Lecture notes

Exercise Physiology

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Physiology
Physiology can be defined as one of the branches of natural science, which deals with; functional aspect of living organism.

Exercise:
Exercise represents a subset of physical activity that is planed with a goal of improving or maintaining fitness.
Series of muscular work or movement that is carried out in a sequential manner are called exercise .This is economical, skillful, coordinated and graceful manner in order to fulfill a particular task.

Exercise physiology:
Study of how exercise alerts the structure and function of the human body. Exercise physiology is the study, which deals with how the human body responds and adjusts to exercise.
Exercise physiology is an applied science that deals with various interaction and adjustment physiologically before, after and during exercise.

Clinical exercise physiology:
Study of exercise use in the treatment or rehabilitation of clinical disorders.

Importance of exercise physiology:

Exercise physiology is an aspect of sports medicine that involves the study of how the body, forms a functional standpoint,responds,adjust and adapts to exercise.

Now a day's sports training purely based on science.Exercise physiology is one of the important subject of that science.

Exercise physiology provides the physiological basis of physical education fitness and athlete programme.

Exercise physiology provides the physiological basis of therapeutic exercise which is mostly important for physiotherapy.

Exercise physiology gives us the knowledge about structure and function of various types of muscle of human body.

It give us knowledge about Bio-energetic system.

It provide information about nervous control of muscular movement.

It is helpful for understanding of the functional aspect of respiratory and cardiovascular system.

Exercise physiology is informative for sports and nutritional effect on sports performance.

It gives the knowledge about work and environment such as summer, winter humid and high altitude.

Physical fitness and its development-Exercise physiology gives the knowledge how to improve strength,speed,endurance,flexibility and coordinative abilities.

Exercise physiology is helpful for scientific basis of training schedule and its evaluation.

It gives the knowledge about the effect of doping and alcohol on sports performance.

It is helpful to know the immediate and long term effect of physical training.

Exercise physiology is important for understanding body adaptation.

Exercise physiology is also important for right selection of activity for individual.

Benefits of Exercise

Exercise has enormous beneficial effects in our body. Physiologically, it benefits virtually every system and cell of the body.Some of those are given below:

1.It increases the size of the muscle fibres,consequently increasing the muscle mass and muscular activity in the body.
2.It increases bone calcium, thus helps in maintenance of bone mass, particularly in the later age and post-menopausal women.
3.It increases cardiac output, increasing the stroke volume of the heart.It produces electric stability of the heart muscles reducing the risk of cardiac arrhythmia.
4.It increases venous return.
5.It increases hemoglobin concentration in the blood, providing better oxygen carrying capacity.
6. It increases vascular resistance in the inactive muscles.
7.It inhibits the blood clotting processes and stickiness of the blood. contributing reduction in heart attacks.
8.It increases oxygen pick up in the lungs.
9.It increases oxygen supply in the heart muscles and increases greater extraction of oxygen at the peripheral level.
10.It strengthens the tendons,ligaments,muscles and other tissues around the joints,lubricating the joint cartilages and capsules,maintaining proper flexibility of joints.Greater the flexibility of joints,lesser will be the chances of injury.
11.It decreases resting heart rate.
12.It avoids senility-increases oxygen delivery of brain.
13.It activates the sympathetic nervous system and put the whole body on the alert.
14.It increases gastrointestinal tone.
15.It lowers the blood cholesterol,which is a majo risk factor in coronary heart disease,improving blood high-density cholesterol (HDL), which is cardioprotetive.
16.It decreases blood triglycerides.
17.Blood pressure increases during exercise, but in the long run,it decreases the blood pressure.
18.It decreases insulin requirement,increases insulin Sensitivity thus ameliorates diabetes mellitus.
19.It increases glycogen storage.
20.It burns carbohydrate(suger)
21.It helps better control of hunger,increasing the level of leptin in the circulation.
22.It decreases body fat .It benefits the cardiovascular system by reducing body weight.
23.It enhances metabolic functions i.e.controling the body weight,thus preventing obesity.
24.It increases aerobic threshold.
25.It decreases stress(attitude).
26.It increases ability to handle stress(biochemical).
27.It improves resistance to cold.
28.It increases basal metabolic rate(BMR).
29.It decreases load on the heart.
30.It decreases muscle dependence on suger.
31.It increases emotional lift.
32.It helps in increased production of endorphins by the brain,which are nature’s own opiates.
33.The physical exercise has positive influence on the psychological functioning also. It reduces anxiety and depression,thus elevates the mood.
34.It enhances the psychomotor development and capacity to face impediments.
35.It improves memory and increases self-esteem.

Skeletal Muscle

Role of skeletal muscles in determining sports performance, a thorough understanding of muscle structure and function is important to the exercise scientists physical educator, physical therapist and coach. It is the purpose of this chapter to discuss the structure and function of skeletal muscle.

Human body contains over four hundred skeletal muscle, which constitute 40-50% of the total body weight.

Major functions of skeletal muscles:

i) Force production for locomotion and breathing
ii) Force production for postural support
iii) Heat production during cold stress.

- Skeletal muscles are attached to bones by tough connective tissue called tendon.
- One end of the muscle is attached to a bone4 that does not more (origin), while the opposite end is fixed to a bone (insertion) that is moved during muscular contraction.
- Flexors: Muscles that decrease joint angles are called flexors.
- Extensors: Muscle that increase joint angles are called extensors

Organization of skeletal muscle:

Skeletal muscle is made up of individual muscle fibres that are the "building block" of the muscular system in the same sense that the neurons are the building blocks of the nervous system.

Most skeletal muscles begin and end in tendons, and the muscle fibres are arranged in parallel between the tedious ends.

- Each muscle fibre is a single cell
- Muscle fibres are made up of myofibrils, which are divisible into individual filaments.
- The filaments are made up of the contractile proteins

Muscles fascia

Individual muscles are separated from each other and held in a position by connective tissue called fascia.

Muscle fibres:

Muscle fibre is a single cell that is multinucleated, long, cylindric and surrounded by a cell membrane (sarcolemma).

Muscle fascicle:

Individual bundle of muscle fibres are called muscle fascicle.

- Skeletal muscle in composed of muscle fascicle.
- Muscle fascicles are composed of muscle fibres or cells.
- Each fibre is composed of myofibrils

Composition of skeletal muscle

Muscle cells themselves
Nerve tissue
Blood
Various types of connective tissue

Layers of skeletal muscle:

- Epimysium: The outmost layer that surrounds the entire muscle in called epimysium
- Perimysium: Connective tissue inward from the epimysium is called perimysium. It surrounds individual bundles of muscle fibers.
- Endomysium: Each mucle fibers within the fasciculus is surrounded by connective tissue is called the endomysium.

Properties of skeletal muscle:

Excitability: the ability to respond to a stimulus (e.g., a neurotransmitter or hormone) by the generation and conduction of a reversal in membrane potential (action potential).

Contractility: the ability of muscle to contract and generate tension, at the expense of metabolic energy, when an adequate stimulus is received.

Extensibility: The ability of muscle to be stretched.

Elasticity: The ability of muscle to resume its resting length after being either stretched or contract

Structural Characteristics of skeletal muscle:

-Voluntary muscle having well developed cross – striations.

- Individual muscle fibers are separated (i.e. single cell)
- Muscle cell is multinucleated long and cylindrical
- Contains alternate light and dark band.
- There is no syncytial bridges between muscle cells.
- Does not normally contract in the absence of nervous stimuli.

Muscle cell proteins:

1. Thick filaments:

-Thick filament (MW: 480000); they are filamentous protein.

-Each filament contains 200 myosin molecules.
-Each myosin molecule contains six polypeptide chains
-Two heaving chains arranged in helical structure and from tail body and portion of myosin head.
-Four short chains is the part of myosin head.
-Each molecole of myosin contains myosin head.
-The myosin heads have binding sites for:
    The Actin molecules in the thin filaments and
    ATP and contains AT Pase enzyme .
-Interaction of myosin head with actin filament cause muscle contraction.

2. Thin filaments:

These are filamentous protein. It is thin filament. Actin filament is composed of
    Fibrous actin (globular protein)
    Tnopomyosin
    Troponin (T, C, I)

Fibrous actin: Contains active sites that bind with myosin head and cause muscle contraction.

Tropomyosin: Fibre like protein which wraps helically around thin filament.

Troponin: Globular protein complex, which binds Ca^{++} and initiates contraction cycle, is a complex of 3 proteins.

Troponin T: It binds troponin to tropomyosin and form troponin tropomyosin complex.

Troponin C: It binds with calcium (ca^{++}) that initiates muscle contraction.

Note – Each molecule of Troponin C can bind up to 4 calcium ions.

Troponin I: It inhibits the interaction of myosin with actin.

Muscle triad

The arrangement of central T tubule and terminal cisternae on each side of the T tubule is called muscle triad.

Sarcoplasmic reticulum

Within the sarcoplasm the membranous channels that surround each myofibril and run parallel with it are called the sarcoplasmic reticulum.

- Storage sites for calcium
- Plays an important role for muscular contraction

T tubules:

The membranous channels extend inward from the sarcolemma and pass completely through the fiber, are called T tubules.

-It provides connection between outside and inside of muscle fiber.
-Action potential then releases Ca^{++} from sarcoplasmic reticulums which initiates muscle contraction.
-Each sarcomere contains two T – tubules.

Terminal Cisternae

Transverse tubule passes between two enlarge portion of sarcoplasmic reticulum. The terminal part of the sarcoplasmic reticulum is terminal cisternae

Neuromuscular junction

The side where the motor neuron and muscle cell meet is called the neuromuscular junction.

Motor end plate

In the neuromuscular junction, the sarcolemma forms a pocket is called the motor end plate.

Neuromuscular cleft

The short gap between the end of the motor neuron and muscle fiber is called neuromuscular cleft.

The end of the motor neuron does not physically make contacted with the muscle fiber but it is separated by a short gap.

10.12 Carbon dioxide dissociation curve.

Question: What are the characteristics of slow Twitch & Fast Twitch Fibre?

Or ,write down the differences between Slow & Fast Fibre?

Characteristics	Slow Fibre/Type- I	Fast Fibre/Type-II	
		IIa	IIB
Morphology	Dark/Red	White/Red	White
❑ Colour			
❑ Capillery	High	Intermittent	Low Capillery
❑ FibreDiametre	Small	Intermediate	Large Diameter
Bio-Chemistry			
❑ Oxidative/glycolytic	So(Slow Oxidative)	FOG(FastOxidative Glycolytic)	FG(Fast Glycolytic)
❑ Mysin ATPase Activity	Low	High	High
❑ Calcium Capacity	Low	Intermediate	High
❑ Glycolytic Capacity	Low	High	High
❑ Oxidative Capacity	High	Medium/High	Low
Function &Contractility			
❑ Speed of action	Slow	Fast	Fast
❑ Fatiguability	Low	Mderate	High
❑ Force Capacity	Low	Intermediate	High

Muscle twitch:

A single action potential causing a brief contraction followed by relaxation is called muscle twitch.

Parts of muscle twitch (contraction cycle)

1. Latent period 5 m sec	Time between application of AP and initiation of contraction
2. Contraction 40 m sec	Muscle shortens and does its work
3. Relaxation 50 m sec	Muscle elongates and returns to original position
4. Refractory period m sec	Time of recovery between stimulations of muscle

Duration of muscle twitch

Fast muscle fiber: 7.5 ms (millisecond)
Slow muscle fiber: 100 ms (millisecond)

Myasthenia Gravis:

The disease myasthania gravis is an autommune disorder in which antibodies are produced against the acetylcholine receptors. These antibodies destroy the acetylcholine receptors. So, though the acetylcholine release is normal it cannot act because of the destruction of the receptors. The result is inability to transmit signals from the nerve fibres to muscle fibres. Thus reduce the amplitude in end plate potentials (EPPs).As a result the person becomes paralysed because of inadequate stimulation of muscle fibre.

The disease is characterized by

Drooping of the upper eyelid (ptosis)
Double vision (Diplopia)
Difficulty in swallowing (dysphagia)
Difficulty in talking (Dysarthiria)
General muscle weakness and
Fatigue.

Rigor Mortis

The stiffness of muscle after death is called rigor mortis**.** Several hours after death all the muscle of the body go into a state of contracture that is the muscle contracts and becomes rigid even without action potentials.

This rigidity is due to destruction of all ATP and phospho-creatinine which is required to cause separation of the cross bridges from the actomyosin complex during the relaxation process.

The muscle remain in rigor until the muscle proteins are destroyed, which usually results form autolysis caused by enzymes released from the lysosomes (15 to 25 hours later) .The process occurring more rapidly at higher temperature

Sliding filament theory of muscle contraction:

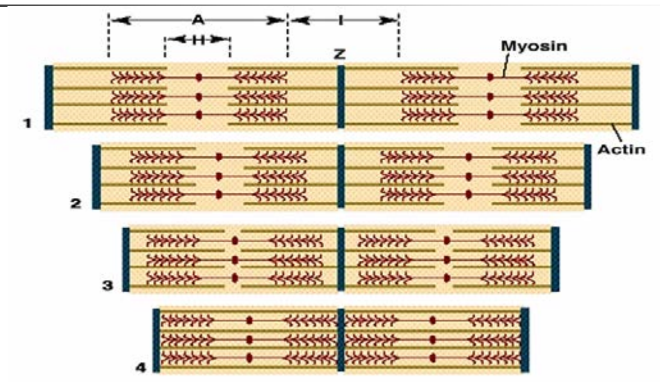
During muscular contraction the actin filaments slide over the myosin filaments forming the actomyosin complex. There is no shortening, thickening or folding of the individual filaments.

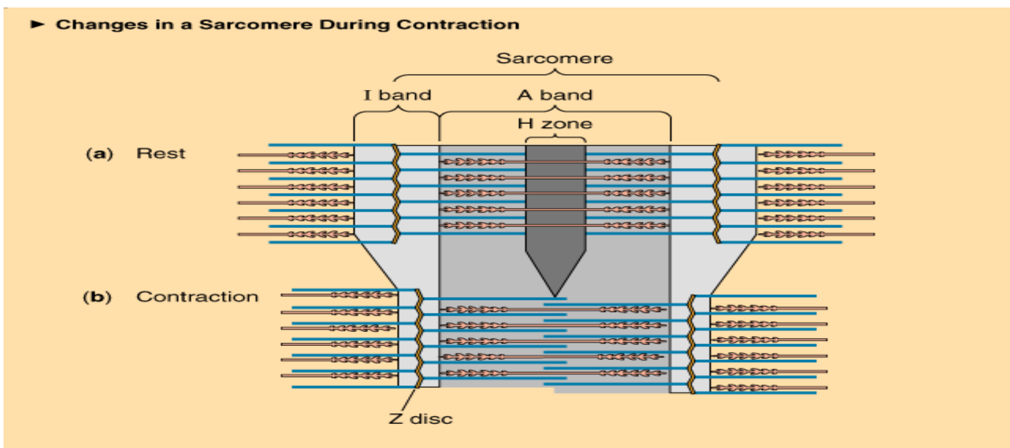
A band remains constant in size
H Zone becomes denser
I band varies in length becoming shorter

As a muscle contracts,
The Z lines come closer together
The width of the I band varies in length
The width of the H zones decreases but
There is no change in the width of the A band.

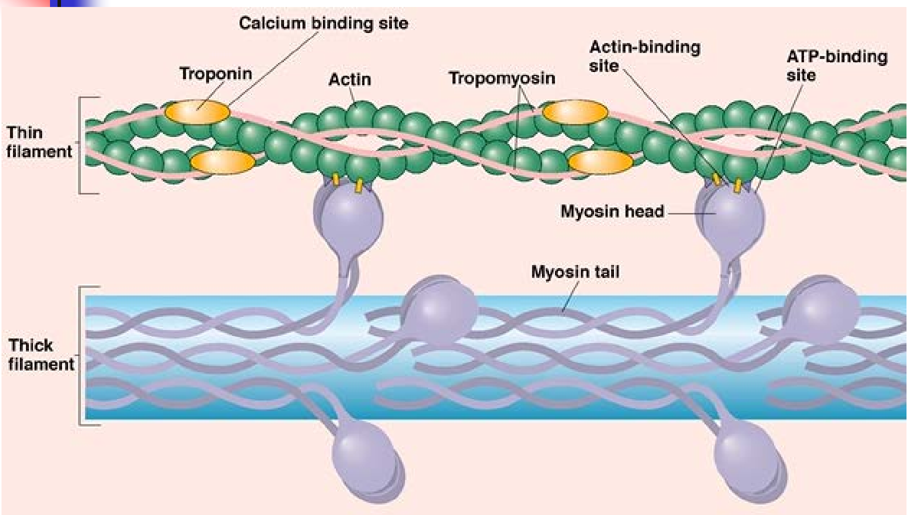
Conversely, as muscle stretched
The width of the I band increases
The width of the H zones increases but
There is still no change in the width of the A band.

