadvantage of the step tests is that it may be associated with muscle soreness in subjects who are not accustomed to exercise. In addition, there is a danger that subjects may stumble during the latter parts of the exercise and injure themselves.

Recommendations for enhancing physical fitness:

In this section, physical fitness in equated with cardio-respiratory fitness. Studies have shown that the intensity of effort required for effective aerobic training is in the region of

65 to 85 % of maximal heart rate for 30 mins, 3 to 5 times a week. Maximal heart rate can be computed very simply by: 220 – Age (yrs). Thus a 20 yr old will have a predicted maximal heart rate of 200 and the desirable range of training would be a heart rate between 130 and 170 beats per minute. A slightly more accurate equation for assessing absolute heart rate is:

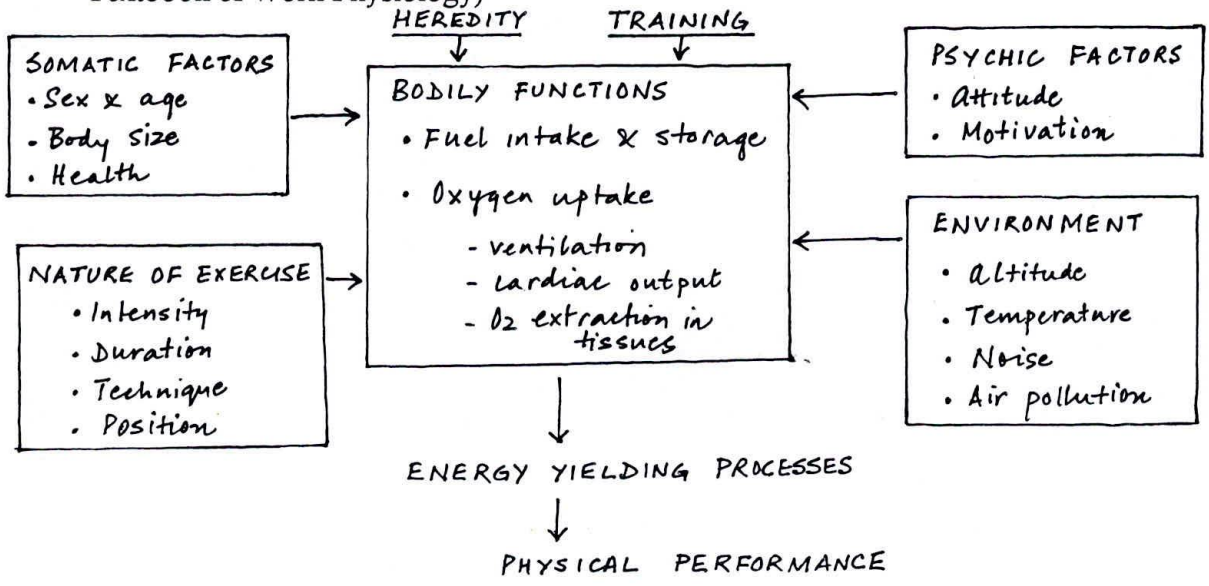
214 – (0.8 x Age (yrs))

Thus a 20 yr old would, by this equation have a heart rate of 198 beats per minute.

The concept of exercising within a certain heart range is important and is referred to the Training Heart Rate. Exercising at too high an intensity will lead quickly to exhaustion, and may be dangerous in older individuals who have been sedentary for a number of years. Conversely, too low an exercise intensity will not lead to any significant improvement in cardio-respiratory fitness. More recently, studies have shown that brisk walking has a similar cardioprotective effect as exercise at a higher intensity in middle-aged women.

Factors affecting sustained physical performance:

Physical fitness is only one of the factors that affects physical performance. Other factors that are operative are depicted in the diagram below: (modified from Astrand and Rodahl, Textbook of Work Physiology)



Factors affecting Aerobic capacity:

- Sex: is lower in women
- Age: varies inversely with age. The aerobic capacity of a 75 year old man is half that of a 17 year old youth.
- Size: in absolute terms aerobic capacity increases with stature, weight and body surface area.

- Body composition: lean body mass is more closely correlated with aerobic capacity than body weight
- Bed rest: enforced bed rest for three weeks reduces aerobic capacity by 17%
- Semistarvation: Aerobic capacity can be reduced by as much as 37% on prolonged semistarvation.
- Altitude: aerobic capacity is reduced by 26% at an altitude of 4000 m.

Aerobic capacity is not affected by the prior ingestion of a small meal (750 kcals) or exposure to heat stress of upto 90 °F.

KEYPOINTS:

- Assessment of physical fitness is important in sports physiology as well as in clinical medicine where there is cardiac or respiratory dysfunction.
- The techniques to assess cardio-respiratory fitness are varied, but the gold standard is the measurement of maximal oxygen uptake (aerobic capacity).
- Aerobic capacity is affected by a large number of factors. These need to be taken into account when assessing the measured fitness level.

FURTHER READING:

- Textbook of Physiology. Third Edition. P-O Astrand and K Rodahl. McGraw-Hill Book Company, New York, 1986.
- Exercise in Health and Disease. Second Edition. ML Pollock and JH Wilmore. WB Saunders Company, Philadelphia, 1990
- Cardiopulmonary Exercise Testing. AR Leff ed. Grune & Stratton, Inc. Orlando, 1986.
- Laboratory manual for physiology of exercise. LE Morehouse. The CV Mosby Company, Saint Louis, 1972.
- NIH Consensus Development Conference on Physical Activity and Cardiovascular Health. NIH Continuing Medical Education, Bethesda, MA, 1995.

STUDENT PRACTICAL WORKSHEET:

AIM:

a) To determine your own cardio-respiratory fitness using a simple walking test
b) To determine whether the cardio-respiratory fitness in your practical batch is determined by habitual physical activity patterns (as determined in the physical activity questionnaire)

REQUIREMENTS FOR THE PRACTICAL

- The walking test in our institution was carried out at the athletic track of the college grounds, with a known perimeter of 400 m.
- The test is best conducted in the morning, to avoid the hottest part of day.
- Students should have their watches on and should be able to count the pulse well prior to this practical.
- When we conducted this test, we divided the practical batch (30 students) into three equal groups and staggered the start of the walking exercise by 5 mins. Between each group. The entire exercise took approximately 40 minutes to complete.
- Students should wear light clothing and carry a bottle of water.
- Tutors should screen students for cardio-respiratory ailments eg. exercise induced asthma which may preclude participation in the test.

METHODS:

You will be required to walk 2 km. around the athletic track i.e. 5 rounds. You are required to walk the distance as fast as possible using normal walking style and even pace. Soon after completing the 2 km. measure your heart rate by palpating the radial artery at your wrist for 10 seconds.
(Source: The International Union of Physiological Sciences (IUPS) Commission on teaching Physiology. In: A source book of practical experiments in physiology requiring minimal equipment. World Scientific Publishing Co. Pvt. Ltd, Singapore,1991)

No of pulsations in 10 secs:_____

Your heart rate: (no of pulsations in 10 seconds X 6) = _____

Time taken to complete 2 kms:_____mins_____secs.

Your physical fitness is given by the following equations:

MEN: 420-(11.6 X min) - (0.20 X sec) - (0.56 X heart rate) + (0.2 X age)
- (2.6 X BMI)

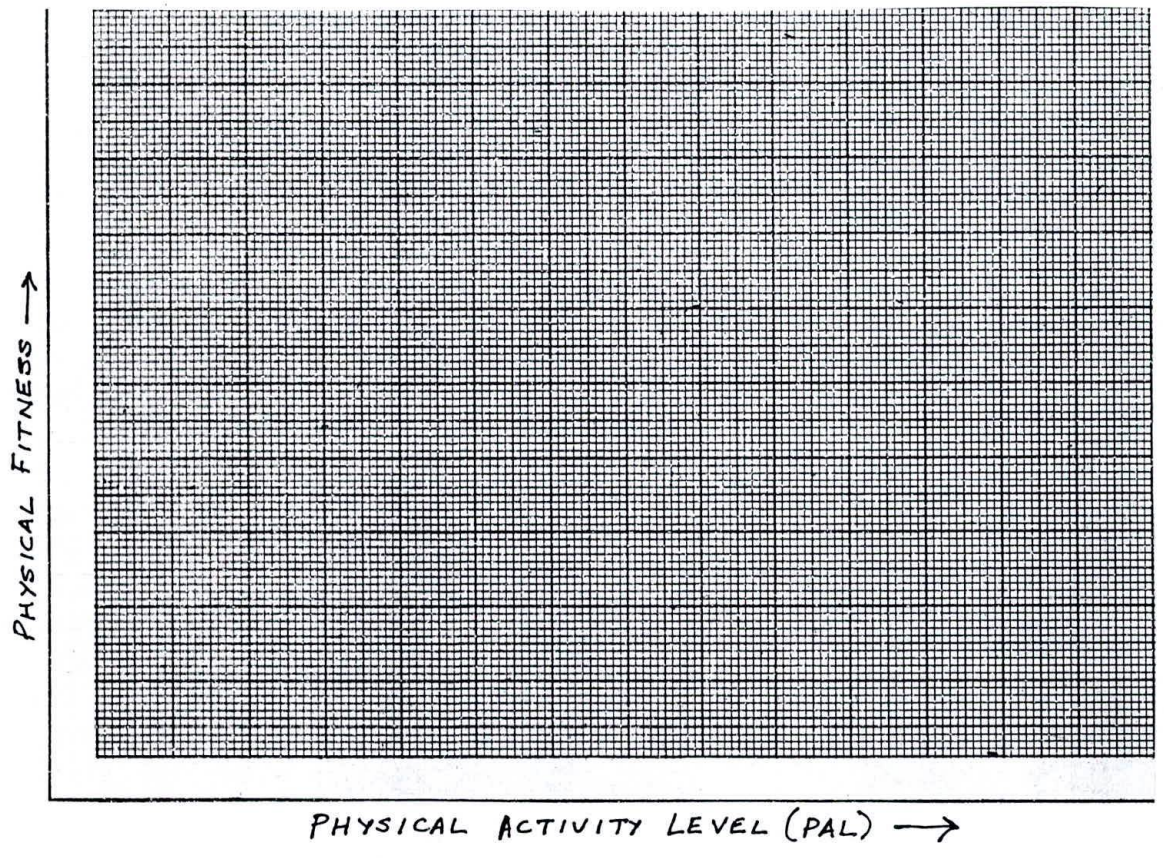
WOMEN: 304 - (8.5 X min) - (0.14 X sec) - (0.32 X heart rate) + (0.4 X age)
- (1.0 X BMI)

Physical fitness index = _____.