The Sliding Filament Model of Muscle Contraction





Cross-Bridge Formation in Muscle Contraction



Comparison between skeletal, cardiac and smooth muscle

CHARACTERSTICS	SKELETAL	CARDIAC	SMOOTH
Anatomic location attaches to bones or skin	Attaches to bones or skin	Attaches to fibrous walls of the heart	In or surrounding walls of blood vessels and organs
Multicellular arrangement	Cells (fibers) grouped into fascicles, which comprise a whole muscle	Atrial and ventricular fibers separated by a connective tissue sheath Single fibers connected a fibrous skeleton	Single cells within a connective tissue matrix
Cellular morphology	Single, long, cylindric, striated, and multinucleated	Branching cell, uninucleated or binucleated, and striated	Single, uninucleated, and nonstriated
Subcellular morphology	Myofibrils with sarcomeres	Myofibrils with sarcomeres, filaments	Dispersed actin and myosin
Presence/location of t-tubules	Yes, at A-I junctions	Yes, at Z line	No
Sarcoplasmic reticulum	Elaborate	Elaborate	Rudimentary
Gap junctions	No	Yes at intercollated discs	Yes, in single unit muscle
Nerve-muscle interaction	Yes,neuromuscular junction	No	Yes, in multiunit muscle

Regulation of contaction	Voluntary nervous system	Involuntary nervous system, intrinsic rhymicity, and hormones	Involuntary nervous system, hormones, local chemicals, stretch
Source (s) of calcium	Sarcoplasmic reticulum	Sarcoplasmic reticulum and extracellular fluid	Sarcoplasmic reticulum and extracellular fluid
Contraction mechanisms	Actin and myosin	Actin and myosin	Calmodulin and myosin
Autorhythmicity	No	Yes	Yes, single unit muscle
Type of contraction	Motor units	Atrial and ventricular syncytium	Singular or mlti-unit
Speed of contraction	Heterogenous slow to fast	Homogenous slow	Homogenous very slow
Stretch response	Contraction	Contraction	Relaxation
Metabolism	Heterogenous oxidative to glycolytic	Homogenous oxidative	Homogenous mainly oxidative

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Aging:

The process of growing old involving the inability to reverse the gradual deterioration of cells important to the life process.

Aging should not be viewed as a sickness but as a natural process that involves the gradual alteration of body appearance function and tolerance to stress.

Aging has been defined as a progressive loss of physiologic capacities that culminates in death.

Life expectancy:

The average, statistically predicted length of life for an individual.

Chronological:

The age of a person expressed relative to time (usually years). Chronological age is best represented by a person's birth date.

Biological age:

The functional age of an individual based on physiologic conditioning. Biological age is assessed by such variables as maximum oxygen uptake, bone mineral content, muscles strength or flexibility.

e.g A person who is 65 years of age may have a biological age of 45 based on that person's fitness and health status.

Longevity:

The duration of a life beyond the norm.
longevity is deified in the random house dictionary as a long dunation of life.

Individual live depends on

- Heredity
- Environmental factor
- Availability of good health services

Changes during the aging process

Appearance:

- Graying of hair
- Balding
- Drying and winkling of skin

Nervous system:

- Impairment of near vision
- Some loss of hearing
- Reduced taste and smell
- Reduced touch sensitivity
- Slowed reaction (reflexes)
- Slowed mental function
- Mental confusion.

Cardiovascular system:

Increased blood pressure
Increased resting heart rate
Decreased functional capacity
Decreased cardiac output.

Body composition / metabolosm:

Increased body fat
Raised blood cholesterol
Slowed energy metabolism (blood metabolic rate)

Other physical characteristics:

Meno pause (women)
Loss of fertility (men)
Joints (loss of flexibility)
Loss of teeth (gum disease)
Bone mineral density.

Body function involving the contraction of one or more of the three types of muscle:

Function	Predominant muscle type
Body movement	Skeletal
Speech	Skeletal
Eye movement	Skeletal
Stomach movement	Smooth
Urination and defecation	Smooth
Heart pumping	Cardiac
Shivering	Skeletal
Sweat extrusion	Smooth
Breathing	Skeletal
Blood vessel constriction	Smooth

FEMALE ATHLETE TRIAD

It is generally accepted that the three most common health problem young, female athlete are:

1. Amenorrhea
2. Eating disorders and
3. Bone mineral loss

Collectively, these problems have been called the "Female athlete triad". Current evidence suggests that these problems are interrelated and that one problem can potentially lead to another. For example an eating disorder can lead to inadequate nutrient and calcium intake and eating disorders are known to promote amenorrhea. Long-term amenorrhea can result in low blood estrogen levels. The combination of inadequate calcium intake and low estrogen levels can result in a loss of bone mineral content.

Anorexia Nervosa:

Anorexia nervosa is a state of starvation in which the individual becomes emaciated due to refusal to eat. The psychological cause of anorexia nervosa is unclear but it seems to be linked to an unfounded fear of fatness that may be related to family or social pressure to be thin. Currently it is estimated that the incidence of anorexia nervosa is as high as one out of every 200 adolescent girls.

Bulimia:

Bulimia is over eating (called binge eating) followed by vomiting (called purging) the bulimic repeatedly ingests large quantities of food and then forces herself to vomit in order to prevent weight gain.

Bulimia may result in damage to the teeth and the oesophagus due to vomiting of stomach acids.

Warning signs for anorexia nervosa:

Rapid weight loss
Mood swings
Avoiding food related activities
Excessive exercise
Preoccupation with food, calories and weight
Wearing baggy clothing.

Warning signs for bulimia:

Noticeable weight loss
Depressive moods
Strict dieting followed by eating binges
Excessive concern about weight
Increasing criticism of one's body.
Bathroom visits after meals.

HEAT ACCLIMATIZATION

Regular exercise in a hot environment results in a series of physiological adjustments designed to minimize disturbances in homeostasis due to heat stress - this is referred to as heat acclimatization. It is essential for athletes to do exercise in a hot environment for obtaining maximal heat acclimatization.

Elevation in core temperature is the primary stimulus to promote heat acclimatization. In order to promote higher core temperatures the athlete is recommended for strenuous interval training or continuous exercise (intensity >50% $V0_2$).

Heat acclimatization results in

1. Increase plasma volume.
2. Earlier onset of sweating during exercise.
3. Higher sweat rate.
4. Reduced sodium chloride loss in sweat.
5. Reduced skin blood flow.

CARDIO VASCULAR SYSTEM

HEART: The human heart is true wonder of nature, its 100000 beats per day allows us to live and breath.

Heart is the central pumping organ it receives and pumps out blood to the whole body.

Shape – Conical or roughly heart shaped.

Size – 12 cm from base to apex,
6 cm from anterior to posterior.

Situation: On middle mediastinum in between two lungs.

Weight: 250 to 300 gm.

Nerve supply – Sympathetic
_ Parasympathetic

Heart muscle/ Cardiac muscle:

a. Atrial muscle
b. Ventricular muscle
c. Specialized excitatory and conductive muscle fibers

- The Sinus node (Sino-Atrial or SA rode)
- Inter-nodal pathway
- The AV node (Atrio-ventricular node)
- The A-V bundle.

Penetrating portions
Distal portions

- The left and right bundles of purkinjie fibers

Layers of the heart wall:

From out to inward
1. Epicardium
2. Myocardium
3. Endocardium

Chambers of the heart:
1. Receiving chambers -Rt atriums
   -Lt atrium
2. Distributing chambers -Rt ventricle
   -Lt ventricle

Valves of the heart:
1. Atrio – Ventricular (or cusepid) valves:
   Rt - Tnicuspid (three cusps)
   Lt – Bicuspid or mitral
2. Semilunar valves
   - PUL, semilunars
   - Aortic semilunars valve

Properties of Cardiac muscle:

1. Automaticity
2. Autorhythmicity
3. Conductivity
4. Excitability
5. All or none law
6. Frank starling law
7. Refractory period
8. Functional syncytium

Circulation: it is the process of blood and lymph flow through a close system of vessels, called circulation.

Types of circulation:

a. Systemic circulation or greater circulation
b. Pulmonary or lesser circulation
c. Portal circulation

Sequence of circulation through heart:

From body

↓

Superior and inferior venacava

↓

Rt atrium

↓ Tricuspid value

Rt ventricle

↓ Pulmonary artery (Rt&Lt)

Lung (Rt & Lt)

↓ Pulmonary vein (Rt & Lt)

Lt atrium

↓ Bicuspid valve

Lt ventricle

↓

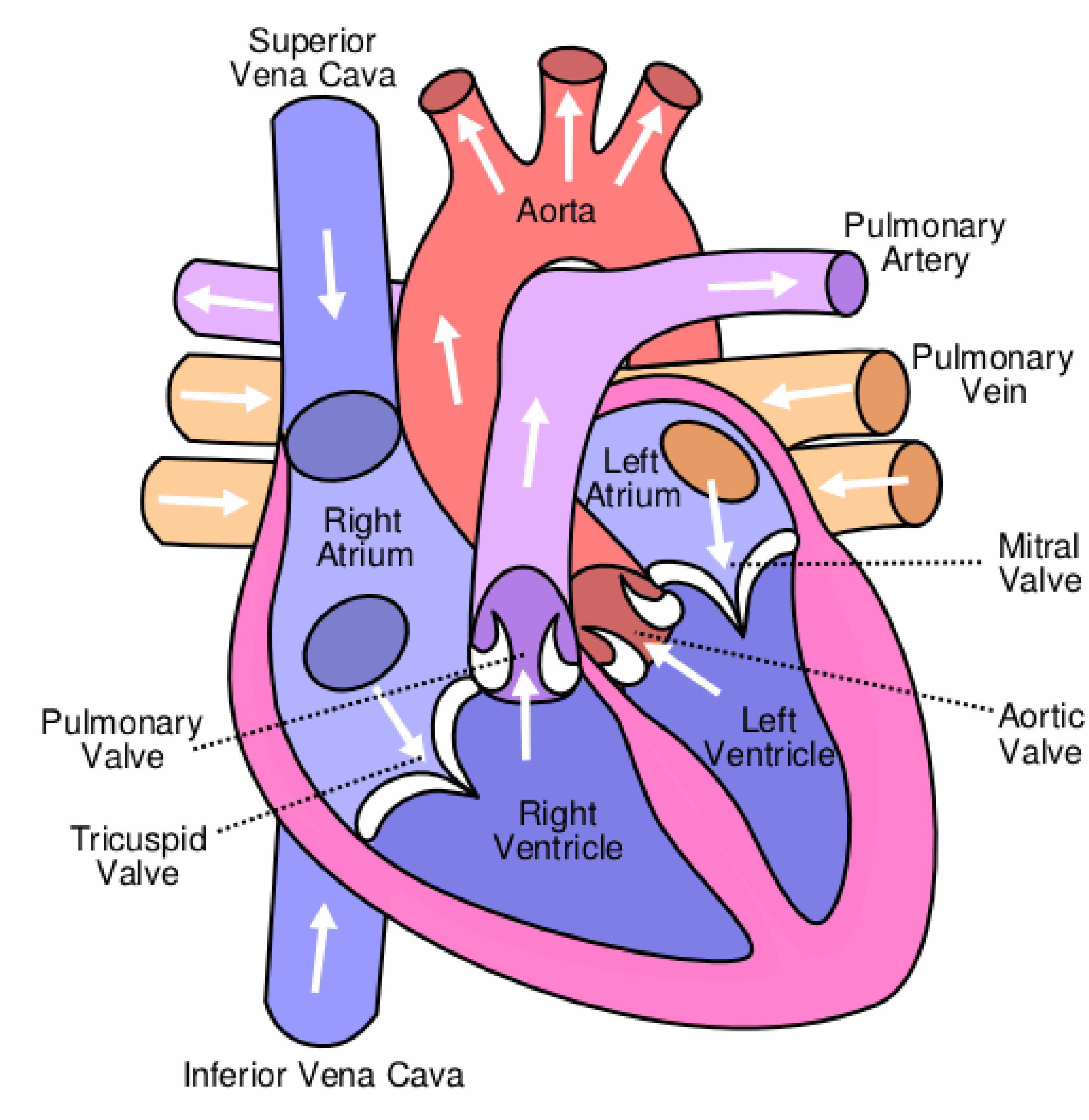
Arch of aorta

↓

Thoracic and abdominal aorta

↓

Body



Superior Vena Cava
Aorta
Pulmonary Artery
Pulmonary Vein
Left Atrium
Right Atrium
Mitral Valve
Aortic Valve
Left Ventricle
Pulmonary Valve
Tricuspid Valve
Right Ventricle
Inferior Vena Cava

Venous Return:

It is the amount of blood that comes from periphery to right atria of heart in each minute. It is equal to cardiac out put.
It is about 5 liters/min.

Factors affecting venous return:

1. Muscular activity
2. Pumping action of heart
3. Pressure gradient in vessels
4. Respiratory pump
5. Gravity
6. Vasomotor tone

Cardiac cycle:

The cardiac events that occur from the beginning of one heart beat to the beginning of the next are called the cardiac cycle.

Events of cardiac cycle:

1. **In atria:**
   (i) Atrial systole: 0.1second
   (ii) Atrial diastole: 0.7 second

2. **In ventricle:**
   (i) Ventricular systole: 0.3 second
   (ii) Ventricular diastole: 0.5 second

- **Ventricular systole:**
  (i) Iso volumetric (isometric) contraction phase: 0.02 to 0.05 second
  (ii) Rapid ejection phase
  (iii) Reduced ejection phase.

- **Ventricular diastole:**
  a. Proto diastolic phase: 0.04 second
  b. Isometric (volumetric) relaxation phase: 0.03 to 0.06 second
  c. Filling phase: 0.4 second
  (i) First rapid filling phase
  (ii) Slow filling phase
  (iii) Last rapid filling phase

Changes associated with cardiac cycle:

1. Changes in pressure:
   Intra-ventricular pressure change
   Intra atrial pressure change
   Pressure changes within aorta
   Pressure changes within Pulmonary artery
2. Changes in volume:
   Atrial volume change
   Ventricular volume change
3. Production of heart sound and apex beat
4. Production of pulse and appearance
5. Electrical change
6. Electro cardiogram (ECG) changes
7. Systemic, pulmonary and coronary circulation changes

Pressure changes in ventricle during cardiac cycle:

	Systolic pressure	Diastolic pressure
a. Aorta	120 (90-140)	80 (60-90)
b. Left ventricle	120 (90-140)	0-5 (4-12)
c. Right ventricle	25 (15 – 30)	0 (0 – 5)
d. Right atrium	8	0
e. Left atrium	12	4
f. Pulmonary artery	15 – 30	5 – 15

Cardiac reserve:

The maximum percentage that the cardiac output can increase about the normal level is called the cardiac reserve.

Normal value:

- ✱ Healthy young adult: 300 to 400 percent
- ✱ Athlete: It is occasionally 500 to 600 percent
- ✱ Whereas in heart failure there is no reserve.

Example: During severe exercise the cardiac output of the healthy young adult can rise to about five times normal; this is an increase above normal of 400 percent that is a cardiac reserve of 400 percent.

Factors affecting cardiac reserve:

Any factor that prevents the heart from pumping blood satisfactorily decreases the cardiac reserve.

This can result from –

a. Ischaemic heart disease
b. Primary myocardial disease
c. Vitamin deficiency
d. Dosage to the myocardiam
e. Valvular heart disease
f. Diphtheria etc.

Heart sound:

The vibratory motion of heart produced during the different events of cardiac cycle conducts through the structure surrounding the heart and produces special audible sound called heart sound.

Physiological basis that cause the heart sound:

a. Vibration of the taut values immediately after closure.
b. Vibration of the adjacent blood
c. Vibration of the walls of the heart and major vessels around the heart.

Clarification of heart sound:

1st heart sound 2nd heart sound	Audible by Stethoscope
3rd heart sound	detected by

4th heart sound phonocadiograph

1st heart sound:

Cause: caused by vibration set up by the sudden closure of the mitral and tricuspid valves at the start of ventricular systole.

Identification point:

Duration	:	about 0.15 second
Frequency	:	25 – 45 Hz
Time	:	Just before ventricular systole
Pitch	:	Low
Best heard at	:	Apex
Hearing character	:	Lub

Audible with a stethoscope.