In Finland, where the test was developed,
an index between 90 and 110 was considered AVERAGE
greater than 110 was ABOVE AVERAGE
less than 90 was BELOW AVERAGE

How do you compare with the Finns? What problems do you think there are in using the cut-offs that have been described for Finns for Indians?

In the graph below, plot the physical fitness against the PAL's of the members of your batch. Indicate females by ' *' and males by '□'.



Interpret the findings of the graph.

QUESTION FOR INDEPENDENT READING:

What are the ways in which physical activity prevents cardiovascular disease?

THIS PRACTICAL IS NOT FEASIBLE FOR TESTING DURING THE PRACTICAL EXAMINATION.

SESSION 4

Special Senses

The demonstration of primary colors and color mixing in the eye

Aim

To understand color mixing in the eye.

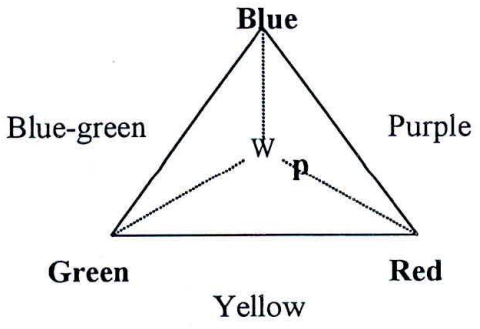
Background

The visual equivalent of a "pure" tone (i.e., a single frequency of sound) is a monochromatic light. The ear is capable of analyzing complex sounds by breaking it down into its component pure tones. Thus, a good musician, when listening to an orchestral chord produced by many instruments, can actually say which instruments are producing which tones (frequencies) in that chord. However, good painters, when shown a color, cannot really say which monochromatic colors (wavelengths) were used in producing that color. This is because, unlike the ear, where there are thousands of receptors, each responding best to a particular frequency, the eye has only 3 classes of color receptors. The relative stimulation of each of these receptors by monochromatic wavelengths of light in a color mixture is what produces the rich world of color around us. If we therefore shine two monochromatic lights on a screen, the result is a new color that bears *no* obvious relationship to its components; for example, red and green produces a yellow color.

It is this fact that permits artists to paint beautifully hued pictures with relatively few colors on their palette. Closer to home, it is this property of light that permits color television to be a reality, since one can design a TV system with three primary colors much more easily than one could design a sound system with all possible frequencies, such as a synthesizer.

There are 3 primary colors: red, green and blue, and the mixture of all these in equal quantities produces white color. There is at least one property of color that is important here: their *chroma* (hue) or actual color. We can make each chroma (from a light bulb, for instance), more or less luminescent, i.e., we can change its intensity. If we take a triangle, with each corner representing a primary color (chroma), the center of this triangle would yield white color (W). The line joining the center of the triangle (W) to each corner represents grades of the primary color. Mixing primary colors yields other colors as shown in the figure below.

The closer one is to the center, the more we say the color is *desaturated*. Thus the point '**p**' in the graph below, represents pink. Although it really is red color mixed with white, it lies on the line represented by red: in other words, pink is a desaturated red.



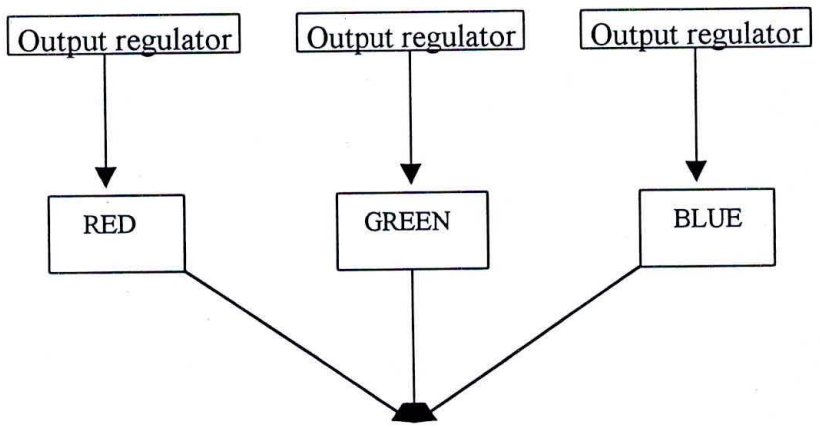
This yields another property of color: the saturation, or the degree that white is mixed in with the color. The sensations of color yielded by the boundaries of this three dimensional world of color (chroma, intensity and saturation) are determined by the purity of the original colors.

You may see this in the difference between a good and a bad quality color TV. If the phosphors (which yield primary color) on the screen of the color TV are relatively desaturated to start with, the size of the triangle shown above will decrease, and therefore, so will the range of colors. It is actually quite difficult to get fully saturated primary colors. In fact flesh tints (emerging from red) and green grass (from green) are usually good, but blue tints tend to be more desaturated, yielding poor purples and blue-greens. If you have enjoyed watching a cricket match on TV, remark on this fact! Indeed in present day TV's (like the Trinitron tube) primary color filters are embedded in the screen, so as to yield more saturated primary colors. The same principle applies to color printers , color photography, and copiers. order to get high quality color printing (for example, in reproductions of paintings), it is necessary to use more than 3 primary colors, such as 6 or more, so as to get as close as possible to fully saturated mixtures.

Experiment

You can mix colors by having a set up which can project the 3 primary colors on a screen. This can be built readily, if you use dimmerstats (potentiometers) that are readily available.

The setup is as follows:



The output regulators can be manipulated to give the desired mix of primary colors. Remember that you are altering the *intensity* of the color when you manipulate the regulator. Using ordinary white light lamps, and interposing red, green or blue filters in front of them can generate the colors as a projection. The filters can be made of colored gelatin paper sandwiched between layers of clear glass (they may melt otherwise). Start by mixing 2 colors at a time, and plot your results on a graph. Repeat this experiment for the other two color combinations. Now do the experiment with all three lights, and record your results in a tabular fashion. *At all times imagine that the screen in front of you is the retina with 3 different types of cones, and that the relative stimulation of different cones gives the actual perception of different colors.*

The mixing of colors in equal proportions to yield white color can also be demonstrated by **Newton's disk**. This is a circle, which is painted into equal areas representing each color of the visual spectrum. Recall that Newton was able to separate ordinary white light into colors by using a prism. He could differentiate 7 colors, and these have been immortalized in the acronym VIBGYOR. When such a painted disk is spun rapidly, the surface appears white due to the color images fusing in the retina.

To make your experiment a little organized, try changing the color in steps of 50%, i.e., from 0% to 100% in 2 steps. You can then create a matrix in the following fashion, and fill it in terms of the colors. You can buy a color chart at any paint store, if you have trouble giving names to the hues that you see. Fill in the names of the colors.

For Green 0 %

Red (%)		0	50	100
Blue (%)	0	_____	_____	_____
	50	_____	_____	_____
	100	_____	_____	_____

For Green 50 %

Red (%)		0	50	100
Blue (%)	0	_____	_____	_____
	50	_____	_____	_____
	100	_____	_____	_____

For Green 100 %

Red (%)		0	50	100
Blue (%)	0	_____	_____	_____
	50	_____	_____	_____
	100	_____	_____	_____

While the scheme of color vision shown above appears quite simple, the reality is a little more complex! There is a great deal of processing of the visual signal within and after the retina. Read Best & Taylor or Samson Wright for a more detailed account of color vision.

Questions

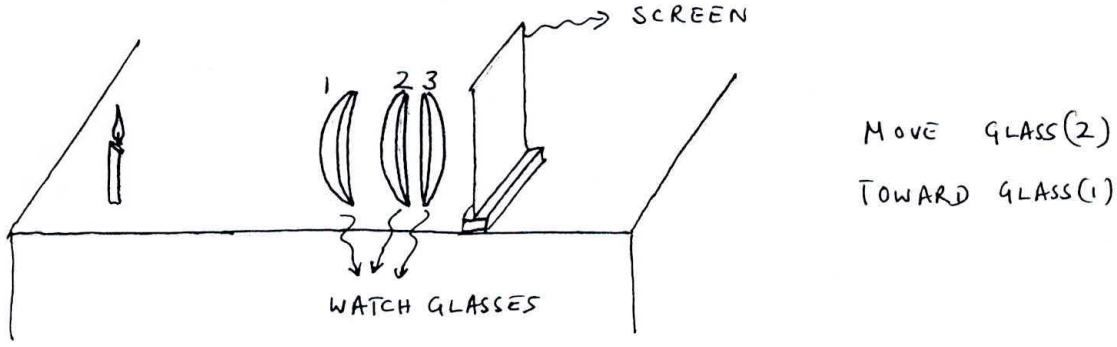
1. Can you think of a more elegant way to display your results with the 3 color mixing experiment? Draw it below.
2. What lamp was used in this experiment? Which color did you think predominated in this lamps' light output?
3. What are the types of color blindness? What color does the absence of all colors yield?
4. What is the color opponens phenomenon?
5. How will a person with only one type of color cone perceive color?
6. What is the Purkinje shift?