Importance or significance:

a. Loud: In mitral stenosis, hyper dynamic circulation.
b. Soft: In calcified mitral valve
c. Diagnosis of congenital heart disease.
d. Differentiating the murmur whether it is systolic or diastolic in origin.

2nd heart sound:

Cause: Caused by vibrations associated with closure of the aortic and pulmonary valves just after the end of ventricular systole.

Identification point

Duration	:	about 0.12 second
Frequency	:	50 Hz
Time	:	Just before ventricular diastole
Pitch	:	High
Best heard at	:	Base
Hearing character	:	Dub

Audible with a stethoscope.

Importance 2nd heart sound

a. Reserved splitting: In aortic stenosis, hyper dynamic circulation.
b. Wide physiological splitting of 2nd heart sound: In bundle branch block.
c. Diagnosis of congenital heart disease
d. Differentiating the murmur whether it is systolic or diastolic in origin.

Apex beat:

Definition: Apex beat is the lowest and outer most point of definite cardiac pulsation.

Location: In the 5th intercostal space 9cm from the midsternal line just medial to the left nipple.

Importance:

1. Measurement of heart rate
2. Position of heart whether dextro cardia or not
3. Different heart disease diagnosis
4. Displacement of mediustinum due to pneumo thorax, pleural, effusion left ventricular hypertrophy etc.

Heart rate:

The number of heart beat per minute is called heart rate.

Normal heart rate:
Adult (range) : 60 – 90 / minute
Average : 72 / minute
In fetus : 140 – 150 / minute
In newborn : 130 – 140/ minute
In children : 80 – 120 / minute
In old age : 75 – 80 / minute

Factors affecting/Regulating heart rate:

1. Higher centre: Stimulation of posterior group of hypothalamic nucleus increases heart rate, while middle group decreases heart rate stimulation of area 13 of frontal lobe, causes trachycardia.

2. Respiration: Heart rate increases during inspiration particularly in children and decreares during expiration.

3. Cardio varcular reflexes:
    a. Baroreceptor reflex: Stimulation of baroreceptor decreases the heart rate
    b. Brain bridge reflex: Stimulation of brain bridge increases heart rate

4. Temperature: Increase body temperatures increases heart rate by directly stimulating the S.A node

5. Intra cranial pressure: Increase intra cranial pressure stimulates cardio inhibitory centre and causes slowing heart rate.

6. Muscular exercise: it increases heart rate

7. Age: From infancy to old age heart rate progressively decreases

8. Sex: Females have slightly faster heart rate then male

9. Surface area: Heart rate is inversely proportional to surface area

10. Endocrine factors:
    a. Adrenaline: Accelerate
    b. Thyroxin: Accelerate
    c. Posterior pituitary hormone: depresses.

Effect of exercise on heart rate:

(i) Decreasing 0_2, increasing CO_2 & H^+ tension
(ii) Increasing body temperature
(iii) Increasing venous return
(iv) Increasing secretion of adrenalin.

Distribution of blood flow

Hemodynamics:

Hemodynamic is the study of the factors that determine the blood flow and BP in the body.

Blood flows in the vascular system from a higher to the lower pressure.

The primary determinants of blood flow are -

(i) Pressure gradient
(ii) Resistance

The principles of rate of blood flow are –

(i)Rate of flow (F) & Pressure gradient

(ii) Rate of flow (F) $\propto \frac{1}{\text{resistance (R)}}$

Blood flow depends upon the flowing factors

(i) Pressure gradient
(ii) Velocity
(iii) Viscosity
(iv) Length of the vessel

Types of blood flow

(i) Laminar flow

(ii) Turbulent

Blood pressure:

The lateral pressure exerted by the blood per unit area of vessel wall while flowing through it is called BP.

BP= CO x TPR

Blood pressure = Cardiac output x Total peripheral resistance.

Components of blood pressure:

(i) Systolic blood pressure

(ii) Diastolic blood pressure.

Unit of BP

Unit is mm of Hg.

It is writhen systolic over diastolic pressure.

Blood pressure of a normal adult:

Systolic pressure: 100 – 140 mm of Hg

Average 120 mm of Hg

Diastolic pressure: 60 – 90 mm of Hg

Average 80 mm of Hg

Importance of blood pressure:

(i) It is essential for blood flow

(ii) It provides motive force for filtration at the capillery bed

(iii) It is essential for tissue nutrition

(iv) It is needed for urine formation

(v) It is needed for lymph formation

(vi) It is important for venous return

Normal values of blood pressure at different ages:

1. Infant : 60/30 mm of Hg
2. 1 year : 80/40 mm of Hg
3. 3 years : 100/60 mm of Hg
4. 20 years : 120/80 mm of Hg
5. 45 years : 145/90 mm of Hg
6. 70 years : 170/95 mm of Hg

Blood pressure measurement (method):

(i) Auscultatory method (both systolic and diastolic)

(ii) Palpatory method (only systolic

Systolic pressure:

It is maximum pressure during systole.

It is about 100 –140 mm of Hg

Average: 120 mm of Hg

Significance:

1. The extent of work done by heart
2. The force with which the heart is working
3. The degree of pressure which the arterial walls have to withstand
4. It increases during excitement, exercise, meals etc.
5. It decreases while sleep, rest etc.

Diastolic pressure:

It is the minimum pressure during diastole.

It is about 60 - 90 mm of Hg

Average: 80 mm of Hg

Significance:

1. It indicates the constant load against which the heart works.
2. Increased diastolic pressure indicates that heart is approaching to failure
3. It is the index of peripheral resistance

Pulse pressure:

It is the difference between systolic and diastolic pressure.

It is about: 30 – 60 mm of Hg

Significance:

1. It is indicates the cardiac
2. It depends on age, stroke volume and arterial elastic constant

(arterial volume)

Mean pressure:

It is the average pressure persists in the circulation .

It is the diastolic pressure plus one-third (1/3) of pulse pressure.

It is about 78 – 98mm of Hg.

Average: 96mm of Hg.

Significance:

1. Mean pressure is the driving force for blood flow.
2. It depends on cardiac output and peripherals resistance.

Q. Why blood pressure increases in old age exercise and pregnancy?

1. In old age – blood pressure increasess due to -
    a. Aherosclerotic change in the artery and its wall become thick
    b. Artery become stiff and its elasticized decreases.

2. In exercise: Blood Pressure increases due to -
    a. Increased venous return
    b. Increased metabolic activity and much energy and 02 is required
    c. Increased heart rate and cardiac output due to increased venous return.

3. In pregnancy: Blood volume both plasma and corpuscles increase which increases cardiac output thus blood pressure is raised.

Factors that influence blood pressure:

a. Cardiac output

b. Peripheral resistance

c. Others:

1. Age: Increases with age
2. Sex: In female slightly lower (5mm of HG). After menopause it reaches male level.
3. Build: The systolic pressure is usually high in an obese person
4. Exercise: Systolic Pressure rises; diastolic pressure is usually a lower.
5. Posture: During standing diastolic pressure is slightly higher; systolic pressure lowers. In recumbent position this condition is reversed.
6. Diurnal Variation: During daytime pressure rises up to 2-0 clock and then there is a slight fall. In case of night workers the blood pressure rises during morning
7. During deep sleep there is fall of blood pressure by 15 – 20 mm of Hg
8. After meal: increased up to 20mm of Hg
9. Emotion and excitement: systolic pressure increase

10 Respiration: Falls during most part of inspiration.

Factors that control blood pressure:

a. Cardiac output: Cardiac output depends upon -

(i) Blood volume

(ii)Venous return

(iii)Force of contraction of heart

(iv)Frequency of heartbeat

b. Peripheral resistance: peripheral resistance depends upon –

(i) Elasticity of arterial wall

(ii) Velocity of blood

(iii) Viscosity of blood

(iv) State of lumen of blood vessels.

Q. Flow blood pressure is regulated by stress – relaxation mechanism:

When the pressure in blood vessels become too high they become stretched keep or stretching more and more for minutes or hours as a result the pressure in the vessels falls toward normal. This continuing stretch of the vessels called stress relaxation can serve as an intermediate term pressure buffer.

Food and Nutrition

Food

Any material that provides the nutritive requirements of an organism to maintain growth and well-being is called food.

Constituents of food:

a. Proteins

b. Fats

c. Carbohydrates

d. Vitamins

e. Minerals, and

f. Water

Food may be classified as:

- Energy yielding foods i.e. foods provides energy e.g., food rich in fat and carbohydrate
- Body building foods i.e. food responsible for normal body growth e.g. protein
- Protective foods i.e. foods responsible for protection of the body from various diseases e.g. proteins, vitamins, and minerals.

Food functions as:

1. Energy sources
2. Essential for growth
3. Protection from various diseases, and
4. Repair of the daily wear and tear.

Nutrition:

The study of the foods and liquids the body needs for optimal functioning.

Nutrition is the science of food and its relationship to the health.

Nutrition is the life-sustaining process by which elements of nature are assimilated and used:

1. For growth and development
2. For maintenance of healthy tissue, and
3. As mediators of physiological and metabolic processes

Good Nutrition

Good nutrition means maintaining a nutritional status that enables us to grow well and enjoy good health.

Carbohydrates
Daily requirement: 400 -- 600gm
Minimum daily intake: 50 -- 100 (To prevent ketosis)

Energy value: 4 kcal / gm

Dietary composition of Carbohydrates:
Monosaccharides
Glucose : Fruits, sweet corn honey
Frotose : Fruits, honey

Disaccharides
Sucrose : Table sugar, maple syrup. (glucose + Frucrose)

Lactose : Milk sugar
Glucose + Galactose

Nutrients: are organic and inorganic complexes contained in food that is essential for the growth and maintenance of normal cells.

Essential nutrients obtained from the diet

A. Energy yielding nutrients (proximate principals)

Carbohydrates
Proteins
Fats
Alcohols

B. Essential amino acids (EAAs): 10 in number
C. Essential fatty acids (EFAs): 2 in number
D. Vitamins, and
E. Minerals

Nutrients are subclasses into macronutrients and micronutrients.

Micronutrients: Essential food components those are required only in small quantities.

Micronutrients are those essential nutrients whose daily requirement is less than 100 mg.

Micronutrients generally as
-Coenzymes or cofactors in metabolic reactions,
-Gene activators, or
-Free radical scavengers.

Macronutrients: Essential food components those are required in large quantities.

Macronutrients are those essential nutrients whose daily requirement is more than 100 mg.

Macronutrients are used
- Primarily for energy metabolism,
-As sources of essential amino acids and
- As sources of fatty acids.

Macronutrients serve
-As the backbone of all physiological processes involving proteins sugar, eicosanoids, phospholipids, or steroid.

- It serves for muscle contraction.
-Enzyme catalysis.
- Interellular and intercellular communication,
-And vascular transport.

Macronutrients:	**Micronutrients**
Carbohydrates	Vitamins
Protein	Some minerals particularly
Fat	Trace elements:
Some mineral	Iodine
Ca^{++}	-Iron
Na^{+}	-Zinc
K^{+}	- Copper
Mg^{++}	- Cobalt
Cl^{-}	- Manganese
PO_4^{3-}	

Criteria of good nutrition

1. Should protect the body from infections
2. Should protect from nutritional deficiency disorders
3. Good nutritive state makes the person energetic
4. Nourish the body
5. Should help in fair complexion of the body

Signs of good nutrition

Skin	:	shiny
Hair	:	glossy
Eyes	:	bright
Body build	:	Well developed muscles and bones
Appearance	:	Strong build and energetic

Function of carbohydrates

1. Carbohydrates are the main of the mammalian tissues and universal fuel of the fetus
2. Provides two – third energy of the body
3. Prevent ketosis and loss of muscle protein

Vitamins:

Organic micronutrients of food those are essential to normal bodily functions.

Minerals:

Inorganic micronutrient that is essential to normal bodily functions.

Carbohydrates
Daily requirement: 400 – 600gm
Minimum daily intake: 50 – 100gm (To prevent ketosis)

Energy value: 4 kcal /gm.

Dietary composition of Carbohydrates:
Mono saccharides:
Glucose: Fruits, sweet corn, honey
Fructose: Fruit, honey

Disaccharides
Sucrose: Table sugar maple syrup. (Glucose + Frustose)

Lactose: Milk sugar
Glucose + Calactose

Maltose: Beers
Glucose + glucose

Polysaccharides
Starch: Wheat, Rice, Potato dried peas and beans.

Fibre: Wheat, Potatoes, Fronts, Vegetables.

(Non starteh Polysaccharide)

Functions of Carbohydrates:

1. Carbohydrates are the man fuel of mammalian tissues
2. Provides two thirds energy of the body
3. Prevent ketosis and loss of muscle protein.

Fibres :
Fibres are non-starch polysaccharide (NSP). The principal chasses of fibres are:

Cellulose Hemi cellulose Lignin	More Insoluble Fibres in diet
Gums Pectins	More soluble Fibres in diet

Sources – Wheat bran, Fruits, vegetables

The colonic bacteria producing gas and valatib fatty acids mainly breakdown fibres (Non stanch pohysaccharide)

Daily requirement of fibre : 20 – 35gm

Action of dietory fibres:

1. Fibre reduces cons typation hemorrhoid formation
2. A high fibre dict increases bowel motility
3. Reduces the incidince of divierticulosis and colon cancen
4. Fibres lower the blood cholesterol levels, possibly by binding bile salts and ditery cholesterol.
5. Fibre reduces the inciduce of candiovas culan disease and diabetes mellitus.

Note: Fibres provide no energy.
Proteins:
Daily requirement: 0.75 – 1.00gm/kg body Weight

Energy value – 4 kcal / gm.

Minimum requirement: 40 – 50 gm per day (To maintain Nitrogen balance)

Note – Requirement of Dictory protein varics with its biologic value.

E.g. Animal protein is less rearined

Because – Animals proteins have a high biological value due to contain all the essntial aminsccids proteins from plant sources have a lower biological value.

Classification of protein

Class – I Proteins / Grackle I proteins

- Contains all the essential amino acids
- Proteins are easily digestible
- Portions are mainly of animal origin (meat, fish, milk)

Class – II Proteis / Grade II proteins

- Proteins do not contain all the essential amino acids
- Proteins are not essily digrstible
- Proteins are mainly of plant oragin (Pulses beans etc)

Functions of proteins:

1. Groudth durig growing age
2. Maintenance of growth during adilt
3. Repair of daily wear and team
4. Required for the production of hormones enzymes antibiotics.

Essential amino acids:

Essential aminoacids are recessary for

- Protein synthesis
- Mainteance of nitogen bolance
- bioligic value of protein

There are 10 (Ten) essential amine acids in human

Essental amino acids (EAAS)

Phenylalanine
Valine
Tryptophan
Threonine
Isoleicine
Methionine
Histidine
Achinine
Leucine
Lysine.

Fats
Daly requirements: 10 – 20gm
Every value: 9.3 kale/gm
Composition of dietary fats:

Triglyurol (TG) {> 90%}
Cholesterol and cholesterol ester
Phospholipids and
Unesterified (“Free”) fatty
acids (UFAS)

Sounccs of fats
Animal fat
Butter, Lard
Ohee, milk — Saturated fatty ands

Fish oil — Unsaturated fatty ands.

Vegetable fat
Coconut oil
Palm oil — Saturated fatty ands

Soyabean oil
Corn oil
Canula oil — Polyunsaturated fatty acids.

Function of fat:

1. Lipids acts as the dietary vehicle for the lipid solule vitamins
2. Lipid suoolies essential polyunsa tureted fatty acids
3. Lipid proides a significan proportion of the dietary requirement for energy
4. Phospholipids and cholesterol maintain cell membrave integrity
5. Helps in formation of myelinsheath

Essrntial fatty acids

1. Linoleic
2. Linolenic

Anachidonic acid may be formed from linoleic acid and is not essenmtial.

Essential (fatty acid)

1. Not synsthesized by the body
2. Must be supplied by the liet
3. Deficiency menitestated by clinical conditions (e.g. scaly dermetiris,hair loss poor wound healing.

Calcium

Recommended Dietary Allowance (RDA)	Male-1200mg, Female-1200mg,
Dietary Sources	Milk, cheese, Dark green vegetables, Dried legumes, dried beans.
Major body functions	Required for strong teeth and bone formation. Maintenance of good muscle tone and heart beat, Required for blood clotting Necessary for Nerve transmission
Deficiency	Stunted growth

	Bone pain and fractures Rickets, Osteoporosis Convulsions Muscle cramps
Excess	Not reported in humans

Phosphorus

Recommended Dietary Allowance (RDA)	Male-1200mg, Female-1200mg,
Dietary Sources	Milk, Cheese, Yogurt, Meat, Poultry, Grains, Fish
Major body functions	Required for strong teeth and bone formation. Energy release regulation Acid-Base balance
Deficiency	Weakness Demineralization of bone Loss of calcium
Excess	Erosion of jaw (phossyjaw)

Potassium

Recommended Dietary Allowance (RDA	Male-2000mg, Female-2000mg,
Dietary Sources	Leafy vegetable, can-telope, lima beans, potatoes, bananas, milk, meats, coffee, tea.
Major body functions	Fluid balance Heart action Bone formation and maintenance. Regulation of energy release Acid-Base balance Nerve Transmission

Sports drinks / Athletes drinks

During endurance exercise (events lasting longer than 90 minutes or continuous effort) The best fluid replacement beverage is that tastes good doesn't cause gastric upset and provides a source of carbohydrate for energy.

According to need three recovery trails are available for athlete:

a. Consumed a water placebo
b. Consumed a glucose polymer (Solution (3g/kg BW)
c. Received a glucose infusion throughout the subsequent exercise.

Sports drinks taste good and thus stimulate voluntary fluid intake. The major benefit of consuming sports drinks is to supply carbohydrate to help maintain blood glucose levels and to delay fatigue during events lasting longer than 1hour. For most athletes who are exercising for 1 hour or less in moderate temperature plain water or sports drinks meet the athlete's needs.

Studies show that commercial sport beverages containing 4 – 8 % carbohydrate in the forms of glucose, glucose polymers or sucrose are all absorbed quickly and help maintain blood glucose levels during exercise. If beverages containing fructose level high enough may cause cramps, diarrhoea and nausea in some athletes.

Energy:
Energy is regarded as the capacity to do work.

Forms of energy:
There are five forms of energy that are relevant to exercise physiology. These are:

1.Chemical energy: It is stored or released during the making or breaking of molecular bonds.

2.Thermal energy: It is absorbed or released in the form of heat.

3.Mechanical energy: It is expanded in the performances of physical activities.

4.Electrical energy: It reflects the work needed to move electrically charged particles against the forces produced by electric fields.

5.Radiant energy: It is transmitted in the form of electromagnetic waves.

Energy currency

Energy is used by the body for its various physiological purposes. The rate at which energy is use varies greatly with different physical activities. Exercise increases this rate. In fact it is the function of metabolism to provide this energy. Energy sources are stored metabolized and utilized by the body. Food particles are ingested absorbed and finally metabolized and transfer their chemical energy into high-energy phosphate bonds in adenosine tri-phosphate (ATP) which can be regarded as the energy currency of our body. During physical activities the enzyme ATPase breaks the high-energy bond in ATP and makes the energy available for muscular contraction.

Energy used in physical Activities

Activity	Cal/Kg/hr
Sitting and standing	1.7
Sedentary occupations (overall rate)	1.7
Light industrial work (overall rate)	2.5
Personal necessities, e.g. dressing undressing shaving, bathing etc.	3.0
Walking (5km per hour)	4.0
Active recreation (e.g. cricket)	4.0
Heavy work (overall rate)	5.0

Sources of energy

The major sources of energy in our body are carbohydrates, fats and proteins. They are provided by nutrients that must be digested and absorbed into the body.

Carbohydrates:

They are composed of carbon, hydrogen and oxygen molecules. They may be divided into:

1. **Monosaccharides:** It is the simplest form of Carbohydrates that is not further digested. The main Monosaccharides in the diet are glucose, fructose and galactose.

2. **Disaccharides:** They are formed when pairs of monosaccharides are linked together. The main Disaccharides in the diet are sucrose, lactose and maltose. Sucrose is comprised of glucose plus fructose. Lactose is comprised of glucose plus galactose. And maltose is comprised of glucose plus glucose.

3. **Polysaccharides:** They are large complex molecules that consist of many units of monosaccharides linked together. Starch is a Polysaccharides made by plant cell from units of glucose and glycogen is a Polysaccharides made by animal cells from units of glucose.

Fats:

Fat is a major source of energy in the resting state and during prolonged low- intensity exercise. It is obtained mainly from the diet, but can also be synthesized in the body from carbohydrate. If excess fat is supplied in the diet, this may be stored as fat reserves in the body.

Proteins:

During exercise, quantitatively, protein is a less important fuel than either carbohydrate or fat Protein generally accounts for less than 2% of the fuel metabolism during exercise of less than one hour's duration; during prolonged exercise, protein can account for as much as 10% of the total energy usage.

Immediate source of energy for muscle contraction

The immediate source of energy for muscular contraction is the high-energy phosphate ATP.

ATP is degraded via the enzyme ATPase as follows

$$ATP \xrightarrow[ATPase]{} ADP + Pi + energy$$

Formation of ATP without the use of O_2 is termed anaerobic metabolism in contrast production of ATP using O_2 as the final electron acceptor is referred to as aerobic metabolism

Muscle cell can produce ATP by any one or combination of three metabolic pathways:

(i) ATP – PC system
(ii) Glycolysis
(iii) Oxidative Phosphorylation

The ATP – PC system and glycolysis are two anaerobic metabolic pathways that are capable of producing ATP without O_2

The Biological energy Cycle

All energy in our solar system originates in the sun. Where does this energy is called Solar energy.

Actually this energy arises from nuclear energy. Some of this nuclear energy reaches the earth as sunlight or light energy.

The millions of green plant that populate our earth store a portion of this energy from the sunlight in still another form-chemical energy.

In turn this chemical energy is utilized by green plants to build food molecules such as glucose cellulose. Proteins and lipids from carbon dioxide (CO_2) and water (H_2O). This process whereby green plants manufacture their won food is called photosynthesis.

We on the other hand are not capable of doing this. We must eat plant and other animals for our food supplies. We are therefore directly dependent on plant life and ultimately on the sun for our energy.

Food in the presence of O_2 is broken down to CO_2 and H_2O with the liberation of chemical energy by a metabolic process called respiration.

The sole purpose of metabolic respiration is to supply the energy we need to carry out such biological processes as the chemical work of growth and the mechanical work of growth and mechanical work of muscular contraction.

This entire process is called the biological energy cycle.

Muscle metabolic system during exercise:

The same basic metabolic systems are present in muscle as all other parts of the body. These important metabolic systems are-

(i) The phosphagen system
(ii) Glycogen lactic acid system
(iii) The Aerobic system.

The Phosphagen system

The combined amount of cell ATP and cell phosphocreatinine are called phosphagen energy system.

This energy system can provide maximum muscle power for 8-10 seconds, Almost energy for the 100-meter dash.

ATP: The basic source of energy for muscle contraction is Adenosine tri phosphate (ATP) which contain the following formula-

Adenosine – $po_3 \sim po_3 \sim po_3$-

The bonds attaching the last two phosphate radicals to the molecule, designated by the symbol (~) are high-energy phosphate bond.

Each of this bond stores 7300 calories of energy per mole of ATP under standard conditions when one phosphate radical is removed from the molecule. 7300 calories of energy is released and that can be used to energize the muscle contractile process and same for the second phosphate molecule.

Removal of phosphate radical converts the ATP into ADP (Adenosine di- phosphate) and removal of the second, converts this ADP into Adenosine mono phosphate (AMP).

Release of energy from PC (Phosphocreatinine):

Phosphocreatinine also called creatinine phosphate (CP) it is another chemical compound that has a high-energy phosphate bond. That has following formula-

Creatinine ~ po_3-_

This can decompose to creatinine and phosphate ion and in doing so release large amount of energy. In fact the high energy phosphate bond of phosphocreatinine has more energy than the bond of ATP (10,300 calories permole**)**
Special characteristics of energy transfer from phosphocreatinine to ATP within a small fraction of a second. Therefore, all the energy stored in the muscle phosphocreatinine instantaneously available for muscle contraction, just as the energy stored at ATP.

Glycogen lactic acid sysytem:

The stored glycogen in muscle can be split into glucose then used for energy. The initial stage of this process is called glycolysis. This occurs without use of oxygen and therefore is said to be anaerobic metabolism.

During glycolysis, each glucose molecule is split into pyruvic acid molecules and energy is released to form ATP molecule. Ordinarily the pyruvic acid enters into the mitocondria of the muscle cells and reacts with oxygen to form still many more ATP molecules. How ever when there is insufficient oxygen for this second stage (the oxidative stage) of glucose metabolism most of the pyruvic acid converted into lactic acid.
(Lactic acid defuse from blood & interstitial fluid)

Therefore in effect much of the muscle glycogen becomes tactic acid and considerable amounts of ATP are formed entirely without the consumption.

Under optimal conditions, this anaerobic glycolysis mechanism (i.e. – glycogen lactic acid system) can provide energy for short to mrdium periods of muscle contraction. The period of muscle contraction is 1.3 to 1.6 min.

The Aerobic System

The aerobic system means the oxidation of food staffs in the mitochondria to provide energy. Glucose, fatty acid and anino acids from the food after some intermediate processing combined with 0_2 to release tremendous amount of energy. This energy are used to convert AMP and ADP into ATP. This system is used for prolonged athletic activity.

The brief overview of important metabolic system that supply energy for muscle contraction-

(i) Phosphocreatinine	Creatinine + PO_3	ATP	Energy
(ii) Glycogen	Lactic acid	ADP	for
(iii) Glucose			muscular
Fatty acid			
Amino acid	CO_2 + H_2O	AMP	contraction

Energy Balance:

Energy is another word for “Calories”

Adenosine triphospate (ATP)

1. Definition: ATP (Addeosine triphosphate) is a high energy phosphate compound which is the strong form of energy in the body.
2. Composition:
   a) Adenine
   b) Ribose
   c) Phosphates.
3. Source:
   a) Oxidative phosphory lation
   b) Glycolysis
   c) TCA cycle.
4. Functions It helps in
   a) Synthetic process
   b) Muscular contraction
   c) Nerve conduction
   d) Active transport
   e) Secretion by the gland.

5. Role of ATP is metabolism: Removal of each phosphate radicle liberates 12000 cals of energy. After loss of one phosphate from ATP the compound becomes ADP and after losing of the second phosphate radicle the compound becomes AMP.

	-12000 Cals →	ADP	-12000 Calls →	AMP
ATP		+		+
	← +12000Cals	PO^3	← +12000 Cals	$2PO^3$
ATP				

In the living cell, the principal high-energy intermediate or carrier compound is adenosine triphosphate (ATP)

Catabolic process: Synthesized ATP
Anabolic process: Used ATP

ATP: is a nucleotide triphosphate containing adenine, ribose and three phosphate groups.

ATP: plays a central role in the transference of free energy from the exergonic to the endergonic process.

Exergonic: ATP → $ADP+P_1$
Endergonic: glucose + Pi → Glucose 6p+H^20

ATP: in its function in the cell, it function as the mg++ complex

2mg-ATP 2mg-ADP+pi

$C0_2+NH_4$ Carbamoyl phosphate

ATP: The turnover over rate of ATP is very high. In humans, an amount of ATP approximately equal to the body weight is formed and broken down every 24 hours.

ATP: The rapidity of ATP turnover precludes its use as a storage from of energy.

Motor Unit:

Each motor neuron that leaves spinal cord innervates many different muscle fibres, the number depending on the type of muscle.

All the muscle fibers innervated by a single motor nerve fiber are called a motor unit.

In general small muscles that react rapidly and whose control must be exact have few muscle fibers (as few as two to three in some of the laryngeal muscles) in each motor unit.
On the other hand, the large muscles that do not require very fine control such as the soleus muscle, may have several hundred muscle fibers in a motor unit.

An average figure for all the muscles of the body is questionable but a good guess would be about 100 muscle fibers to the motor unit.

The muscle fibers in each motor unit are not bunched together in a muscle but instead overlap other motor units in microbundles of 3 to 15 fibers. This interdigitation allows the separate motor units to contract in support of one another rather than entirely as individual segments.

Muscle Fatigue

Prolonged and strong contraction of a muscle leads to the well-known state of muscle fatigue. Studies in athletes have shown that muscle fatigue increases in almost direct proportion to the rate of depletion of muscle glycogen. Therefore most fatigue probably results simply from inability of the contractile and metabolic processes of the muscle fibers to continue supplying the same work output.

However, experiments have also shown that transmission of the nerve signal through the neuromuscular junction diminishes after prolonged muscle activity thus further diminishing muscle contraction.

Interruption of blood flow through a contracting muscle leads to almost compete muscle fatigue in 1 or more minutes because of the loss of nutrient supply, especially loss of oxygen.

Remodeling of Muscle to Match Function

All the muscles of the body are continually being remodeled to match the functions that are required of them.

Their- diameters are altered,
-Lengths are altered
-Strengths are altered
-Vascular supplies are altered and
Even the types of muscle fibers are altered at least slightly.

This remodeling process is often quite rapid within a few weeks.
Indeed experiments have shown that even normally the muscle contractile proteins can be totally replaced in as little as 2 weeks.

SOMATOTYPE

Somatotype deals with the body type of physical classification of the human body. According to Sheldon, the components are-

(i) Endomorph (ii) Mesomorph (iii) Ectomorph

Endomorph: The first component is endomorph. The characteristics of endomorph are- (i) Roundness and softness of the body

(ii) Predominance of abdomen over thorax

(iii) High square shoulder

(iv) Short neck

In layman's term endomorph is the 'fastness' of the body

Mesomorph: The second component is mesomorph. The characteristics of mesomorph are- (i) Square body with hard and prominent musculation.

(ii) The bones are large and covered with thick muscle.

(iii) Legs, trunk and arms are usually massive in bone.

(iv) Forearm thickness.

(v) Heavy wrist, hand and fingers.

(vi)Thorax is large.

(vii) Waist is slender.

(viii) Shoulder is broad.

(ix)Trapezeus and deltoid muscle are quiet massive.

(x) Abdominal muscles are prominent and thick.

Ectomorph: The third component is ectomorph. The characteristics are –

(i) Linearity, fragility and delicacy of body.

(ii) The bones are small.

(iii) The muscle is thin.

(iv)The Shoulder is droop.

(v) The abdomen and lumber curve flat.

(vi)The thoracic curve is relatively sharp and elevated.

Measurement of Fat

Anthropometric method (skin fold calipers)

1. All the skin fold measurement are taken on the dominant side of the body and are recorded in millimeters
2. The skin fold is picked up between the thumb and index finger
3. The calliper is applied about one centimeter form the finger
4. the procedure is repeated three times and the average is recorded
5. Measurement should be time preferably in the morning.

BLOOD

Blood is a specialized connective tissue, composed of fluid portion-plasma and the cellular elements, circulating through the cardiovascular system and carrying the substances essential for living.

Composition:

2. Main constituents:

A) Plasma (55%)

Water (90%) Solid (10%)

Organic	Inorganic
Plasma protein	Na
Enjymes	K
Hormones	Ca
Antibodies	Mg
Clotting factors	Fe
Fat	Cl
Glucose etc.	

B) Cellular elements (formed elements)

1. RBC
2. WBC
3. Platelets

Functions:

Transport of respiratory gases (Co2 & O2)
Transport of nutrients from GIT
Transport of metabolic wasts product to the site of elimination.
Carries antibodies for immunity
Acts as a vehicle for hormones and other substances that regulates cellular function.
Contain buffer system which regulate normal acid base balance of the body.
Maintain body temperature
Responsible for maintenance of water balance.
By the action of plasma protein it maintain colloidal osmotic pressure.
By the process of coagulation it prevent hemorrhage.

Athlete Heart

A non pathological enlarged heart often found in endurance athlete. It is the result of LVH (left ventricular hypertrophy) in response to training. This is common in athletes who exercise more than an hour almost every day and occasionally in heavy weight trainers.

Mechanism:

- Prolong endurance and weigh training

  Blood volume and left ventricular filling pressure

  Left ventricular volume (i.e. the walls stretch more when filled with blood)

- Natural physical Adaptation occurs in the athlete's heart due to regular exercise.

Thickness of the wall (Through the addition of sarcomeres) and increase Chamber size.

- Endurance training improves heart performance by increasing left ventricular volume and cardiac contractility.

Changes in Athlete Heart

- Axis deviated to left more.
- Increase thickness of the wall
- Increases stroke volume (stroke volume 170ml. (Approx.) in elite endurance athlete)
- Increase cardiac out put.
- Brady cardiac (Decreased resting and sub maximal exercise heart rate)
- Improved calcium release and transport.
- Altered ECG (Electro Cardiogram)

Introducion

Sports persons are directly involved in regular physical exercise to enhance their performances in competition of different levels. Exercise physiology laboratory which is the most important in this field, because study about exercise, how it creates impact on human body, that is exercise physiology.

To find out the physiological changes or responses, various interaction and adjustments physiologically before, during and after exercise are the aim of this department.