The demonstration of Purkinje-Sanson images

Aim:
To observe the changes in the convexity of the curvature of the lens, as it happens during accommodation (Purkinje-Sanson images)

Background
The ability of a person to focus on objects held at varying distances from the eye is due to ***accommodation***. This is due to the ability of the eye to change its dioptric power. However, the dioptric power of the cornea is *invariant*, and this means the other refracting surface in the eye (the lens) must be able to change its dioptric power. The lens is able to change its shape and power, due to *contraction* of the ciliary muscle, which *relaxes* the suspensory ligament of the elastic lens, thereby allowing it to assume a more spherical shape. The question we must ask is, which surface of the lens (anterior or posterior) actually changes its curvature when the eye focuses a near object?
Purkinje and Sanson separately investigated this, in an elegant experiment involving a lighted candle and a subject's eye. Contrary to what you may expect, this is not a painful experiment! The subject relaxes his eye by gazing into the distance, and then gazes at a near object. In both these situations, a lighted candle held to the side of the eye, shows three images (also called Purkinje-Sanson images) reflected in the eye: two upright and one inverted. The brighter upright image is from the anterior surface of the cornea, and the larger image is from the anterior surface of the lens. The inverted image is small and faint, and comes from the posterior surface of the lens. When a near object is gazed at, the upright image from the anterior surface of the lens becomes smaller and brighter, indicating that this surface has bulged forward. The other images do not change.

Experiment
Take three watch glasses, and mount them in a row, with the two anterior watch glasses facing convexity forward, and the posterior watch glass facing concavity forward. Approximate the two posterior watch glasses to from a rudimentary lens shaped structure. Place a candle in front of the watch glasses, in a darkened room, and look at the images. You will see three images as described above. Try moving the second (middle) watch glass toward the candle (anteriorly) and you will see the image becoming brighter.



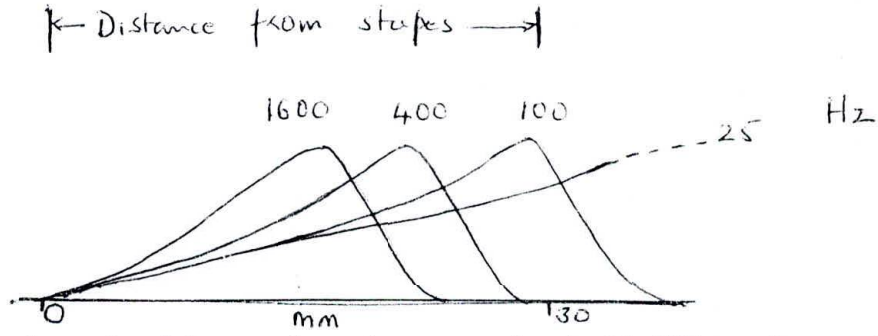
Questions
1. When you moved the watch glass forward did the image become brighter *and* smaller? If not, why?
2. How can you modify this experiment to make it more physiological?
3. What are the components of the accommodation reflex?
4. What is an Argyll-Robertson Pupil?

The demonstration of a model of the travelling wave phenomenon.

Aim:
To generate and observe a traveling wave.

Background:

The mechanism of transduction of sound by the cochlea is by the vibration of the basilar membrane. Different regions of this membrane in the cochlea, are sensitive to different frequencies in a systematic way. Georg von Békésy found (about 40 years ago), that, at any given frequency of sound presented to the cochlea, the amplitude of vibration increased to a maximum and then fell off sharply. The *position* of this maximum vibration was dependent on the frequency: at lower frequencies, it was nearer the helicotrema, and at higher frequencies it was nearer the oval window. The figure below shows this concept.



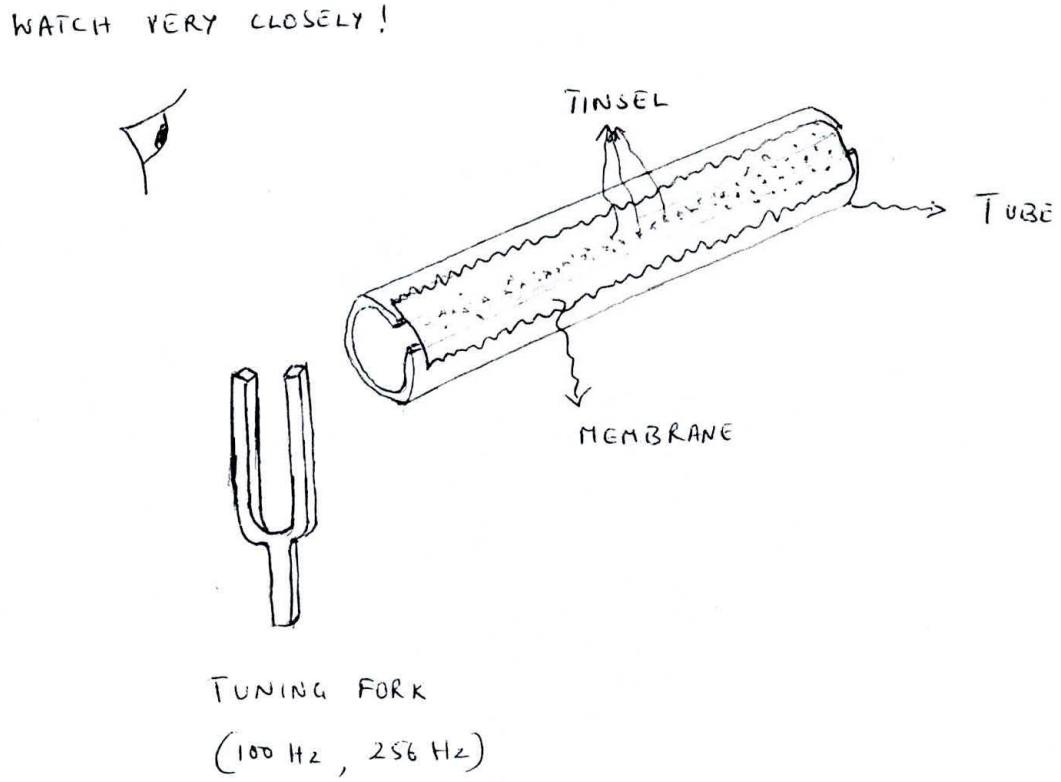
You can see that the peaks of the sound envelopes associated with different frequencies move farther away from the source of the sound, as the frequency decreases. Remember that the cochlea is only some 30-mm in length, and that it has to discriminate frequencies that range from 20 –20000 Hz! In reality, we can only discriminate about 2000 changes in pitch (frequency), and this would mean that the peak vibration for every frequency would shift by only about *0.015 mm*!
After von Békésy, it has now been confirmed that this indeed is the method of transduction in the cochlea, and the traveling wave is, if anything, even more sharply defined that shown in the figure above.

Experiment
Take a tube with a narrow longitudinal strip cut out from it. Let it be open at both ends. Gently stretch a membrane (use a condom, as the slogan says) over the gap left by cutting out the longitudinal strip from the tube, and secure the membrane. This represents the basilar membrane, while the tube represents the scala vestibuli. This design inverts the natural setting, in the sense that the scala tympani is now *under* the basilar membrane, while in the cochlea, it is above the basilar membrane. You must also remember that the basilar membrane is not *tightly* stretched in its physiological setting; therefore do not stretch the membrane too tight. Sprinkle some sparkling tinsel over the membrane, and mount the tube firmly on a stand. Put a vibrating 100 Hz and a 256 Hz tuning fork at the mouth of the tube at one end, but do not touch the tuning fork to the mouth of the tube. Now observe where the tinsel moves the most for each frequency.. You will need to look quite carefully! Since the 256 Hz tuning fork is smaller than the 100 Hz tuning fork, you may need to attach a stiff plastic tag to one of the tines of the 256 Hz tuning fork, to

increase its surface area. As the frequency decreases you will see that the highest amplitude of vibration moves further away from the source (tuning fork). While this is not a physiological design, it serves to illustrate the ability of low frequency waves to move the furthest in a medium.

Questions

1. Can you think of a better design to demonstrate the traveling wave?
2. What is Fourier analysis by the cochlea?
3. Is this principle of the traveling wave similar to *resonation* of the basilar membrane with different frequencies?
4. If your finger blocked the end of the tube opposite to the source of the sound, what would happen to the progressing wave? How is the cochlea designed: is there a block at the end of the scala vestibuli?



Demonstration of Audiometry

Objective:

- To measure air and bone conduction of sound by audiometry
- To perform audiometry and to generate a normalized audiogram.

The Background:

Sound is generated in a medium such as air whenever there is sufficiently rapid movement of a part of its boundary. Then, the moving boundary is compressed or rarefied, leading to propagation away from the site of disturbance. If the disturbance is regular, as in the case with the prongs of a tuning fork, the sound is propagated as waves. Some of the properties of these waves are:

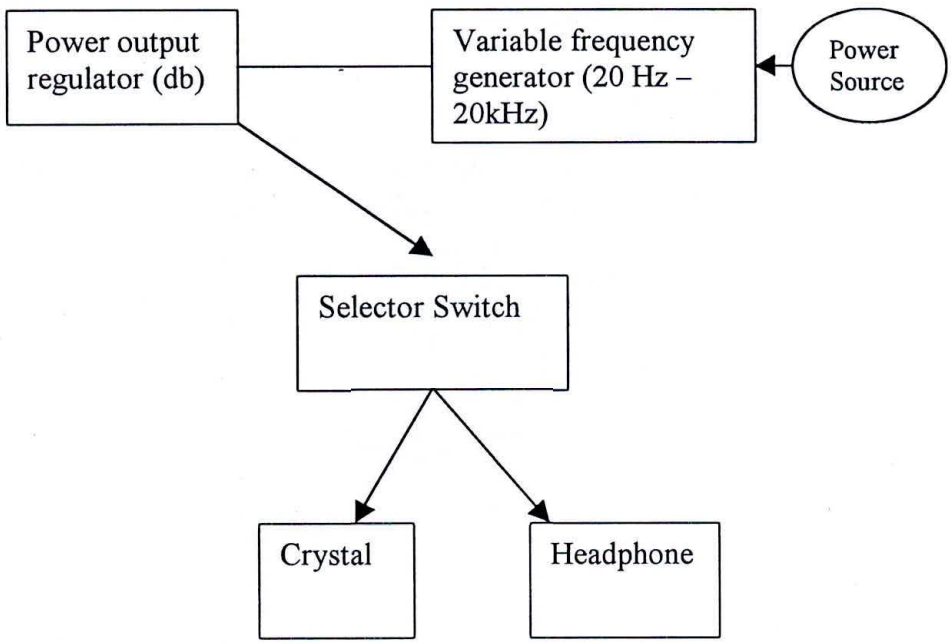
- *Frequency or pitch (Hertz, Hz)*
- *Loudness (Decibel, db)*

Frequency is measured in Hertz (Hz), as number of vibrations/second.
To be audible, the frequency must range between 20 and 20,000 Hz.