We are spending most of our study time examining work physiology how the body reacts to various training regimes, how the adaptation process take place, factors that can limit adaptation and so on.

In this department, periodical evaluations of BKSP students were done on the basis of Energy Index and Vertical jump. This is capable of proving the individual sportsman or woman with a very elaborate evaluation profile.

Barach Index(Energy Index)

The Barach Energy Index has been utilized for over fifty years. This test was devised to measure the amount of energy expended by the heart. The items measured are the pulse rate, the systolic pressure and the diastolic pressure. These measures are taken while the subject is seated and after consistent consecutive readings have been obtained.

The readings are inserted in the formula

$$\text{Energy Index} = \frac{(\text{Systolic Pressure} + \text{Diastolic Pressure}) \times \text{Pulse rate}}{100}$$

to correlate fairly well with a measure of cardiac output which consisted of heart stroke volume for an all –out run on a treadmill divided by body surface area.

Example: An individual has a blood pressure reading of 124/82 and a resting pulse rate of 75. His energy index is:

$$\text{Energy Index} = \frac{(124+82) \times 75}{100} = 154.5$$

Barach indicated that healthy persons could be expected to have scores of about 110 to 160. Individuals scoring over 200 were considered to be hyper tensed and persons scoring below 90 were considered hypo tensed. Hunsicker found the Barach energy Index

THE MEASUREMENT OF POWER

Power may be identified as the ability to release maximum force in the faster possible time, as is exemplified in the vertical jump, the broad jump the short put and other movements against a resistance in a minimum of time.

The measurement of power in physical education has recently become controversial enough to warrant recognition of two types of such measurement. The two types are identified as follows:

Athletic Power Measurement: This type of measurement is expressed in terms of the distance through which the body or an object is propelled through space. Such tests as the Sargent jump broad jump and medicine ball put are both practical and common tests of athletic power. While such tests involve both force and velocity other factors also influence testing results. However the factors of force and velocity are not measured as such thus only the resultant distance (inches or feet) is recorded in athletic power measurement.

Uses of Power Test

1. As a factor in physical fitness and motor ability test
2. As a means to motivate students to improve their status within the class
3. As a measure for determining achievement and grades when improvement in athletic power is a specific objective in a physical activity class.
4. As a means to indicate an individual's potential for varsity athletics.

Vertical Jump Test

Objective: Using a double- foot take off o jump vertically as high as possible with maximum effort.

Validity: Construct of validity of jumping ability

Equipment: A smooth wall of sufficient height a yardstick and chalk, weight scales are required for the test. The subject must be dressed in shorts, light shirt, and no shoes.

Direction: Record the performer's weight and them have him assume a standing position facing sideways to the jump board the preferred arm behind the back (hand grasping top of shorts at the back) and the other arm raised vertically with the hand turned outward and fingers extended. Holding the described position the performer should stand as tall as possible on the toes so that the height of the extended middle finger of the raised arm can be recorded. Chalk dust is then placed on the middle finger and the performer adopts a fill squat position with head and back erect and body in balance. The performer's is then told to jump as high as possible (using only the legs) and to touch the board at the top of the jump. The tester must watch and disregard any jump in which balance or position is lost. The tester should recover the height of the chalk mark on the jump board. Each performer is allowed three trials. On the last trial the tester should say, "This is your last jump. Try to beat your last two jumps."

Scoring: Using the measure of the best jump (difference between the reaching height and jumping height).

Norms: Vertical jump norms for boys and girls are listed in Table-1

Table-1

Percentile	13	14	15	16	17
95	17	18.5	19.25	20.25	21.5
75	14.5	15.75	16.75	17.5	19
50	13.0	14.5	15.23	16.25	17.5
25	11.25	12.5	13.5	14.5	15.75
05	7.75	9.00	10	10.75	12.2

Girls				
95	14.0	14.5	15.25	15.25
75	11.75	12.25	13	13
50	10.25	10.75	11.75	11.75
25	09	9.5	10.25	10.25
05	6.75	7.25	8.00	8.00

Onset of Blood Laclate Accomulation(OBLA):

During steady state exercise,aerobic metabolism is reached to the energy requirements of the active muscles.Under these conditions there is little or no accumulation of blood lactate.

The term lactate threshold refers to the highest exercise intensity or level of oxyzen uptake that is not avouted with an elevation in blood lactate concentration above the pre-exercise level(or an increase less than 10mm).

The region in which blood lactate shows a systemic increase equal to or above than a level of 4.0mm is termed the point of Onset of Blood Lacate Accomulation or simply OBLA.

Often the term lactate threshold and OBLA are used interchangeably although their precise points of demarcation in terms of exercise intensity are operationally different.

OBLA implies a maximum exercise intensity that a person can sustain for a prolonged period.In reality ,this maximum stable lactate level is probably quite variable among individuals.

OBLA represents a distinct point for the onset of muscle anaerobiosis.
OBLA, it generally considered to reflect the start of the exponential accumulation of lactate acid in yje active muscle.

Blood Lactate Accomulation is associated with changes in carbondioxide production(respiratory exchange ratio)via buffering ,blood PH, bicarbonate,and H+ concentration.These variables have been used to indirectly assess OBLA.

Specificiality of the point of OBLA as with many measures of physiologic fumction and exercise performance;OBLA is specific to the exercise task.Differences in OBLA occurs when comparing bicycle treadmill and armcranck exercise at all levels of oxyzen uptake.

Measurement of the Skin fold Thickness

Beneath the skin is a layer of subcutaneous fat and the percentage of total body fat can be measured by taking the skin fold at selected sites on the body. Only equipment needed is a pair of calipers.

- All the skin fold measurements were taken on the dominant side at the body and were recorded in millimeters.
- The skin fold was picked up between the thumb and the index finger so as to include two thicknesses of skin and subcutaneous fat.
- The calipers were applied about 1 cm from the fingers and at a depth about equal to the thickness to the fold.
- The procedure was repeated three times and the average was recorded.

Durnin and Rahaman have suggested the following sites for taking the skin fold measurements. While taking measurements the subjects was standing in anatomical position.

- Triceps: The skin fold was taken midway between the top of the shoulder and the tip of the elbow.
- Biceps: The skin fold was taken at a point midway between the elbow and the armpit.
- Subscapular: The skin fold was taken just below the tip of the shoulder blade at an angle of 45^0 to the inferior angle of scapula.
- Suprailiac: The skin fold was taken just above the crest at the hip.

All the four measurements were recorded in millimeters and summed up. With the help of a ready reckoner, the body composition was estimated.

Factors influencing training effects:

1.The intensity of training session .
2.The frequency of training session and duration of training programmes.
3.Type of training programme i.e.specificity of training effects.
4.Genetic limitation
5.The mode of exercise used during the training program.
6.Maintainance of training effects.

Intensity of training :
It represents the degree of effort made by the sports person while performing an exercise.
The degree of effort is always considered in relation to time .
It is equated with the amount of force or energy spent in relation to time.

Types of intensity training:
1.Intensity of stimulus/load intensity
2.Density of stimulus/load density.

Density of intensity:
The intensity of stimulus can be describe by speed in a cyclic exercise,amount of load during muscle strength exercise,the pace of game and frequency of movement.
The intensity of stimulus is always expressed in percentage in relation to the maximum possible intensity i.e 100%.

Density of stimulus:
The duration of stimulus refers to the duration of recovery phages between two motor stimuli and sets of motor stimuli.
It is also termed as the ratio between the phages of load and recovery.
(It is the rest period between two stimuli).

Principles of intensity of stimulus:
1.No development effect (if intensity <30%).
2.In endurance exercise,intensity should create and effect on cardiovascular system.
3.Only high intensity creates supercompensation effect in sports person.
4.High intensity causes rapid improvement but performance is less stable.

**Extensive training causes slow improvement but performance is more stable.]

Volume of training/Volume of load/load volume:
It is the total amount of work done while performing an exercise or training session.

Types of volme load:
1.Duration of stimulus/movement duration.
2.Frequency of stimulus/movement frequency.

1.Duration of stimulus/movement duration:-
The duration of stimulus represents time of influence of one stimulus or a set of stimuli e.g lifting time in strength training exercise,distance run in a running activity(interval running).

2.Frequency of stimulus/movement stimulus:
The frequency of stimulus is the number of times an exercise or a movement is repeted.
It is the number of repetation.

Principles of volume of training:

1.The dose of volume should be given depending upon the sports person best capacity.
2.The dose of volume should be given such that visible symptoms of tiredness are seen.
3.Volume should be gradually increased
4.Volume of training should always be in harmony.

Doping

Doping is the work used in sport when atheletes use prohibited substances or methods to unfairly improve their sporting performance.

Doping is the use of substances or the employment of means in an attempt to augment artificially the performance of an athlete, during, either participation or preparation.

Doping is the deliberate or inadvertent use by an athlete of a substances or method prohibited by the IOC.

Why doping is prohibited:

Doping is prohibited because-

1.Doping undermines the fundamental joy of sport and our collective persuit of human and sporting excellence.
2.To protect atheletes from the unfair advantage which may gained by doping.
3.To prevent from the possible harmful side effects.
4.Doping severely damages the integrity,image and value of sport.
5.To achieve integrity and fairness in sport.
6.The distribution and prohibited substances(eg anabolic agents) may be illegal in many countries,if not for a medical justified reason.

THE PRE-COMPETITION MEAL

The pre-competition meal is extremely important to the athlete so as to ensure optimal performance during athletic competition. It should help give the athlete the necessary energy and hydration in order to perform at a high level throughout the competition. It should also keep the athlete fro feeling hungry during the competition. The following guidelines will help plan the pre-competition meal so the athlete can get the most out of their body when they need it the most.

- Eat the meal at least three hours before the event
- Eat high starch foods – carbohydrates should make up about 60 of your pre-competition meal

Examples include spaghetti, pasta, ravioli, noodles, macaroni, breads (rolls, whole or multi-grain sliced breads, bagels), rice (preferable brown or wild), potatoes (russet and sweet), pancakes, cereals (hot & cold), crackers and carrots. Fresh fruits and low-fat granola bars are also good choices for pre-comp meals.

- Limit fats and oils
- Restrict high sugar foods
- Avoid foods and drinks that contain caffeine
- Avoid foods that produce gas (i.e. certain raw vegetables, certain fruits, or certain beans, high fiber foods)
- Avoid foods that may cause acid reflux (i.e. spicy foods)
- Avoid drinking carbonated beverages
- Avoid eating food that are unfamiliar to you and your body is not accustom to digesting
- Drink plenty of fluids with your pre-comp meal

The pre-competition meal is extremely important, but will not work miracles for the athlete in terms of competition performance. The pre-comp meal and the competition performance are set up by sound nutrition habits days, weeks, and months before the competition.

Primary Factors that Affect Athletic Performance

-Genetics
-Training
-Nutrition

Rewards of High- Performance Nutrition

-Train longer and harder
-Delay fatigue
-Help your body recover faster after working out
-Perform much better overall

Nutrients: the body's fuel

-Carbohydrates: primary fuel source
-Protein: used for repair & maintenance
-Fat: secondary fuel source
-Water: most essential nutrient
-Vitamins: colorful foods first
-Minerals: supplements second
-Fiber: 20-35 grams per day

Nutrient Distribution

Each meal should contain the following estimated calories from the 3 fuel sources

55-65% carbohydrates
15-20% protein
20-25% fat

Protein Needs of Athletes

Take your body weight and divide it by 2 = Grams of protein needed per day for athletes

Sources of Protein

Amount	Grams of Protein
Milk (1 cup)	8 grams
Tuna (1 oz)	7 grams
Meat (1oz)	7 grams
Egg (1)	7 grams
Cheese (1 oz)	7 grams
Beans (1/2 cup)	7 grams

Menu Planning for Athletes

-Follow the Handout
-Find your gender sheet (female or male)
-Find your weight (goal weight if wanting to gain or lose)
-Review what you should be eating
-Compare to what you really eat

Guidelines for Choosing the Best Pre-Event Meal

-Provide athlete with foods he/she likes
-Choose foods rich in carbohydrates, moderate in protein, and low in fat
-Avoid sugary foods right before exercise
-Allow plenty of time for food to digest
-3-4 hours for a large meal
-2-3 hours for a smaller meal
-1-2 hours for a snack
-Liquid foods leave stomach faster than solids
-Always eat familiar foods before competition

-Drink plenty of fluids before competition

Hydration & Fluid Replacement

-Our body is water 60% water
-120 lb person has ~ 72 pounds of water
-Most individuals need ~ 8-10 cups of water per day
-Calculate your needs: Take your body weight divide by 2 = ounces per day.

Signs of Dehydration

-Thirst
-General discomfort
-Headache
-Nausea
-Vomiting
-Heat sensation in head or neck
-Chills
-Decreased performance
-Dizziness
-Confusion

Fantastic Fluids for Fantastic Performance

Water is one of the most important nutrients in your sports diet.

How Much is Enough?

Before exercise
-Up to two hours before event, drink at least 16 oz. of fluid
-5 to 10 minutes before event, drink 4 - 8 oz. of fluid
During exercise
-8 oz. of fluid every 15 - 20 minutes
After exercise
-Drink 2 cups fluid for every pound lost

Choosing the Right Fluids During Exercise

-Cold water
-absorbs quicker
-tastes better
-cools down body temperature in warm weather
-economical
-Fluid replacement beverage
-provides carbohydrates and electrolytes
-Increases thirst for water
-Consider if exercise is continuous and lasts longer than 90 minutes

Vitamins & Minerals:Hype or Help

n small amounts, vitamins function as catalysts - substances that increase the speed of a reaction without being used up by the reaction. The fact that vitamins are not used up explains why they are needed only in small amounts.

Your Game Plan for High-Performance Nutrition

Eat a variety of high-carbohydrate, moderate protein, low-fat foods
Drink enough fluids to avoid dehydration
Take supplements only when necessary

Dissolved O_2:

After entering into the blood,oxygen is transported as dissolved state in the plasma(about 3%) which is called dissolved oxygen.
The amount of dissolved oxygen in the arterial blood at PO_2 95mmHg approximately(0.27-0.3)ml/100ml of blood.

Significance: Respiratory for the pressure of O_2 in the blood.

Oxyhaemoglobin:

O_2 difuses into red blood cells and combines reversebly with the haemoglobin and thus form oxyhaemoglobin .
This reaction is oxygenation not an oxidation because it is non-enzymatic reaction.Oxidaized haemoglobin is useless for the biological carriage of O_2.
O_2 combine resersibly with the iron porphyrin complex of 4 heme units of Hb.So each Hb can combines with 4 molecules of O_2.

Hb_4+O_2- Hb_4O_2

$Hb_4O_2+O_2$- Hb_4O_4

$Hb_4O_4+O_2$- Hb_4O_6

$Hb_4O_6+O_2$- Hb_4O_8

(i.e. Hb is 100%saturated)

Structure of the Respiratory Tract:

1.Upper Respiratory Tract
- a.Nose
- b.Naso-pharynx
- c.Larynx

2.Lower Respiratory Tract:
- a.Trachea
- b.Bronchi
- c.Bronchioles &The Acinus.

Functions of the Respiratory Tract:

Nose:1.Warming of air during nasal breathing.
2.Humidification of air.
3.Filtration of inspired air.
Collectively those are called "conditioning of air".
Pharynx: Air continues through the pharynx.
Larynx:1.Basic function is to keep blood and drink out of the airway.
2.Additional role to produce sound.
Trachea:1.Air enter into the body through trachea.
2.Provide a muco-ciliary escalator for removal of debris trapped of the mucus.

Bronchi: From the trachea air enters into the lungs through bronchi.
Acinus: The acinus is the gas exchange unit of the lungs.Each acinus comprises:
a.Respiratory bronchioles liading to.
b.Alveolar ducts,Alveolar sacs and
c.Alveoli.

Altitude Acclimatization:
Physiological adjustment through continued exposure to attitude and which significantly improve performance are called acclimatization.For unacclimatizatized person,additional oxygen is essential at above the sea level(18000feet/5488m).
Longer you remain at altitude better becomes your performance.But that is not equal at the sea level.This improve performance during staying at altitude is brought about through acclimatization.Time for the acclimatization depends on the altitude.e.g.

7-10days for 10000 feet
15-21days for 12000 feet
21-25days for 15000 feet.

It depends on individuals ,some people will never acclimatization and they suffer mountain or altitude sickness.
The symptoms of altitude sicknesss are-
a.Pulmonary edema.
b.Nausea
c.Vomiting
d.Headache
e.Rapid pulse
f.Loss of appetite
g.Congestion of lungs.