Loudness is measured in decibels, where,
decibel (1/10 bel) = 10 $\log_{10}$ Intensity of sound / Intensity of standard sound
The intensity of standard sound is the threshold of hearing in ideal conditions.

Audiometry, and the record thereof, which is called an audiogram, is a key investigation of hearing. In this test, pure tones, of varying frequencies are presented to a subject's cochlea, by air or bone conduction. The loudness is modulated between 0 and 100 decibels, and the subject is asked to indicate the lowest decibel level at which he can hear that particular frequency. The results of several frequencies over the entire hearing range, tested in this way, are then plotted on a graph (see graph 1). The procedure is repeated for bone conduction and air conduction. This is a non-normalized audiogram, which should have a "U" shape, as the best heard frequencies would be in the middle of the range of frequencies.
However, for clinical use, this "U" shaped audiogram is normalized to a straight line.
How is this done?
The "U"shaped audiogram is first plotted for a normal population. Then, for every frequency, there will be a decibel level, at which the population is *just* able to hear the sound. These amplitudes (decibel levels) for every frequency, are used as the starting, or reference point of the normalized test. When the normalized test is done, every frequency of sound is presented to the subject at the decibel level that the population can *just* hear the sound. This level is then represented as "0" on the graph (see Graph 2). Thus, a normal subject would have "0" plotted against every frequency presented to him, since he is similar to the random population, thereby presenting a ***straight line***. This is useful for clinical use, as one does not have to interpret curves, and one has a comparison with normal populations in a single graph. Any fall off below the "0" line, is therefore representative of a hearing loss, which is a rather elegant and simple way of representing a complex phenomenon.

Building a sophisticated audiometer is expensive. But, if you want a simple instrument, you can build one, if you have some electronics background. The general layout of the instrument is:



A detailed circuit diagram is provided as an appendix.

Experiment

1. Define a population audiogram

Randomly select 10 members of your batch. How do you do this?

Random number generation

Random sampling of the population is a preferred method when we need to select a representative group from the batch. In simple random sampling, (in, for example, a batch of 30 students), you could make 30 pieces of paper, each bearing numbers from 1 to 30, and put it in a hat. Then, you could draw out of the hat, 10 pieces of paper, thus obtaining a random selection.

Obviously, if you wanted to do this in a batch of 1000 students, you would spend your entire practical writing numbers on bits of paper! What can you do then?

In large populations, you could make use of *tables of random sampling numbers*. These give the results of very extensive random selections made in the past by various reliable methods. These tables can be found in statistics book, and are easy to use. You could also use your calculator, if it has a random number function, to generate a set of random numbers.

Now perform the audiometry test on the selected subjects, as shown below.

Air conduction: Test each ear separately. The ear to be tested can be selected on the instrument. Explain to each subject, that he will hear through a headphone, a set of sounds. He must indicate, with his hand, when he hears each sound. Now, the experimenter must face the subject, and select each of 20 preset frequencies on the instrument. One at a time, these frequencies are played into the headphone, for a short duration, and the volume (loudness) is increased in steps of 20 decibels. When the subject indicates that he has heard the sound, the experimenter notes the decibel level for that frequency and repeats the process for the next frequency. *Obviously, you will need a silent atmosphere for this test!* Try and use a quiet room.

Bone conduction: Place a device that can generate vibrations, on the mastoid process. This device is a piezo-electric crystal, which has the property of vibrating at set frequencies by the application of a variable frequency current, and typically is made of quartz or Rochelle salt. Tape the crystal firmly in place. Repeat the experiment above in exactly the same manner.

Now, calculate the mean value (for all subjects) of the lowest decibel level that each frequency was heard at. Plot this curve. Assess the curve, and if it is not "U" shaped, look at your data again for any possible outlying data points. This curve will now serve as the basis for your "normalized audiogram".

2. Plot a normalized audiogram

Take a member of your batch, who was not in the random list selected above. Now perform audiometry on him as detailed above. However, the *starting* decibel level for each frequency, will be the *mean value for the lowest decibel level that frequency was heard at for the randomly selected group*. If the subject hears the frequency at this decibel level, then plot his value for this frequency at the "0" point on the normalized audiogram. If he can only hear the sound at a higher decibel level, say, 20 decibels higher, then this frequency is plotted at "-20" on the normalized audiogram. This procedure is repeated for each frequency, and for bone and air conduction.

3. Induce an abnormality

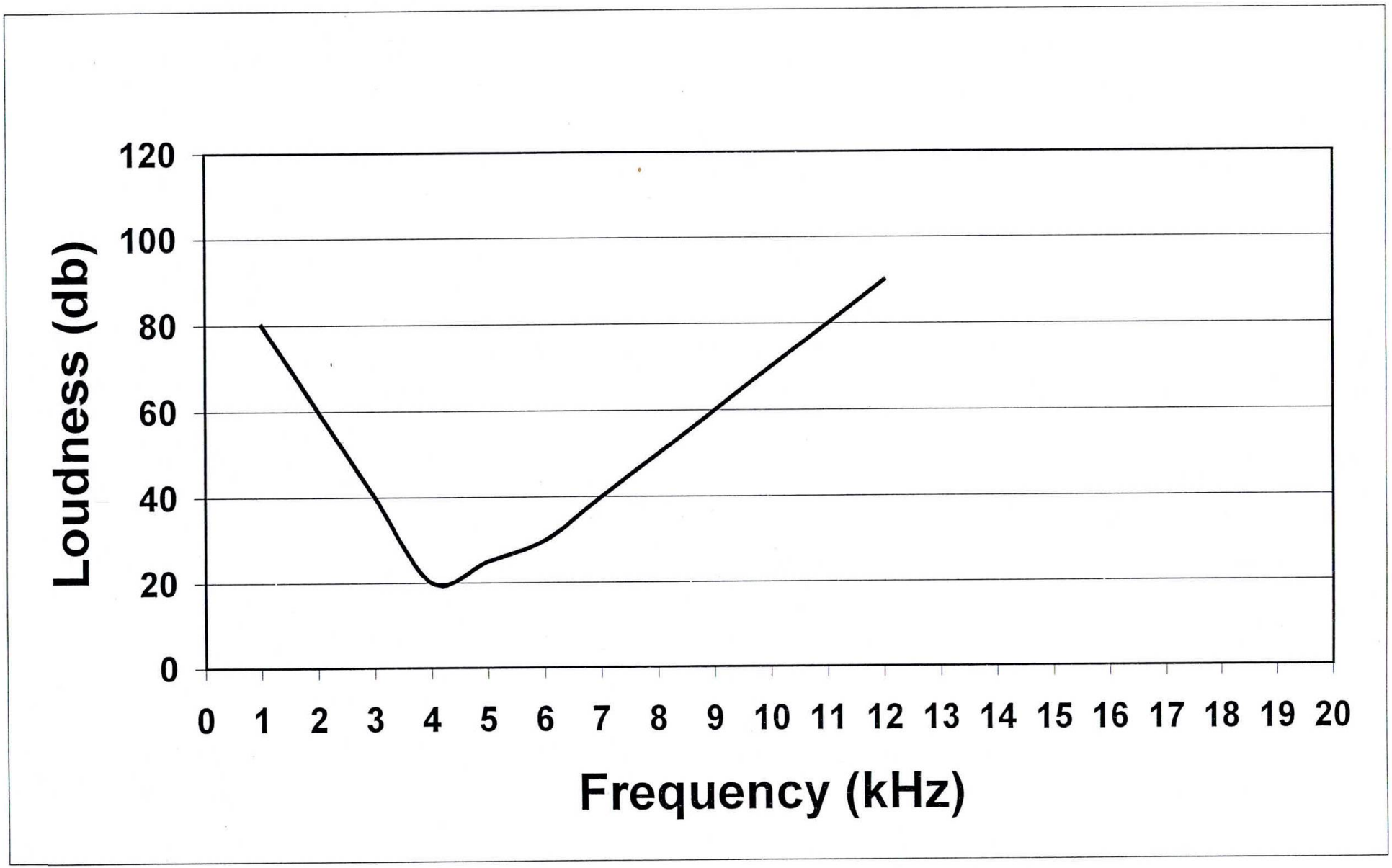
You can induce abnormalities in a variety of ways. One easy way is to take a person whose normal audiogram you already have and then, block his ear with cotton and repeat the test. What do you observe?

Questions

1. What is the normal decibel range of hearing? Why is it a log scale?
2. What was the effect of ambient noise (masking) on the experiment?
3. At what frequencies are sounds best heard by the human ear?
4. Does this experiment indicate what a Rinné or Weber test would have shown? Does it provide more information than these tests? What did you find?
5. What is the piezo-electric effect? If you made a quartz crystal vibrate mechanically, could you induce a current from it? What is the cochlear microphonic?
6. What would you describe as the "ideal" conditions for this test?
7. Draw a line on the normalized graph to show the effects of aging on cochlear function.
8. What is speech audiometry?

Audiometry chart

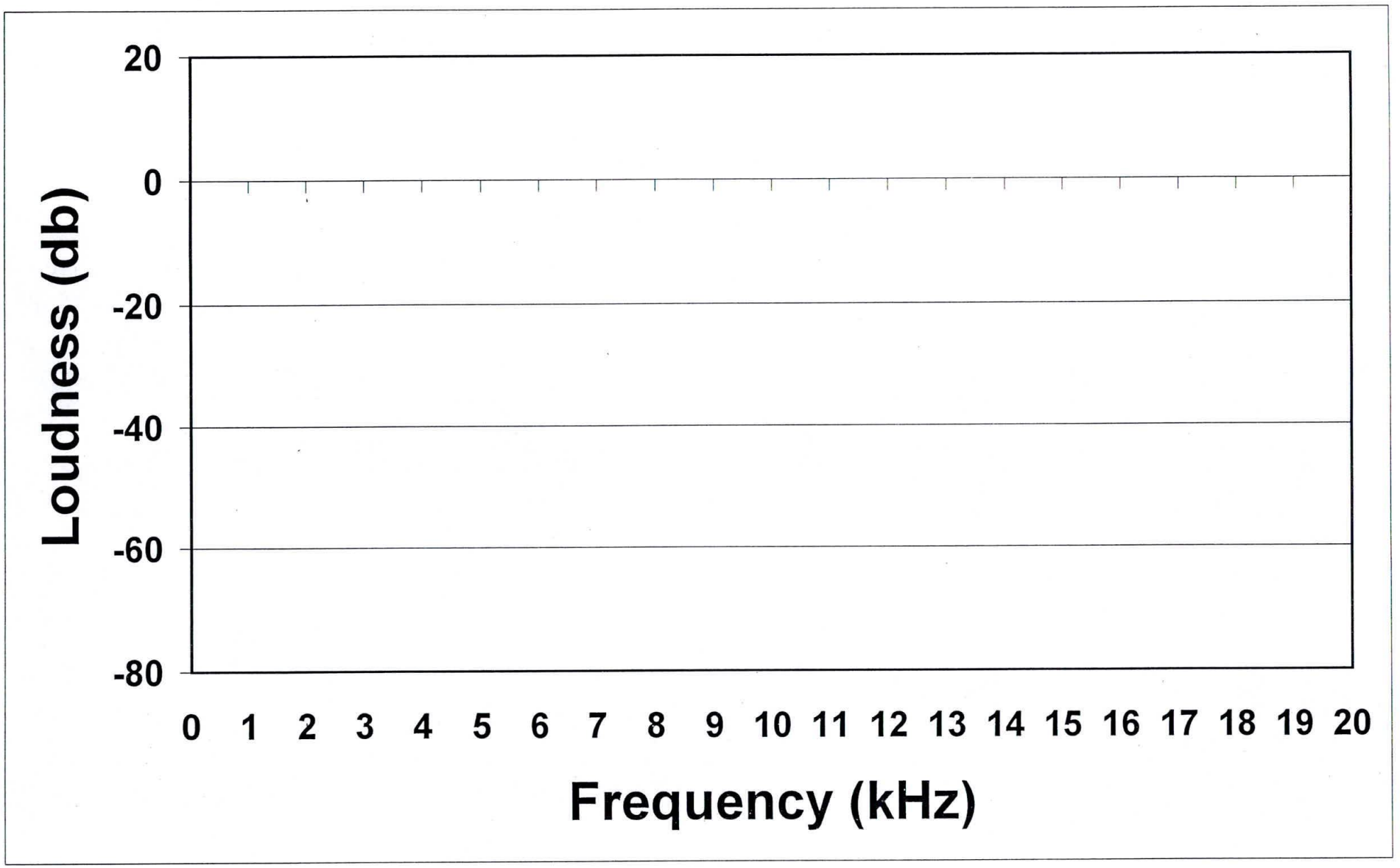
x = air conduction o = bone conduction



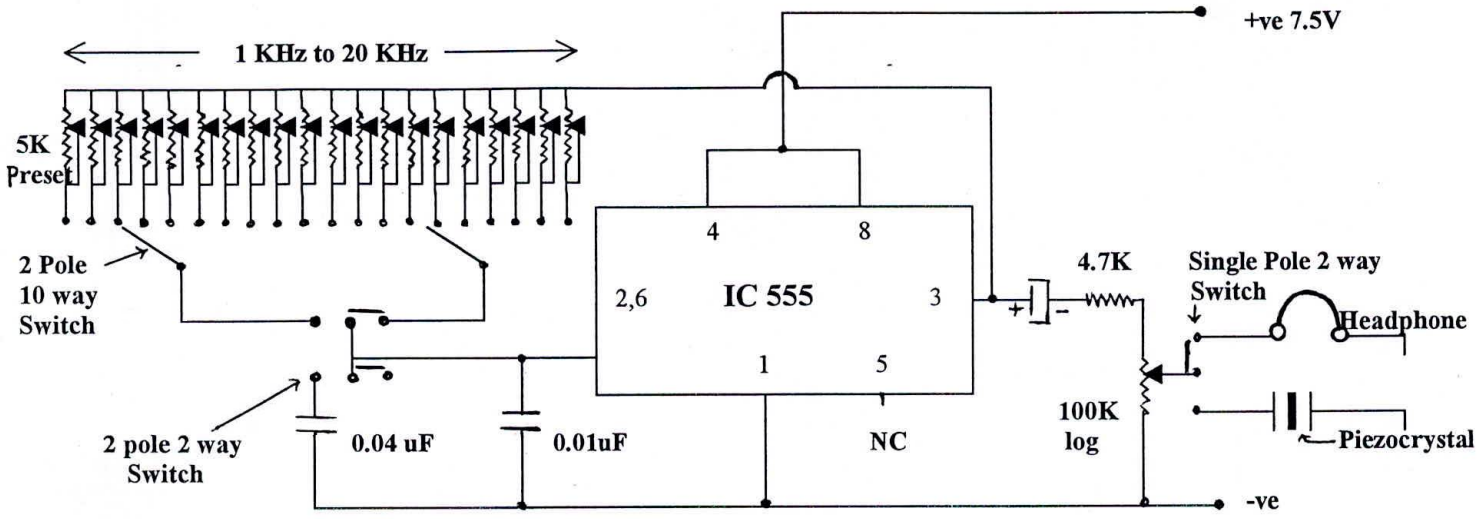
Line represents a normal "U" shaped pattern

NORMALISED AUDIOMETRY CHART

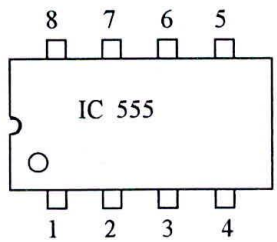
o = air conduction x = bone conduction



Circuit diagram of the electronic oscillator



IC 555 TOP VIEW



The demonstration of nystagmus using a modified Bárány chair

Aim

To observe side to side nystagmus in a human subject.

Background

The vestibular apparatus forms part of the inner *labyrinth* of the ear. This complex structure evolves, along with the cochlea, from the lateral line organ in fishes. The vestibular apparatus detects movements of the head, and the cochlea detects movements of surrounding air (in the form of sound waves). We are concerned here with the vestibular apparatus. There are two parts to the vestibular apparatus: the semicircular canals, and the otolith organs (utricle and saccule). The otolith organs are concerned with linear acceleration, and are not concerned with this practical.

There are three semicircular canals on each side arranged in more or less mutually perpendicular planes: superior, horizontal and posterior. The semicircular canals are filled with endolymph which by virtue of its inertia, moves in the *opposite* direction to the rotation of the canal when the head is rotated. The endolymph movements in turn cause movement of hairs borne by sensory hair cells within the canal, thereby transducing the movement into electric potentials. For a more detailed account, read Samson Wright's Applied Physiology, 13th Edition.

When an upright person is rotated fairly rapidly on a vertical axis, and the rotation suddenly stopped, his eyes show nystagmus. This is a lateral movement of the eye, with a slow component to one side, and a jerky, fast component to the other side. The slow component is seen in the *opposite* direction to the rotation, while the fast component is seen to the *same* side as the rotation. The nomenclature for the type of nystagmus is with reference to the *fast* side: thus a person with a fast component to the *right* side has a *right nystagmus*.

Why does this happen? It is an attempt by the subject to keep objects fixed within his gaze. If you imagine that the person is trying to fixate objects as he rotates, then his eyes would be drawn to the opposite side that he is rotating, until, when the object moves out of his visual field, he quickly "corrects" his gaze to catch up with the rotation.

Bárány experimented on this by using a rotating chair (Bárány's chair, see experiment below), or by irrigating the ear with warm and cold saline (Bárány's caloric test). The latter experiment is useful when assessing the vestibular function of patients who are lying down. If the head is thrown back to look upward by about 60° from the horizontal plane, and also looks to one side at about 50° from the center, then the lateral (horizontal) canal of the other side is placed in a vertical fashion. If the external ear is now irrigated slowly with about 50 ml of cold saline, this causes the endolymph in the canal to get denser and move downward. This gives the effect of the head being moved to the opposite side. If the right ear is irrigated, a left-sided nystagmus is seen. Remember, it is the horizontal canal that is being affected, by placing it in an artificial vertical plane: the net effect is that the brain is 'fooled' into thinking the head is moving horizontally. If the patient can stand, he would fall to his right, as if countering the movement to the left. The opposite happens when warm saline is used. You can remember the "side" of the nystagmus, i.e., the direction of the fast movement, by the acronym COWS: Cold – Opposite; Warm – Same.

Do not to do this without supervision, as this test is extremely unpleasant in a conscious individual, nausea and vomiting can occur, and worse, there may even be vagal stimulation leading to heart stoppage!