Treatment of mountain sickness:
a.Administering O2
b.Removal the sufferer to lower altitude
c.Or both

The main reason for less performance at altitude is a consequence of the lowered O2 pertial pressure(PO2).This lowered PO2 results to hypoxia .Hypoxia stimulates the acclimatization mechanism depending upon the altitude and duration of stay.

Physiological changes due to altitude acclimatization:
1.Increase pulmonary ventilation (within few hours).
2.Increase number of R.B.C.&haemoglobin concentration (within few weeks)
3.Elimination of Bi-carbonate(HCO3).(HCO3 in the urine)
4.Tissue level changes-
a.Increase muscle & tissue capilarization.
b.Increase mytochondria density
c.Increase myoglobin concentration
d.Enhance the oxidative capacity.

Partial pressure of gases:

The amount of pressure exerted by the individual gas in a gas mixture,which is directly proportionate to the concentration(i.e. number) of gas molecule in that mixture.

Sites	PO2(mmHg)	PCO2(mmHg)
1.Atmospheric gas(inspired air)	158	0.3
2.Alveolar gas	100	40
3.End-Pul.capillery blood	100	40
4.Systemic arterial blood	95	40
5.Mixed venous blood	40	46
6.Expired gas	110	32

Gas exchange & transport:

Transport of O2 by blood:

1.From lung alveoli to arterial blood.

Partial pressure of oxygen in the lung alveoli is 104mmHg and in the arterial blood is 95mmHg.Due to this pressure gradient(104-95=9mm of Hg),O2 goes from alveoli to arterial blood.

2.From arterial blood to tissue fluid:

The partial pressure of O2 in arterial blood is 95mmHfg and in the tissue fluid level is 40mmHg.So,O2 enters into the tissue fluid at the pressure gradient of(95-40=55mm Hg)

3.From tissue fluid to cell:

The partial pressure of O2 in the tissue fluid is 40mmHg and in the cell is 23mmHg.So,O2 diffuses from tissue to cell at the pressure gradiant of(40-23=17mmHg).

Transport of Carbon-dioxide:

1.From body cell to tissue and arterial end of pulmonary capillary:

The pressure of CO2 in cell is 46mmHg and in the tissue it is 45mmHg .So, CO2 diffuse out of the cell and enters into tissue due to pressure gradiant (46-45)=1mmHg.

2.From arterial end of pulmonary capacity to alveoli:

The pressure of CO2 in the arterial end pulmonary capacity is 45mm of Hg and in the alveoli is 40mmHg.So,CO2 enters into the alveoli due to pressure gradiant of(45-40)=5mmHg.

BLOOD

Definition:

Blood is a specialized connective tissue, composed of fluid portion-plasma and the cellular elements, circulating through the cardiovascular system and carrying the substances essential for living.

Properties-5

Composition:

2. Main constituents:

A) Plasma (55%)

Water (90%)	Solid (10%)
Organic	Inorganic
Plasma protein	Na
Enjymes	K
Hormones	Ca
Antibodies	Mg
Clotting factors	Fe
Fat	Cl
Glucose etc.	

B) Cellular elements (formed elements)

1. RBC
2. WBC
3. Platelets

Functions:

Transport of respiratory gases (Co2 & O2)

Transport of nutrients from GIT

Transport of metabolic wasts product to the site of elimination.

Carries antibodies for immunity

Acts as a vehicle for hormones and other substances that regulates cellular function.

Contain buffer system which regulate normal acid base balance of the body.

Maintain body temperature

Responsible for maintenance of water balance.

By the action of plasma protein it maintain colloidal osmotic pressure.

By the process of coagulation it prevent hemorrhage.

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Chamber size.

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- Increases stroke volume (stroke volume 170ml. (Approx.) in elite endurance athlete)
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- Brady cardiac (Decreased resting and sub maximal exercise heart rate)
- Improved calcium release and transport.
- Altered ECG (Electro Cardiogram)

VO2max

Fitness can be measured by the volume of oxygen you can consume while exercising at your maximum capacity.

VO2max is the maximum amount of oxygen in millilitres, one can use in one minute per kilogram of body weight.

Those who are fit have higher VO2max values and can exercise more intensely than those who are not as well conditioned.

Numerous studies show that you can increase your VO2max by working out at an intensity that raises your heart rate to between 65 and 85% of its maximum for at least 20 minutes three to five times a week.

A mean value of VO2max for male athletes is about 3.5 litres/minute and for female athletes it is about 2.7 litres/minute.

Normative data for VO2max

Normative data (Heywood 1998) for Female (values in ml/kg/min)

Age	Very Poor	Poor	Fair	Good	Excellent	Superior
13-19	<25.0	25.0 - 30.9	31.0 - 34.9	35.0 - 38.9	39.0 - 41.9	>41.9
20-29	<23.6	23.6 - 28.9	29.0 - 32.9	33.0 - 36.9	37.0 - 41.0	>41.0
30-39	<22.8	22.8 - 26.9	27.0 - 31.4	31.5 - 35.6	35.7 - 40.0	>40.0
40-49	<21.0	21.0 - 24.4	24.5 - 28.9	29.0 - 32.8	32.9 - 36.9	>36.9
50-59	<20.2	20.2 - 22.7	22.8 - 26.9	27.0 - 31.4	31.5 - 35.7	>35.7
60+	<17.5	17.5 - 20.1	20.2 - 24.4	24.5 - 30.2	30.3 - 31.4	>31.4

Normative data (Heywood 1998) for Male (values in ml/kg/min)

Age	Very Poor	Poor	Fair	Good	Excellent	Superior
13-19	<35.0	35.0 - 38.3	38.4 - 45.1	45.2 - 50.9	51.0 - 55.9	>55.9
20-29	<33.0	33.0 - 36.4	36.5 - 42.4	42.5 - 46.4	46.5 - 52.4	>52.4
30-39	<31.5	31.5 - 35.4	35.5 - 40.9	41.0 - 44.9	45.0 - 49.4	>49.4
40-49	<30.2	30.2 - 33.5	33.6 - 38.9	39.0 - 43.7	43.8 - 48.0	>48.0

50-59	<26.1	26.1 - 30.9	31.0 - 35.7	35.8 - 40.9	41.0 - 45.3	>45.3
60+	<20.5	20.5 - 26.0	26.1 - 32.2	32.3 - 36.4	36.5 - 44.2	>44.2

The Rockport Fitness Walking Test:

The Rockport Walking Test is a simple self-paced test to predict aerobic power (VO_2max). The test is ideal for use with large groups of subjects but can also be used for individuals.

The Test

The test consists of individual walking 1mile(1609 Meters) as fast as safely possible, without jogging or running.

Test procedure

-The test can be administered outdoors on a track or indoors on a Treadmill and will gives similar results .

-The subject's weight is recorded in Kg or Pounds.

-The subject is instructed for Walking one mile (1609meters) as fast as safely possible.

-Time is recorded after completion of one mile walk.

-Post exercise (Immediately on finishing the walk) heart rate (beats per minute) is recorded.

-Predicted VO_2 max (ml/Kg/min) is calculated by using the formula.

VO_2max= 132.853-(0.0769 × Weight) – (0.3877× Age) + (6.315× Gender) - (3.2649 × Time) - t(0.1565× Heart rate)

Or VO_2max (ml/Kg/min) is calculated by using the online calculator.

Where,

Weight is in Kg or pounds (lbs).

Gender Male = 1 and Female = 0

Time is expressed in minutes and 100ths of minutes.

Post Exercise Heart rate is in beats /minute.

Age is in Years.

The result is compared with the norm.

Improving your VO2max

The following are samples of Astrands (a work physiologists) workouts for improving oxygen uptake:

- (1) - Run at maximum speed for 5 minutes. Note the distance covered in that time. Let us assume that the distance achieved is 1900 metres. Rest for five minutes, and then run the distance (1900 metres) 20% slower, in other words in six minutes, with 30 seconds rest, repeated many times. This is equal to your 10 Km pace
- (2) - Run at maximum speed for four minutes. Note the distance covered in that time. Rest for four minutes. In this case, we will assume you run a distance of 1500 metres. Now run the same distance 15% slower, in other words in 4 minutes 36 seconds, with 45 seconds rest, repeated several times. This approximates to a time between the athlete's 5 Km and 10 Km time
- (3) - Run at maximum effort for three minute. Note the distance covered in that time. The distance covered is, say 1000 metres. Successive runs at that distance are taken 10% slower or at 3 minutes 18 seconds, with 60 seconds rest, repeated several times. This approximates to your 5 Km time
- (4) - Run at maximum effort for five minutes. Note the distance covered in that time. The distance covered is 1900 metres. Rest five minutes. The distance is now covered 5% slower with one and a half minutes rest. This is approximately 3K pace for you, i.e., five minutes 15 seconds/1900 metres
- (5) - Run at maximum effort for three minutes. The distance covered is 1100 metres. When recovered, the athlete then runs the same distance 5% slower, i.e., three minutes nine seconds/1100 metres, with one minute rest, repeated several times. This is at 3 Km pace

When and how often

It is suggested that in the winter sessions (1) and (2) are done weekly, and in the track season sessions (3), (4) and (5) are done weekly by runners from 800 metres to the half-marathon. Although it would be convenient to use the original distance marks made by the duration efforts, this does not take into account the athlete's condition before each session, so the maximum effort runs must be done on each occasion when they may be either more or less than the previous distance run. The maximum duration efforts are in themselves quality sessions. If the pulse rate has not recovered to 120 beats per minute in the rest times given, the recovery period should be extended before the repetitions are started. The recovery times between the repetitions should be strictly adhered to. These workouts make a refreshing change from repetition running. When all five sessions are completed within a month, experience shows substantial improvements in performance.

The effect of altitude

VO2 max decreases as altitude increases above 1600m and for every 1000m above 1600m maximal oxygen uptake decreases by approximately 8-11%. The decrease is mainly due to a decrease in maximal cardiac output (product of heart rate and stroke volume). Stoke volume decreases due to the immediate decrease in blood plasma volume.

% MHR and %VO2max

It is possible to estimate your exercise intensity as a percentage of VO2max from your training heart rate. A study by David Swain et al. (1994) using statistical procedures examined the relationship between %MHR and %VO2max. Their results led to the following regression equation:

- %MHR = 0.64 × %VO2max + 37

The relationship has been shown to hold true across sex, age and activity.

%VO2max and Speed

% of VO2max	Speed
50	Very slow running
60	Slow running
70	Steady running
80	Half Marathon speed
90	10 km speed
95	5 km speed
100	3 km speed
110	1500 metres to 800 metres speed

Free Calculator

- %VO2max to %MHR Calculator - a free Microsoft Excel spreadsheet which you can download and use on your computer. The spreadsheet will be loaded into a new window.

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Cooper VO2max Test

Testing and measurement are the means of collecting information upon which subsequent performance evaluations and decisions are made but in the analysis we need to bear in mind the factors that may influence the results.

Objective

The Cooper Test (Cooper 1968) [1] is used to monitor the development of the athlete's aerobic endurance and to obtain an estimate of their VO2max.

Required Resources

To undertake this test you will require:

- 400 metre track
- Stopwatch
- Whistle
- Assistant

How to conduct the test

This test requires the athlete to run as far as possible in 12 minutes.

- The athlete warms up for 10 minutes
- The assistant gives the command "GO", starts the stopwatch and the athlete commences the test
- The assistant keeps the athlete informed of the remaining time at the end of each lap (400m)
- The assistant blows the whistle when the 12 minutes has elapsed and records the distance the athlete covered to the nearest 10 metres

Assessment

For an evaluation of the athlete's performance select the age group and gender, enter the total distance covered and then select the 'Calculate' button.

Age Gender Distance [ ] metres

Assessment - [ ]

Normative data for the Cooper Test

Male Athletes

Age	Excellent	Above Average	Average	Below Average	Poor
13-14	>2700m	2400-2700m	2200-2399m	2100-2199m	<2100m
15-16	>2800m	2500-2800m	2300-2499m	2200-2299m	<2200m
17-19	>3000m	2700-3000m	2500-2699m	2300-2499m	<2300m
20-29	>2800m	2400-2800m	2200-2399m	1600-2199m	<1600m
30-39	>2700m	2300-2700m	1900-2299m	1500-1899m	<1500m

40-49	>2500m	2100-2500m	1700-2099m	1400-1699m	<1400m
>50	>2400m	2000-2400m	1600-1999m	1300-1599m	<1300m

Female Athletes

Age	Excellent	Above Average	Average	Below Average	Poor
13-14	>2000m	1900-2000m	1600-1899m	1500-1599m	<1500m
15-16	>2100m	2000-2100m	1700-1999m	1600-1699m	<1600m
17-20	>2300m	2100-2300m	1800-2099m	1700-1799m	<1700m
20-29	>2700m	2200-2700m	1800-2199m	1500-1799m	<1500m
30-39	>2500m	2000-2500m	1700-1999m	1400-1699m	<1400m
40-49	>2300m	1900-2300m	1500-1899m	1200-1499m	<1200m
>50	>2200m	1700-2200m	1400-1699m	1100-1399m	<1100m

VO2max

An estimate of your VO2max can be calculated as follows:

- (Distance covered in metres - 504.9) ÷ 44.73

For an estimate of your VO2max enter the Distance covered and then select the 'Calculate' button.

Distance metres VO2max mls/kg/min

For an assessment of your VO2max score see the VO2max page.

Analysis

Analysis of the test result is by comparing it with the athlete's previous results for this test. It is expected that, with appropriate training between each test, the analysis would indicate an improvement in the athlete's VO2max, anaerobic and aerobic thresholds.

Target Group

This test is suitable for endurance athletes and players of endurance sports (e.g. football, rugby) but not for individuals where the test would be contraindicated.

Reliability

Test reliability refers to the degree to which a test is consistent and stable in measuring what it is intended to measure. Reliability will depend upon how strict the test is conducted and the individual's level of motivation to perform the test. The following link provides a variety of factors that may influence the results and therefore the test reliability.

Validity

Test validity refers to the degree to which the test actually measures what it claims to measure and the extent to which inferences, conclusions, and decisions made on the basis of test scores are appropriate and meaningful. This test provides a means to monitor the effect of training on the athlete's physical development. There are published VO2 max tables and the correlation to actual VO2max is high. For an assessment of your Vo2 max see the [VO2max normative data tables.]

Advantages

- Minimal equipment required
- Simple to set up and conduct
- More than one athlete can conduct the test at the same time
- The test can be administered by the athlete

Disadvantages

- Specific facilities required - 400m track
- Assistant required to administer the test

Heart Rate

Heart Rate: Heart rate, determined by the number of times heart beats in each minute, is an important measure of health.

Heart rate can vary as the body's need to absorb oxygen and excrete carbon dioxide changes, such as during exercise or sleep.

How hard your heart has to work during various activities can tell you a lot about your overall physical condition.

Resting Heart Rate: The resting heart rate (HR_{rest}) is a person's heart rate when they are at rest, that is lying down but awake, and not having recently exerted themselves.

Your resting heart rate measures the speed at which your heart beats during periods of little physical activity. The best time to measure your resting heart rate is in the morning before you get out of bed.

The typical resting heart rate in adults is 60-90 bpm,[with rates below 60 bpm referred to as bradycardia, and rates above 100 bpm referred to as tachycardia. Conditioned athletes often have resting heart rates below 60 bpm, with values of below 40 bpm not unheard of. For instance, cyclist Lance Armstrong has been known to have resting heart rates to as low as around 32 bpm, cyclist Miguel Indurain had a resting heart rate of 28 bpm. The low pulse in conditioned athletes is due to hypertrophy of the cardiac muscles, therefore enabling a higher volume of blood being pumped at each beat (i.e. higher stroke volume).

The normal heart rate **in children** is variable and depends on the child's age. Children exercising can have heart rates up to 200 bpm.

Maximum heart rate: The maximum heart rate (HR_{max}) is the highest heart rate an individual can safely achieve through exercise stress, and depends on age.

Often used to calculate your target heart rate, your maximum heart rate measures the speed at which your heart beats during intense physical activity. It is most safely measured in a controlled medical environment, but you can estimate your maximum heart rate by subtracting your age from 220. For example, a 30-year-old's maximum heart rate would be estimated at 190 beats per minute.

The most accurate way of measuring HR_{max} is via a cardiac stress test. In such a test, the subject exercises while being monitored by an EKG. During the test, the intensity of exercise is periodically increased (if a treadmill is being used, through increase in speed or slope of the treadmill), continuing until certain changes in heart function are detected in the EKG, at which point the subject is directed to stop. Typical durations of such atest range from ten to twenty minutes.

Target Heart Rate: Also known as the training heart rate, your target heart rate measures the speed at which your heart beats during peak aerobic exercise and can help you decipher whether you're working out at a level of intensity that's appropriate for you. Your target heart rate is usually equivalent to 60-85% of your maximum heart rate. In the example above, the 30 year old man's maximum heart rate was 190 (220-30), so his target heart rate would be 114-161.5 beats per minute ((190 x .6) - (190 x .85)).

Measuring Heart Rate

The measurement of heart rate is used by medical professionals to assist in the diagnosis and tracking of medical conditions. It is also used by individuals, such as athletes, who are interested in monitoring their heart rate to gain maximum efficiency from their training.

Heart rates are most accurately measured with a diagnostic tool known as an **electrocardiograph** (ECG or EKG), which are often used in a medical setting to noninvasively and painlessly record electrical activity of the heart over time.

Standard textbooks of physiology and medicine mention that heart rate (HR) is readily calculated from the ECG as follows: HR = 1,500/RR interval in millimeters, HR = 60/RR interval in seconds, or HR = 300/number of large squares between successive R waves, In each case, the authors are actually referring to instantaneous HR, which is the number of times the heart would beat if successive RR intervals were constant.

You can also buy a commercial heart rate monitor kit consisting of a chest strap with heart-rate monitoring electrodes and a display you wear on your wrist for easy interpretation of the data gathered.

However, the easiest way to assess your heart rate is by taking your pulse. Using your index and middle finger, simply press on any part of your body where an artery pulsation can be felt on the skin's surface, such as the neck or inside wrist, and count the number of pulses per minute. Be sure not to use your thumb when taking someone else's pulse, as it has a strong pulse of its own.

Heart rate is measured by finding the pulse of the body. This pulse rate can be measured at any point on the body where the artery's pulsation is transmitted to the surface by pressuring it with the index and middle fingers; often it is compressed against an underlying structure like bone. The thumb should not be used for measuring another person's heart rate, as its strong pulse may interfere with correct perception of the target pulse.

Possible points for measuring the heart rate are:

1. The ventral aspect of the wrist on the side of the thumb (radial artery).
2. The ulnar artery.
3. The neck (carotid artery).
4. The inside of the elbow, or under the biceps muscle (brachial artery).
5. The groin (femoral artery).
6. Behind the medial malleolus on the feet (posterior tibial artery).
7. Middle of dorsum of the foot (dorsalis pedis).
8. Behind the knee (popliteal artery).
9. Over the abdomen (abdominal aorta).
10. The chest (apex of heart), which can be felt with one's hand or fingers. However, it is possible to auscultate the heart using a stethoscope.
11. The temple (superficial temporal artery).
12. The lateral edge of the mandible (facial artery).
13. The side of the head near the ear (basilar artery)

Counting the pulse at the carotid artery has proven to be the easiest place to locate the pulse. Press gently on one side of the neck with your index and middle finger until the pulse is felt. Count each beat you feel to determine your heart rate.

Interpreting Your Heart Rate

Measuring your heart rate can not only help you exercise at a level of intensity that's right for you, it can also help provide information about your overall health. Factors like physical fitness, gender and age will impact your readings. As a general rule, the more physically fit you are, the lower your heart rate will be, and the more activity it will take to increase it. However, unreasonably low heart rates (bradycardia) or high heart rates (tachycardia) can be a sign of trouble and should be evaluated by a physician.

Heart rate: its importance to fitness

Exercise must be performed within the aerobic heart rate range for the body to benefit from the workout. This aerobic range is generally between 60 and 85 percent of a person's maximum heart rate. If you are severely overweight or in poor shape, the aerobic range might be 50 to 65 percent of your maximum heart rate.

Adults should get at least 30 minutes of moderate aerobic exercise most days of the week, preferably daily. (Children need at least 60 minutes a day.) Doing less than this will minimize your health benefits. Moderate aerobic exercise is generally defined as requiring about as much energy as walking 2 miles in 30 minutes.

Aerobic exercise uses large muscle groups for a continuous period of time. To handle this workload, the muscles need more oxygen. This requires the heart to beat faster. Breathing gets heavier and faster to take in more oxygen for the muscles.

To estimate your aerobic heart rate range, subtract your age from 220. This gives your estimated maximum heart rate. Then multiply your maximum heart rate by 60 percent and by 85 percent. These numbers are the low and high numbers representing heartbeats per minute in your aerobic range. These numbers are an estimate of how hard your heart needs to work. A few pulse checks during workouts confirm for most people that they are exercising in their aerobic range.

This formula is only an average. It does not apply for 30 to 40 percent of the population. Some people who follow heart-monitored exercise charts based on the formula may not be exercising in their true aerobic range. This can be tested by walking, jogging, or bicycling at a comfortable aerobic pace. Stop and take a pulse check. Your pulse rate may be much higher (or lower) than what the chart says it is supposed to be.

Do not worry. There is an easier method to determine if your exercising effort is within your aerobic heart rate range. Simply rely on your breathing and comfort. You are probably below your aerobic range if breathing is comfortable and talking is easy. If breathing is deep (not gasping) and gabbing is not possible (but speaking is), you are exercising in your range. Being unable to speak more than three words together are signs that you are over your aerobic range.

Remember, exercise that is performed within your aerobic heart rate range maximizes heart and other systemic benefits. Always get a medical checkup before starting any exercise program. Work with a certified exercise leader to learn how to exercise safely.

Monitoring Your Heart RateWhile Exercising

Heart rates are important indicators

Your heart rate will ensure a safe and effective aerobic workout. Monitoring your heart rate will allow you to track the magical changes taking place in your cardiovascular system as you journey on the road to aerobic fitness.

Why monitor heart rates?

One of the goals of your aerobic workout is to improve your cardiovascular fitness. Heart rates taken during exercise indicate how hard your heart is working. Your heart rate is actually a motivating friend when you learn to monitor it properly, for this allows you to objectively detect beneficial changes which you can’t otherwise see.

The benefits of monitoring your heart rate are:

Safety. The heart rate is a gauge by which to assess the intensity of your workout to make sure you’re not overexerting or overextending yourself. For example, if your heart rate is above your working heart rate range, it’s telling you to slow down a little and use fewer arm movements.

Effectiveness. If your heart rate indicates you’re not working hard enough, then you can work out a little more vigorously to maximize the effectiveness of your workout. To maximize your aerobic workout, you need to stay in your working heart rate range for at least 20 to 30 minutes continuously.

Incentive. By monitoring your heart rate from week to week as you participate in an aerobic activity, you’ll discover that you will be able to exercise at a higher level of intensity, but at the same or lower heart rate. This is the way the heart tells you it is becoming stronger and more efficient. When you see positive results, it will motivate you to strive for even better results.

Heart rates to track

It is important to know about three different heart rates:

Resting Heart Rate

The rate your heart is pumping when you have been sitting quietly for a while or when you are sleeping is your resting heart rate. This rate indicates your cardiovascular fitness level. The normal resting heart rate is 15 to 20 beats per minute slower than your “usual” heart rate. A person who is in good aerobic condition usually has a lower resting heart rate. Take your resting heart rate for 60 seconds before you get up in the morning.

Working Heart Rate

While you are exercising, you want to elevate your heart rate to produce a “training effect” but not so high as to be dangerous. Therefore, it is important to monitor your heart rate throughout the class. Gradually increase your working heart rate into a range that is maintained for the 20 to 30 minutes required to assure a training effect and an adequate workout. Find your working heart rate range on the chart and adjust your workout to stay in the middle of your range during the aerobic segment. The more conditioned your heart becomes, the more challenging it is to elevate your heart rate. If your heart rate is too high, lower the level of the next aerobic routine by exercising less vigorously and minimizing your arm movements. If your heart rate is too low, exercise more vigorously. We take the working heart rate for 6 seconds after the booster and each aerobic routine. Multiply this number by 10 (i.e., add a zero to the end of the number) to determine the number of beats per minute.

Recovery Heart Rate

Recovery heart rate is the heart rate measured at a fixed (or reference) period after ceasing activity, typically measured over a one minute period.

A greater reduction in heart rate after exercise during the reference period indicates a better-conditioned heart. Heart rates that do not drop by more than 12 bpm one minute after stopping exercise are associated with an increased risk of death.

Training regimes sometimes use recovery heart rate as a guide of progress and to spot problems such as overheating or dehydration. After even short periods of hard exercise it can take a long time (about 30 minutes) for the heart rate to drop to rested levels.

Recovering to 120 beats per minute or lower is important. If your recovery heart rate is above 120 beats per minute, then during the next class, you should lower your workout level. This is accomplished by doing steps at a walking level and minimizing arm moves. You should always work out at a level that is enjoyable and comfortable for you. As long as you do not exceed your maximum working heart rate during the aerobic part of class and you recover at 120 beats per minute or less, you know that your workout has been safe and effective.

Exercise and Heart Rate

Many people know that monitoring their heart rate during exercise helps them determine how hard they are working. And others know that exercising at an intensity that keeps their heart rate in a specific range will result in a "training" effect.

But, recently, new research has revealed other ways you can use your heart rate to determine not only how hard you are exercising, but, also how healthy your cardiovascular system is. This review will discuss 4 different ways you can use your heart rate to monitor your fitness. Your personal trainer may not even know some of these details.

MAXIMUM HEART RATE

Before you can calculate your "target exercise heart rate," you first need to determine your "maximum heart rate".

The traditional formula for calculating maximum heart rate is:

- **Max HR = 220 - age**

However, several years ago, researchers in the department of kinesiology and applied physiology at the University of Colorado in Boulder noticed that this formula underestimated exercise heart rates in older subjects.

Hirofumi Tanaka, PhD, and his group conducted an exhaustive review of 351 studies involving nearly 19,000 subjects and derived a new formula. They then validated the new formula in 514 healthy subjects.

The formula they propose is:

- **Max HR = 208 - (age x 0.7)**

In 40-year-old subjects, both formulas yield the same result (ie., 180 beats per minute). However, the Tanaka equation produces slightly lower limits (than the old formula) in subjects younger than 40, and raises the limit slightly in subjects older than 40 years old.

Other formulas exist. What's important is that, for the elderly, and people who are not in shape, maximum heart rate should be determined by calculation since it would be too risky for these people to submit themselves to an all-out exercise test.

The formula deemed least objectionable was:

$HR_{max} = 205.8 - (0.685 \times age)$
This was found to have a standard deviation that, although large (6.4 bpm), was still considered to be acceptable for the use of prescribing exercise training HR ranges.

Other often cited formulae are:

- $HR_{max} = 206.3 - (0.711 \times age)$

  (Often attributed to "Londeree and Moeschberger from the University of Missouri")

- $HR_{max} = 217 - (0.85 \times age)$

  (Often attributed to "Miller et al. from Indiana University")

- $HR_{max} = 208 - (0.7 \times age)$

  (Another "tweak" to the traditional formula is known as the Tanaka method. Based on a study of thousands of individuals, a new formula was devised which is believed to be more accurate).

In 2007, researchers at the Oakland University analysed maximum heart rates of 132 individuals recorded yearly over 25 years, and produced a linear equation very similar to the Tanaka formula—$HR_{max} = 206.9 - (0.67 \times age)$—and a nonlinear equation—$HR_{max} = 191.5 - (0.007 \times age^2)$. The linear equation had a confidence interval of ±5–8 bpm and the nonlinear equation had a tighter range of ±2–5 bpm. Also a third nonlinear equation was produced — $HR_{max} = 163 + (1.16 \times age) - (0.018 \times age^2)$.

These figures are very much averages, and depend greatly on individual physiology and fitness. For example an endurance runner's rates will typically be lower due to the increased size of the heart required to support the exercise, while a sprinter's rates will be higher due to the improved response time and short duration. While each may have predicted heart rates of 180 (= 220 − age), these two people could have actual HR_{max} 20 beats apart (e.g., 170–190).

Further, note that individuals of the same age, the same training, in the same sport, on the same team, can have actual HR_{max} 60 bpm apart (160 to 220):[5] the range is extremely broad, and some say "The heart rate is probably the least important variable in comparing athletes."[5]

The 2010 research conducted at Northwestern University revised the maximum heart rate formula for women. According to Martha Gulati, et al., it is:

$$HR_{max} = 206 - (0.88 \times age)$$

A study from Lund, Sweden gives reference values (obtained during bicycle ergometry) for men:

$$HR_{max} = 203.7 / (1 + exp (0.033 x (age - 104.3))$$

and for women:

$$HR_{max} = 190.2 / (1 + exp (0.0453 x (age - 107.5)$$

Determining Maximum HR From An All-Out Run:

The November 2004 issue of **Runner's World** magazine offers a method for fit runners to determine their maximum heart rate:

- warmup
- run as hard as you can for 3 minutes
- walk for 2 minutes
- run as hard as you can for another 3 minutes

During the last minute of running, you should be at your maximum heart rate. NOTE: Do not do this unless you are fit, or have been given a clean bill of health by your physician.

But, let's say you're not interested in winning your age group in next month's neighborhood 10-K; you are only exercising for health reasons. In this case, you still need to know your maximum heart rate. This allows you to determine your "training" heart rate, which is explained below.

There's also a medical use for knowing maximum heart rate. Cardiologists have determined that the inability to attain a target heart rate during exercise appears to be an ominous predictor of mortality. Researchers at the Cleveland Clinic found that patients who could not reach at least 85% of their predicted exercise heart rate had a higher risk of death (Lauer MS, et al. 1999).

TRAINING HEART RATE

Now that you know your maximum heart rate, you can determine your training heart rate. Coaches and their athletes know that driving the heart rate up into a specific range is the key to improving performance in aerobic events like cycling, distance running, etc. For example, Ed Eyestone offers the following guidelines in the November 2004 issue of **Runner's World** magazine:

- **70-80% max HR:** aerobic training pace
- **80-90% max HR:** lactate threshold pace
- **90-97% max HR:** long-interval pace
- **95-100% max HR:** short-interval pace

Serious endurance athletes (triathletes, distance runners, etc.) will train mostly at the aerobic training pace. About 10% of their training will be at the lactate threshold pace. Extremely-intense

"intervals" make up only a small percentage of the overall training plan.

Training heart rate is also helpful for people who want to exercise for health benefits. Research shows that untrained individuals will begin to improve their aerobic fitness when they exercise regularly at 50% of their maximum heart rate (Pollock ML, et al. 1998).

For example, for a 60-year-old person, the maximum heart rate (using the Tanaka equation) is 166. Fifty percent of that is 83 beats per minute. Thus, exercise does not need to be exhausting to achieve a health benefit.

The Target Heart Rate or Training Heart Rate (THR) is a desired range of heart rate reached during aerobic exercise which enables one's heart and lungs to receive the most benefit from a workout. This theoretical range varies based mostly on age; however, a person's physical condition, gender, and previous training also are used in the calculation. Below are two ways to calculate one's THR. In each of these methods, there is an element called "intensity" which is expressed as a percentage. The THR can be calculated as a range of 65%–85% intensity. However, it is crucial to derive an accurate HR_{max} to ensure these calculations are meaningful (see above).

Example for someone with a HR_{max} of 180(age 40, estimating HR_{max} As 220 − age):

> 65% Intensity: (220 − (age = 40)) × 0.65 → 117 bpm
> 85% Intensity: (220 − (age = 17)) × 0.85 → 153 bpm

Karvonen method

The Karvonen method factors in resting heart rate (HR_{rest}) to calculate target heart rate (THR), using a range of 50–85% intensity:

$$THR = ((HR_{max} - HR_{rest}) \times \%\ intensity) + HR_{rest}$$

Example for someone with a HR_{max} of 180 and a HR_{rest} of 70:

> 50% Intensity: ((180 − 70) × 0.50) + 70 = 125 bpm
> 85% Intensity: ((180 − 70) × 0.85) + 70 = 163 bpm

Zoladz method

An alternative to the Karvonen method is the Zoladz method, which derives exercise zones by subtracting values from HR_{max}:

> $THR = HR_{max} - Adjuster \pm 5$ bpm
> Zone 1 Adjuster = 50 bpm
> Zone 2 Adjuster = 40 bpm
> Zone 3 Adjuster = 30 bpm
> Zone 4 Adjuster = 20 bpm
> Zone 5 Adjuster = 10 bpm

Example for someone with a HR_{max} of 180:

> Zone 1(easy exercise): 180 − 50 ± 5 → 125 – 135 bpm
> Zone 4(tough exercise): 180 − 20 ± 5 → 155 – 165 bpm

RECOVERY HEART RATE

"Recovery" heart rate is a determination of how long it takes your heart rate to return to normal after you stop exercising. This concept is mostly for people who are out of shape. People with a slower recovery are at higher risk of sudden death than people who recover more quickly.