Experiment

Take a rotating chair, which you will find at any computer table, or in your Professor's office! Make sure that the chair is locked into a non-tilting position. Place a subject in the chair, put his feet out of the way, and then rotate the chair fairly quickly, making sure that the wheels of the chair are also locked. You will require two people to do this. Stop the chair suddenly, and observe the eyes. If the subject was being rotated to the left, you will see a left-sided nystagmus (fast movement to the left). Since nausea can occur, you should select a subject who enjoys merry-go-rounds. You could also make the subject stand up after stopping the rotation, and observe to which side he leans, or falls toward. Sometimes, subjects can resist the effect of being rotated, by fixating on objects in the visual field, as they are being rotated. Ice skaters who rotate rapidly as part of their routines do this, and although you are unlikely to find accomplished ice skaters this close to the equator, you may still see them in a circus. You can still prevent your subject from the fixation of objects by his eye, by making the subject wear glasses with very convex lenses, which you can easily make, using magnifying glasses. Since the subject cannot focus any object when wearing these "soda bottle" lenses, a more pronounced nystagmus will result. Additionally, the lenses magnify the subject's eye when the observer looks at the subject, making the nystagmus is even more clearly visible.

Children also use this phenomenon at play. You will see them bending over, putting their foreheads on a small pole stuck in the ground, and rapidly moving around the pole, all the while keeping their foreheads in place on the pole. After a few rotations, the child attempts to walk, and will stagger and fall away to the opposite side of the rotation, much to the merriment of their friends who have stood still at this time! If you could observe their eyes at this time (difficult on a staggering child), you would also see a same-sided nystagmus.

Try to keep the subject spinning for about 20 seconds or more (if he can tolerate it). If you can talk to him while he is spinning, ask him whether he has a sense of still being rotated, or does he now feel that he has stopped rotating, and that the universe is actually moving around him?

Questions

1. What are the different types of nystagmus?
2. In which type of patient (what area lesion) would you like to do the caloric test?
3. Can the hairs on the hair cells of the semicircular canals be affected by gravity? If not, why?
4. How is a labyrinthectomy done (destroying the vestibular apparatus) in small animals?
5. Can the semicircular canals adapt to continued rotation?

SESSION 5

Miscellaneous Experiments

ASSESSMENT OF RENAL FUNCTIONS

Introduction: Kidney has a number of functions to perform. They are:

- Regulation of fluid balance.
- Regulation of the ionic concentration of the extra cellular compartments
- Excretion of waste metabolites and
- A number of important endocrine functions.

Among these the role of kidney in the regulation of fluid and electrolyte balance can be assessed.

The excretion of water and dissolved electrolytes in urine is one of the mechanisms regulating the volume and ionic constitution of the extracellular fluid. The mammalian kidney possesses the ability to dissociate the excretion of water from the excretion of solute by varying urinary solute concentration (osmolality). This dissociation of water and solute excretion is made feasible by two features:

A) The unique anatomic and functional characteristics of the nephron parts which are responsible for urinary dilution and concentration and
B) The anatomic and functional integrity of the regulatory mechanism for urinary concentration (vasopressin release).

The ability of the kidneys to maintain both tonicity and water balance of the ECF requires that the tubules be functional and responsive to vasopressin (ADH). These specific functions can be evaluated by measuring the solute concentrations of the urine either randomly or under well-controlled conditions. Additional important information concerning renal function, pathology and etiology behind dehydration and electrolyte perturbations can be obtained when urinary and serum measurements are compared. Solute concentrations of the fluid can be quantitated in the lab by measuring either ***specific gravity or osmolality.***

Specific gravity: is a ratio of the mass of a solution compared with the mass of an equal volume of water. It is not an exact measurement of the number of solute particles.

Osmolality: It is a measure of the number of dissolved solute particles in solution.

There is a good correlation between specific gravity and osmolality under most circumstances. The specific gravity of plasma is fairly constant and ranges from 1010 to 1012. ***Urine specific gravity varies from 1003 to 1035*** reflecting either dilution or concentration of the glomerular filtrate.

Fluid and electrolyte balance: The excretion of water and dissolved electrolytes in urine is one of the mechanisms regulating the volume and ionic constitution of the ECF. Such control is important since it determines both the circulating plasma volume and the concentrations of a variety of functionally important ions eg. Na^+,K^+, H^+, HCO_3^- Also the interstitial osmolality regulates the osmotic movement of water across the plasma

membrane, any abnormality in this variable will lead to a redistribution of fluid between the intracellular and extracellular spaces.

For Ex: Loss of water from extracellular compartment will tend to increase extracellular osmolarity favouring osmotic reduction in cell volume. This will in turn change intracellular conditions and may interfere with normal cell function. Cerebral neurones are particularly sensitive to osmotic changes. It is desirable therefore to maintain a steady state in which the intake of fluid and electrolytes each day exactly balances the loses.

The term **fluid balance** refers to the relationship between fluid intake and output from the body. Excessive intake or decreased loss represents a **positive fluid balance**. While excess loss or a decreased intake is a **negative fluid balance** . Total fluid output can vary widely from a minimum of about 1L /24 hr upto a value of 7L /24 hr. Urine excretion normally amounts to 1-1.5L /24 hr but this rises when there is heavy fluid load or fall if water intake are limited. The other routes by which fluid loss occur in a normal person is insensible fluid loss.

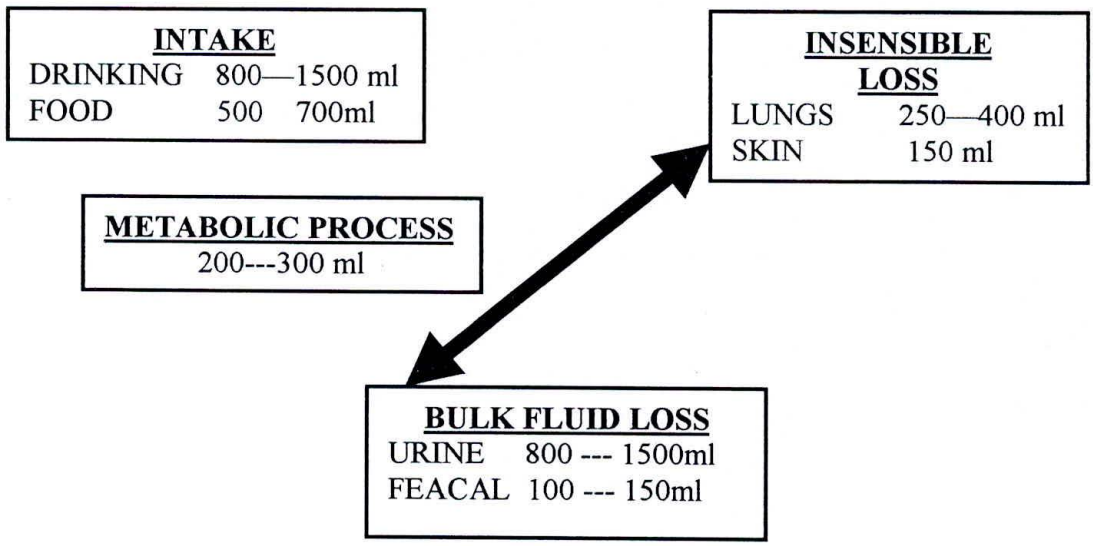
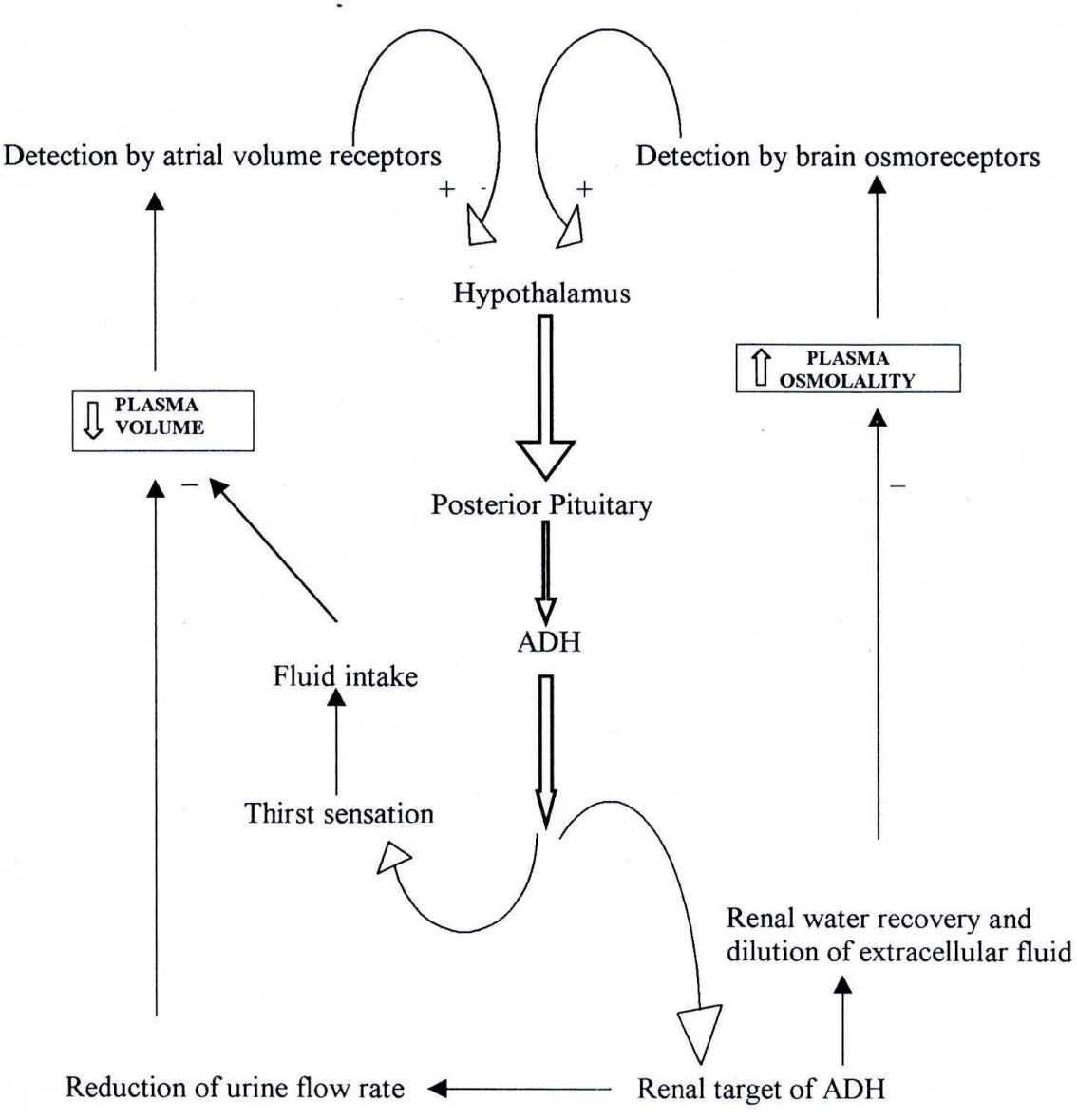


Diagram showing the routes by which water is gained or lost from the body

REGULATION OF FLUID BALANCE: Any mismatch between fluid intake and output will lead to fluid accumalation or depletion with in the body. This alters the extracellular fluid volume and may change its osmolality and it is these effects which are detected by receptors leading to compensatory changes in fluid intake and loss.



Flow chart dipicting the response of ADH to plasma volume and plasma osmolarity

Therefore to urine output: When water is drunk it is rapidly absorbed from intestine the resulting dilution of blood is sensed by the osmoreceptors and commands sent to reduce the ADH release from the posterior pituitary. The kidneys respond to the lower level of hormone by increasing the rate of production of urine. This has low specific gravity.

KEY POINTS TO REMEMBER:

- Na, Cl, urea are main **osmotically active** constituents in urine.
- ~ 0.5 mosmol/min of above **solutes are excreted** in urine on an average diet ~700 mosmol/day.
- **Osmolarity of urine** varies between 50-1400 mosmls/L (Sp.Gr. 1001-1030)
- **Volume of urine** varies between 0.5-15 ml/min.
- **Diluted urine** urinary osmolarity < plasma osmolarity.
- **Concentrated urine** urinary osmolarity > plasma osmolarity.

Total solutes appearing in urine/min is relatively steady and urine becomes concentrated or diluted by reabsorption or secretion of water free of solute which is a **function of ADH.**

References:

Texts

Human Physiology , Foundation and frontiers International edn. Charles Schauf, David Moffett, Stacia Moffett. Pg506-514 ,1990.

Renal and body fluids, Ross. W. Hawker, Churchill Livingstone

Text Book of Nephrology, Anil K Mandal.

Body fluid and Kidney Physiology, Hladky S.B and Rink T.J 1986

Practical:

Practical clinical Biochemistry, Varly

Practical experiments in Physiology requiring minimal equipment IUPS source book.

STUDENT PRACTICAL EXERCISE:

AIM:

To measure the rate of urine secretion.

To measure the volume and specific gravity of urine after

a) water load
b) saline load.

in order to assess the renal function in terms of

1) water balance
2) urine dilution respectively.

- MATERIALS REQUIRED FOR THE PRACTICALS
- Urinometer for measuring the specific gravity of urine.
- Measuring cylinders of 500 ml capacity and 50 ml capacity to collect sample of urine.
- Thermometer to record room temperature.

PRINCIPLE:

1 That water distributes rapidly to equalize osmotic pressure through all the compartments.

2 That sodium salts are confined to the extracellular compartments by virtue of the low sodium permeability of the cell membranes and the presence of sodium pumps. Both water and salt, of course, readily equilibrate between the plasma and interstitial fluids.

METHODS

EXPERIMENTAL PROTOCOL

- To be performed at the same time of the day.
- Following a standard meal.
- Only one cup of water (200 ml) to be drunk during the meal.

Total duration of the experiment 3hrs

To assess water balance:

Experiment protocol: 3subjects

1.Control

2. Experiment I--- water load 15 ml/kg bw

3. Experiment II--- saline load 15 ml /kg bw

AFTER FOLLOWING THE PROTOCOL THE STUDENTS COME TO THE PRACTICAL HALL.

Subject I –Control: Empties the bladder.
Urine discarded.
1hr later bladder emptied.
Urine sample preserved.
Measure : volume
Specific gravity

RATE OF URINE SECRETION ESTABLISHED.

Subject II – expt. gp: Empties bladder
Urine discarded.
Water load given (15 ml /kg bw)
Bladder emptied every 30 mts.
Urine sample preserved.
Measure: Volume
Specific gravity of every 30 mt. Sample.

Subject III- expt.gp: Empties bladder
Urine discarded.
Saline load (0.9%) given (15 ml /kg bw)
Bladder emptied every 30 mts
Urine sample preserved
Measure : Volume
Specific gravity of every 30 mt sample

NOTE HOW LONG IT TAKES TO EXCRETE THE QUANTITY THAT WAS GIVEN

THAT IS ,TIME TO RESTORE FLUID BALANCE
URINE DILUTION

Specific gravity of urine:

Measurement of specific gravity using urinometer:

Description: In the simplest method urinometer is used. Weighted with mercury , this floats in the urine so that the calibration which corresponds to the surface level of the urine is read. The lower the specific gravity the further the urinometer sinks. Since the instrument is usually calibrated at 15°c., it is necessary to correct for temperature. This is done by adding 0.001 for every 3°c. above 15°c. and subtracting 0.001for under 15°c. Make sure that the urinometer clears the sides of the vessel. It is advisable to check the zero of the instrument and to compare a few results with those obtained by weighing.

RESULTS:

Urine sample (S)	Subject-I Control Name: Age: Wt.: Fluid intake: nil		Subject-II expt gp Name: Age: Wt.: Fluid intake: water		Subject-III expt gp Name: Age: Wt.: Fluid intake: Saline		
	Volume	Sp. Gr	Volume	Sp Gr	Volume	Sp.Gr	
1/2hr S—1							
1hr S—2							
11/2hr S—3							
2hr S—4							
21/2 hr S—5							
3hr S—6							

Interpret the data.

QUESTIONS:

Explain the effect that each of the following will have on the quantity and composition of urine.

1. Drinking a large amount of water.
2. Eating a very salty meal.
3. A hot dry day
4. High arterial pressure
5. Low arterial pressure
6. Sleep
7. Prolonged muscular exercise
8. Removal of pancreas
9. Destruction of the posterior lobe of the pituitary.

What two types of sensory inputs are integrated to regulate ADH secretion? Which of the two inputs dominates?

APPETITE & SATIETY TESTING USING VISUAL ANALOGUE SCALES

Learning Objectives:
Using Visual Analog scales to test satiety by
1. Volume loading in the Gastrointestinal tract.

Introduction:

Satiety is defined as the discontinuation of intake. This occurs long before the peak of metabolic consequences of food digestion or absorption. It appears that the upper end of the gastrointestinal tract must derive this information from the act of eating and the meal itself.

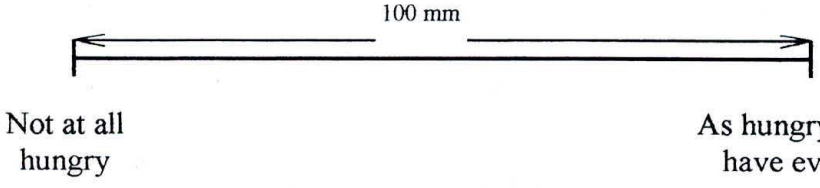
The factors in the gastrointestinal tract that may be responsible for satiety are
1) oropharyngeal factors
2) the volume of the meal itself, and
3) physicochemical composition of the meal including its osmotic character.

Studies done in animals, using sham-feeding and intragastric feeding, by (1,2), have suggested that stimulation of oropharyngeal receptors contributes some satiety value, but is of a limited nature.

On the other hand, studies done in intact animals fitted with gastric fistulas (1), showed that the volume of the meal introduced directly into the stomach caused the inhibition of oral food intake. Similarly noncaloric bulk like water, had essentially similar results. Towbin (3) in 1944, described the role of gastric distention as a factor in the satiation of thirst in dogs and Paintal (4) in 1954, described the gastric stretch receptors and their role in the peripheral mechanism of satiation of hunger and thirst. Studies by Sharma et al. (5,6) indicate that gastric distention also leads to an increase in electrically recorded activity of the satiety center, without alterations in the feeding center or other hypothalamic areas. These results of various studies led to the conclusion that gastric distention acts as a major signal for cessation of feeding.

Visual analogue scales have for many years enabled subjective, quantitative assessments of matters of human concern, which can not be easily and objectively measured like appetite, pain, quality of life etc. Typically, these scales are 100mm horizontal lines, which represent the continuum of the subjective feeling to be rated. The lines are anchored at the two ends with the extremes of the subjective feeling to be qualified. The subject marks a line through the scale at a point between the two extremes of the symptom being rated which they consider to indicate the degree of the subjective feeling being rated. The other types of visual analogue scales that are used are 1) transparent plastic scales with the markings masked and 2) hand held computers.

Example:



In this experiment, the students will be divided into two groups, group 1 and group 2. The subjects of group 1 will receive 200ml of water at each time point and the subjects of group 2 will receive 400ml of water at each time point. Simultaneously, they will be assessed for satiety using visual analogue scales and the results obtained will be compared between the two groups.

Materials required:

1. Potable water
2. Measuring tumbler
3. Timer / Stopwatch
4. Questionnaires containing 4 visual analog scales
5. Standard ruler
6. Printed visual analogue scales

Prerequisite conditions :

1. The subjects have to be fasted overnight (ideally) or should have had his/her last meal atleast 4 hours prior to the experiment.
2. The subjects should have evacuated their bowel & bladder before the experiment.
3. The experiment has to be done in a quiet room with no visual, olfactory or other cues of food.

Procedure:

The questionnaires used in this experiment consists of four visual analogue scales to rate 'hunger', 'fullness', 'urge to eat', and 'preoccupation with thoughts of food'. (7)

- The subjects are divided into two groups, group 1 & group 2. Ideally, group 1 subjects should repeat the experiment as group 2 another day, to enable comparison of results.
- Before the start of the experiment (-5 minutes), each subject is asked to complete a set of questionnaires, each containing the four Visual analogue scales.
- At zero time, each subject in the group 1 is given 200 ml of water to drink and this is repeated every 5 minutes for the next 30 minutes or until the subject can't drink.
- The subjects in group 2 are given 400 ml of water to drink and this is repeated every 5 minutes for the next 30 minutes or until the subjects can't drink.
- The subjects in each group are asked to complete the questionnaires with the Visual analogue scales immediately after each drink.
- At the end of 30 minutes or when a subject reaches his/her limit, they are asked to complete the last questionnaire

Data collection & processing:

All visual analogue scales are to be measured by hand, using a standard ruler, from left (minimum score of 0 mm) to right (maximum score of 100mm) and tabulated as shown below. Subjects from each group should separately tabulate their results obtained from their visual analogue scales.

	Hunger	Fullness of stomach	Thoughts of food	Urge to eat
Basal (-5 min)				
0 min				
5 min				
10 min				
15 min				
20 min				
25 min				
30 min				

Questions:

1. Calculate the mean values at each time point for each group (group 1 & group 2) for the four visual analogue scales.
2. Plot a graph of the mean values of each visual analogue scale and compare the results of group 1 with group 2.
3. Similarly, calculate the means at each time point for males & females in each group for the four visual analogue scales and compare the results.
4. Discuss the factors that regulate the intake of food.

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1. Janowitz, H.D., and M.I. Grossman. Some factors affecting the food intake of normal dogs and dogs with esophagotomy & gastric fistula. Am. J. Physiol. 159:143-148, 1949.

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4. Paintal, A. S. A study of gastric stretch receptors. Their role in the peripheral mechanism of satiation of hunger and thirst. J. Physiol., London 126 :255-270, 1954.

5. Sharma, K. N. Receptor mechanisms in the alimentary tract: their excitation and functions. Handbook of Physiology, Vol 1, Section 6, 225-237, 1967.

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7. Stratton et al. Comparison of the traditional paper visual analogue scale questionnaire with an Apple Newton electronic appetite rating system(EARS) in free living subjects feeding ad libitum. EJCN , 52, 737-741, 1998

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ASSESSMENT SHEETS

SESSION 1

The experiment.....	**Two-point discrimination**	**Properties of thermal receptors**	**Visual reaction Time**
has important learning outcomes	1 2 3 4 5 (circle, key below)	1 2 3 4 5	1 2 3 4 5
tests important 'practical' skills	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
tests 'analytical' skills	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
is easy to conduct for the number of students you have	1 2 3 4 5 **1 = strongly agree 5 = strongly disagree**	1 2 3 4 5	1 2 3 4 5
Involves minimal expenditure	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
can be easily implemented in your college	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
is an important supplement to the Physiology course	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
can be tested effectively at the practical examination	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
What constraints will you face in implementing this expt. in your college?			
Other comments			

The experiment.....	**Tests of memory**
has important learning outcomes	1 2 3 4 5 (circle, key below)
tests important 'practical' skills	1 2 3 4 5
tests 'analytical' skills	1 2 3 4 5
is easy to conduct for the number of students you have	1 2 3 4 5 **1 = strongly agree 5 = strongly disagree**
Involves minimal expenditure	1 2 3 4 5
can be easily implemented in your college	1 2 3 4 5
is an important supplement to the Physiology course	1 2 3 4 5
can be tested effectively at the practical examination	1 2 3 4 5
What constraints will you face in implementing this expt. in your college?	
Other comments	

SESSION 2

The experiment.....	**Breath Holding Time**	**Max. Expiratory Pressures**
has important learning outcomes	1 2 3 4 5 (circle, key below)	1 2 3 4 5
tests important 'practical' skills	1 2 3 4 5	1 2 3 4 5
tests 'analytical' skills	1 2 3 4 5	1 2 3 4 5
is easy to conduct for the number of students you have	1 2 3 4 5 **1 = strongly agree 5 = strongly disagree**	1 2 3 4 5
Involves minimal expenditure	1 2 3 4 5	1 2 3 4 5
can be easily implemented in your college	1 2 3 4 5	1 2 3 4 5
is an important supplement to the Physiology course	1 2 3 4 5	1 2 3 4 5
can be tested effectively at the practical examination	1 2 3 4 5	1 2 3 4 5
What constraints will you face in implementing this expt. in your college?		
Other comments		

The experiment.....	**Sympathetic Nervous Activity**	**Parasympathetic Nervous Activity**
has important learning outcomes	1 2 3 4 5 (circle, key below)	1 2 3 4 5
tests important 'practical' skills	1 2 3 4 5	1 2 3 4 5
tests 'analytical' skills	1 2 3 4 5	1 2 3 4 5
is easy to conduct for the number of students you have	1 2 3 4 5 **1 = strongly agree 5 = strongly disagree**	1 2 3 4 5
Involves minimal expenditure	1 2 3 4 5	1 2 3 4 5
can be easily implemented in your college	1 2 3 4 5	1 2 3 4 5
is an important supplement to the Physiology course	1 2 3 4 5	1 2 3 4 5
can be tested effectively at the practical examination	1 2 3 4 5	1 2 3 4 5
What constraints will you face in implementing this expt. in your college?		
Other comments		

SESSION 3

The experiment.....	**Anthropometric assessment**	**Muscle Strength**
has important learning outcomes	1 2 3 4 5 (circle, key below)	1 2 3 4 5
tests important 'practical' skills	1 2 3 4 5	1 2 3 4 5
tests 'analytical' skills	1 2 3 4 5	1 2 3 4 5
is easy to conduct for the number of students you have	1 2 3 4 5 **1 = strongly agree 5 = strongly disagree**	1 2 3 4 5
Involves minimal expenditure	1 2 3 4 5	1 2 3 4 5
can be easily implemented in your college	1 2 3 4 5	1 2 3 4 5
is an important supplement to the Physiology course	1 2 3 4 5	1 2 3 4 5
can be tested effectively at the practical examination	1 2 3 4 5	1 2 3 4 5
What constraints will you face in implementing this expt. in your college?		
Other comments		

The experiment.....	**Physical Activity Patterns**	**Physical Fitness**
has important learning outcomes	1 2 3 4 5 (circle, key below)	1 2 3 4 5
tests important 'practical' skills	1 2 3 4 5	1 2 3 4 5
tests 'analytical' skills	1 2 3 4 5	1 2 3 4 5
is easy to conduct for the number of students you have	1 2 3 4 5 **1 = strongly agree 5 = strongly disagree**	1 2 3 4 5
Involves minimal expenditure	1 2 3 4 5	1 2 3 4 5
can be easily implemented in your college	1 2 3 4 5	1 2 3 4 5
is an important supplement to the Physiology course	1 2 3 4 5	1 2 3 4 5
can be tested effectively at the practical examination	1 2 3 4 5	1 2 3 4 5
What constraints will you face in implementing this expt. in your college?		
Other comments		

SESSION 4

The experiment.....	**Primary Colours/ Colour Mixing**	**Purkinje Sanson Images**	**Demonstration: Travelling Wave**
has important learning outcomes	1 2 3 4 5 (circle, key below)	1 2 3 4 5	1 2 3 4 5
tests important 'practical' skills	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
tests 'analytical' skills	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
is easy to conduct for the number of students you have	1 2 3 4 5 **1 = strongly agree 5 = strongly disagree**	1 2 3 4 5	1 2 3 4 5
Involves minimal expenditure	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
can be easily implemented in your college	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
is an important supplement to the Physiology course	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
can be tested effectively at the practical examination	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
What constraints will you face in implementing this expt. in your college?			
Other comments			

The experiment.....	**Audiometry**	**Nystagmus: modf. Barany Chair**
has important learning outcomes	1 2 3 4 5 (circle, key below)	1 2 3 4 5
tests important 'practical' skills	1 2 3 4 5	1 2 3 4 5
tests 'analytical' skills	1 2 3 4 5	1 2 3 4 5
is easy to conduct for the number of students you have	1 2 3 4 5 **1 = strongly agree 5 = strongly disagree**	1 2 3 4 5
Involves minimal expenditure	1 2 3 4 5	1 2 3 4 5
can be easily implemented in your college	1 2 3 4 5	1 2 3 4 5
is an important supplement to the Physiology course	1 2 3 4 5	1 2 3 4 5
can be tested effectively at the practical examination	1 2 3 4 5	1 2 3 4 5
What constraints will you face in implementing this expt. in your college?		
Other comments		

SESSION 5

The experiment.....	**Renal Functions**	**Appetite and Satiety**
has important learning outcomes	1 2 3 4 5 (circle, key below)	1 2 3 4 5
tests important 'practical' skills	1 2 3 4 5	1 2 3 4 5
tests 'analytical' skills	1 2 3 4 5	1 2 3 4 5
is easy to conduct for the number of students you have	1 2 3 4 5 **1 = strongly agree 5 = strongly disagree**	1 2 3 4 5
Involves minimal expenditure	1 2 3 4 5	1 2 3 4 5
can be easily implemented in your college	1 2 3 4 5	1 2 3 4 5
is an important supplement to the Physiology course	1 2 3 4 5	1 2 3 4 5
can be tested effectively at the practical examination	1 2 3 4 5	1 2 3 4 5
What constraints will you face in implementing this expt. in your college?		
Other comments		

WORKSHOP ASSESSMENT: OVERALL

(circle your level of agreement for the statements given below). We also welcome any comments that you have about the workshop.

How would you rate the overall usefullness of the workshop	**Very useful**	1 2 3 4 5 6 7	**A waste of time**
How would you rate the 'content' of the workshop	**Very adequate**	1 2 3 4 5 6 7	**Totally inadequate**
Do you think the time allottment for the different sessions was adequate?	**Very adequate**	1 2 3 4 5 6 7	**Totally inadequate**
To what extent were you, individually able to participate in the workshop	**Very much so**	1 2 3 4 5 6 7	**Not at all**
To what extent do you think you will be able to implement these experiments	**All of them**	1 2 3 4 5 6 7	**None**
Any other comments? Could you suggest ways in which the workshop could have been improved?			