Researchers at the Cleveland Clinic exercised patients on a treadmill, then measured their heart rate 1 minute after running stopped and compared it to their peak heart rate. The failure of heart rate to fall rapidly after exercise stopped was associated with increased overall mortality (Cole CR, et al. 1999).

A similar result was seen in a study from France. Cardiologists exercised patients on a stationary bike for 10 minutes, then measured their heart rate 1 minute after cycling stopped and compared it to their peak heart rate. Patients with the poorest recovery had 2.1 times the risk of sudden death compared to patients with the best recovery (Jouven X, et al. 2005).

RESTING HEART RATE

And, finally, the 4th way you can use your heart rate to monitor your exercise program is to simply take your pulse while at rest. Resting heart rate is another indicator of your aerobic fitness.

One of the dramatic things that happens to your heart when you become aerobically fit is that your heart pumps more blood with each beat. This is known as "stroke volume". Since more blood is pumped with each beat, the heart doesn't need to beat as fast, so, resting heart rate is slower.

In one study of female runners, the resting heart rate directly related to how far the women ran per week (Williams PT. 1996):

MILES RUN	RESTING HR
0-10 miles/wk	69
10-20 miles/wk	66
20-30 miles/wk	65
30-40 miles/wk	63
40-86 miles/wk	61

You may have heard of marathon runners who have resting heart rates in the 50's, or, even in the 40's. Generally, this is a sign of a strong heart.

Unfortunately, the opposite is also true. In one study of middle-age men with no evidence of cardiovascular disease, a resting heart rate of 75 beats per minute or higher had 3.5 times the risk of sudden death compared to men with resting heart rates of less than 60 (Jouven X, et al. 2005).

SUMMARY

So, it turns out that something as simple as keeping track of your heart rate can tell you a lot about your health and fitness. Here's how to do it:

• **Resting Heart Rate:** Take your pulse as soon as you wake up in the morning, preferably, without an alarm clock, and definitely before that first cup of coffee. Take it while you are still lying in bed; don't sit up. If you don't want to do a 60-second count, then do a 6-second count and simply add a zero.

• **Maximum Heart Rate:** This was discussed above. To repeat, do NOT do the running test unless you have a clean bill of health from your physician. Instead, use the formula by Tanaka et al. listed above.

• **Training Heart Rate:** If you simply want to exercise for health benefits, you only need to exercise at about 50-60% of your maximum heart rate. However, if you want to improve your times in a 10-K race for example, then you need to push your HR into the 70-90% range periodically. Since it is very difficult to take your pulse when you are exercising this hard, use a heart rate monitor.

Heart rate reserve:

Heart rate reserve (HRR) is a term used to describe the difference between a person's measured or predicted maximum heart rate and resting heart rate. Some methods of measurement of exercise intensity measure percentage of heart rate reserve. Additionally, as a person increases their cardiovascular fitness, their HR_{rest} will drop, thus the heart rate reserve will increase. Percentage of HRR is equivalent to percentage of VO_2 reserve.

$$HRR = HR_{max} - HR_{rest}$$

This is often used to gauge exercise intensity (first used in 1957 by Karvonen).

Karvonen's study findings have been questioned, due to the following:

-The study did not use VO_2 data to develop the equation.
- Only six subjects were used, and the correlation between the percentages of HRR and VO_2 max was not statistically significant.

Abnormalities

Tachycardia:

Tachycardia is a resting heart rate more than 100 beats per minute. This number can vary as smaller people and children have faster heart rates than average adults.

Bradycardia

Bradycardia is defined as a heart rate less than 60 beats per minute although it is seldom symptomatic until below 50 bpm when a human is at total rest. This number can vary as children and small adults tend to have faster heart rates than average adults. Bradycardia may be associated with medical conditions such as hypothyroidism.

Trained athletes tend to have slow resting heart rates, and resting bradycardia in athletes should not be considered abnormal if the individual has no symptoms associated with it. For example Miguel Indurain, a Spanish cyclist and five time Tour de France winner, had a resting heart rate of 28 beats per minute, one of the lowest ever recorded in a healthy human.

Arrhythmia

Arrhythmias are abnormalities of the heart rate and rhythm (sometimes felt as palpitations). They can be divided into two broad categories: fast and slow heart rates. Some cause few or minimal symptoms. Others produce more serious symptoms of lightheadedness, dizziness and fainting.

Female Athlete Triad

The three factors in the triad are disordered eating, amenorrhea, and osteoporosis.

The triad is a relatively new phenomenon that has been identified. Despite its name, not only athletes are at risk for the disorder.

Eating Disorders

Eating disorders contribute to the triad by causing an energy imbalance in the body.

Eating disorders may come in the form of:

-Anorexia Nervosa

-Bulimia

-Disordered eating

Anorexia Nervosa

A person with anorexia will never believe that she is thin enough and thus seeks to avoid food

To be classified as anorexic, the patient must meet four specific criteria

1. Refusal to maintain body weight, even though they are underweight for age and height
2. Has an intense fear of gaining weight
3. Has a distorted body image; feels fat when really extremely thin
4. Has missed menstrual cycle three or more times in a row[1]

Causes of Anorexia

-Media images of beauty are mixed with messages that one must be unhealthily skinny to be pretty

-Mothers or important adults may teach about dieting or make comments causing their daughters to feel overweight

-Coaches oftentimes inadvertently make comments about weight in relation to performance

-Athletic clothing – for some sports, such as swimming or gymnastics, the uniform is tight fitting and revealing

Warning Signs for Anorexia

-Rapid weight loss

-Mood swings

-Avoid food-related activities

-Excessive exercise

-Preoccupation with food, calories, and weight

-Wearing baggy clothing

Who is at risk for anorexia?

-Girls ages 13-35

-From middle-high socioeconomic class

-Athletes in a aesthetic or weight-dependent sports

-People who may have one or more trigger factor:

1) prolonged dieting

2) people who have experienced a traumatic event

3) athletes who have increased training volume[2]

Bulimia

Bulimia is a cycle of binging on food and then purging the food from the system.The cycle becomes addictive.To be diagnosed as bulimic, the patient must meet four specific criteria:

1. Episodes of binging at least twice a week for three months
2. Feels a lack of control during binges
3. Uses one or more of the following methods to purge: self-induced vomiting, laxatives, diuretics, excessive exercise
4. Overly concerned with body weight[1]

Causes of Bulimia

The cause of bulimia may have genetic origins

Other factors may predispose someone to the disorder:

-Perfectionism

-Impaired self-concept

-Poor impulse control

-Stress from peer and parental relationships, puberty, sexuality, marriage and pregnancy

Abnormalities of neurotransmitters in the central nervous system could be a factor

Familial factors: first- and second-degree relatives of a bulimic have an increased incidence of eating disorders

Warning Signs for Bulimia

-Noticeable weight loss

-Depressive moods

-Excessive concern about weight

-Increasing criticism of one's body

-Bathroom visits after meals[4]

-Scabs/scars on knuckles

-Puffy, swollen face

-Sore throat

-Cavities and bad breath

Who is at risk for Bulimia?

-Women are 10 times as likely to be affected as men

-Peak onset between 13-20 years of age

-First- and second-degree relatives of a bulimic

-Other eating disorders

Not all eating disorders can be classified under the four specific criteria of anorexia nervosa or the four criteria of bulimia

-Coaches should be aware of all of the warning signs so that any athlete exhibiting multiple signs may be monitored

-The dangers of eating disorders

-If left unchecked, eating disorders may lead to death

-When you starve your body:

-You cause the metabolic rate to slow

-You cause your body to try to store as much fat as it can for survival

-Your mood can become irritable, anxious and hungry

-Yo-yo dieting can make it hard to lose weight in the future

-Eating disorders lead to a negative energy balance

-Negative energy balance may lead to amenorrhea and in turn stress fractures and osteoporosis

Amenorrhea

Primary amenorrhea is the late start of menarche – after age 16

Secondary amenorrhea is when a woman or young girl stops getting a monthly period for three or more months in a row

Causes of amenorrhea

-Amenorrhea is thought to be caused by an energy imbalance[5]

-The energy imbalance may be from intentionally withholding nutrition from the body or from expending more calories than consumed through an intense exercise regimen

-The body may be turning off the reproductive cycle to conserve energy[1]

-Contrary to common misconception, missing one or more menstrual cycles is neither normal nor a sign of proper training

-Need for Concern

-Whatever the cause, amenorrhea is serious

-A reduced level of estrogen is associated with amenorrhea

-Amenorrhea increases the risk of stress fractures

-Amenorrhea can also lead to osteoporosis

-Amenorrhea disrupts fertility

Warning signs of energy drain

-As many as 44% of physically active women have reported periods of 3+ months with no menstruation

-Sore muscles that do not recover

-The athlete feels stale

-Lacks interest in training

-Injuries do not heal

-Weight loss

-Decreasing performance

-Signs of depression

How to prevent and treat energy drain and amenorrhea

-Non-medicinal means to solve the problem should be the first plan of action

-Examine your diet and training schedule

-Consult a nutritionist if necessary to determine your daily caloric intake and expenditure

-Make sure your energy intake and expenditure are balanced

-Take a day off if necessary

-Add nutrition

-If increased nutrition and a modified training schedule do not help with return of menstruation, hormone therapy may be necessary

-A note of caution about using oral contraceptives to increase the amount of hormones – oral contraceptives are abortifacients and the use of these to treat sexually active women raises ethical questions

Osteoporosis

A decrease in bone density due to a loss of cortical bone; common in older women and implicated in fractures[1]

Risk factors:

-Genetics,

-Smoking and alcohol consumption,

-Anorexia,

-High dietary protein or fiber consumption[6]

Facts about bone density

-Bones reach maximum strength between 30-35 years of age

-Calcium, estrogen and vitamin D are all needed to help your body build bone

-Weight-bearing exercise is also important for remodeling bone

-Sodas inhibit absorption of calcium

-Girls age 12-14 need 1200-1500 mg/day of calcium

-Adult women need 1000 mg/day of calcium

-Caucasian and Asian women have lower bone mass than Hispanic and African American women and may be at greater risk for osteoporosis

-Place of osteoporosis in the Triad

-Eating disorders and amenorrhea can lead to the development of osteoporosis

-It is thought to be the estrogen deficiency of amenorrhea along with a possible calcium deficiency that contribute to the development of osteoporosis in athletes.

Stopping the Triad before it starts

-Coaches and players alike need to be educated about the triad

-Awareness of the problem can help people to identify it before it progresses to more serious stages

-During the pre-season physical, each athlete should be assessed to determine if risk factors exist for energy drain – be it from over training or eating disorders

-Re-assess mid- and post-season

-Coaches should examine their training schedule to make sure it provides for adequate rest and recovery

-Teams could consult with a nutritionist to determine if an adequate nutrition program is being followed by all athletes

-Coaches, parents, peers and significant others need to be aware of the effects their comments can have

-Coaches need to help their athletes develop a positive and healthy body image

Conclusion

It is not just athletes that are at risk for developing the symptoms known as the Female Athlete Triad

-All of the factors are interrelated

-The triad could be initiated by either an eating disorder or an energy imbalance caused by an over-expenditure of calories

-Any one factor by itself poses serious health threats and could be a sign of a worsening problem

-It takes a cooperative effort to help young women and athletes develop a healthy body image

Hypertrophy:

Enlargement of stimulated muscle due to Muscle fibers get thicker

Increase in the diameter of muscle fibers resulting from very forceful, repetitive muscular activity and an increase in myofibrils, SR & mitochondria.

Hypertrophy refers to increase in both the cross-sectional area of the muscle (more myofibrils) and increase in length of the muscle (more sarcomeres per myofibril).

Mainly due to increase of cross sectional area of individual muscle fiber. After weight training the hypertrophy is attributed to the following causes –

a) Increase in myofibre (Pen unit of muscle fiber)
b) Increase of total amount of protein specially myosin component.
c) Increase capillary density / unit of fiber (hyper capillerisation)
d) Increase amount of A.T.P, C.P glycogen, mitochondria (size+number)
e) Increase in various enzyme actives related to aerobic and anaerobic metabolism (quantitative and qualitative)
f) More number of muscle fiber

Heat-Related Problems

Heat Illness	Signs and Symptoms	Immediate Care
Heat Syncope	Headache Nausea	Normal intake of fluids
Heat Cramps	Muscle cramping (calf is very common) Multiple cramping (Very serious)	Isolated craps : Direct pressure to cramp and release, stretch muscle slowly and gently, gentle massage, ice Multiple cramps : Danger of heat stroke, treat as heat exhaustion
Heat Exhaustion	Profuse sweating Cold, clammy skin Normal temperature slightly elevated pale Dizzy Weak, rapid pulse Shallow breathing Nausea Headache Loss of consciousness	Move individual out of sun to a well-ventilated area place in shock position (feet elevated 12-18 in); prevent heat loss or gain Gentle massage of extremities Gentle range of motion of the extremities Force fluids Reassure Monitor body temperature and other vital signs Refer to physician
Heat Stroke	Generally, no perspiration Dry skin Very hot Temperature as high as 106^0F Skin color bright red or flushed (blacks-ashen) Rapid and strong pulse Labored breathing-semi-reclining position	This is an extreme medical emergency Transport to hospital quickly Remove as much clothing as possible without exposing the individual Cool quickly starting at the head and contnuing down the body; use any means possible (fan, hose down, pack in ice) Wrap in cold, wet sheets for transport Treat for shock; if breathing is labored, place in a semi-reclining position.

Hydration

1 to 2 hours before competition-1 litre water
15 to 20 minutes before competition-500-600 cc
Every 15 to 20 minutes during competition 200-300cc.
After the game-check the weight loss –1 litre per kg weight loss
1 litre water-1.5 gram salt (1/3 of tea spoon)
Granulated glucose polymer or sugar 2.5 to 7.5 percent
Banana has potassium and vitamin A B C and protein and fat-it gives immediate energy and gets digested faster.
Cold water is palatable. It reduces the body core temperature. If the environmental temperature is very cold, warm water may be given.

Diet

Pre-competition

2 to 4 hours before competition give complex carbohydrates (rice, wheat, fruits, vegetables).
Adequate amount of water
Less fat (it takes about 6 hours to digest.
Less fiber, less protein and less salt (shrinks cells and causes muscle cramps).
Less sugar, no caffeine and no alcohol.

During competition

Long duration games
50 grams of carbohydrate every hour
Sports drink, dry fruits (figs, legumes, apricot)
Banana, beans, jam sandwich and chocolate bar

After competition

Carbohydrate-1 to 2 gram per kg weight immediately
After two hours 1 to 2 grams per kg body weight.
550 to 800 gram after the game with water
Before going to bed 500 to 600 cc water.

The respiratory quotient (or RQ or respiratory coefficient)

RQ is a dimensionless number used in calculations of basal metabolic rate (BMR).

The Respiratory Quotient or RQ value is a measure of the ratio of carbon dioxide produced and oxygen consumed by an organism per unit time.It is a ratio and therefore has no units.

RQ =volume of carbon dioxide produced/volume of oxygen consumed per unit time.

The respiratory quotient is a valuable measurement as it provides us with Information regarding the nature of the substrate being used by an organism for respiration.

The simplified equation for the aerobic respiration of glucose is:

$C_6H_{12}0_6 \quad + \quad 6O_2 \quad = \quad 6CO_2 \quad + \quad 6H_2O$

In this reaction, six carbon dioxide molecules are produced and

Six oxygen molecules are consumed.

The RQ for this reaction is 6 CO_2/6 O_2 = 1

The RQ value varies with the nature of the substrate being used for respiration.The following equation represents the complete oxidation of the fatty acid,

Oleic acid, when used as the substrate for respiration.The simplified equation for the aerobic respiration of oleic acid is:

$2C_{18}H_{34}0_2 \quad + \quad 51\ O_2 \quad = \quad 36\ CO_2 \quad + \quad 34\ H_2O$

In this reaction, thirty six carbon dioxide molecules are produced and fifty one oxygen molecules are consumed.

The RQ for this reaction is 36 CO_2/51 O_2 = 0.7

The following table shows the RQ values for different classes of respiratory substrate when they are used for aerobic respiration

Glucose- 1

Fatty acid -0.7

Protein-0.9

If any degree of anaerobic respiration occurs RQ values significantly above a value of 1.0 are obtained.

Cardiovascular drift

Cardiovascular drift (CV drift) is a phenomenon whereby some CV responses begin a continuous time dependent change, or "drift,

Cardiovascular drift refers to the progressive increase in heart rate and decrease in stroke volume that begins after approximately 10 min of prolonged moderate-intensity exercise.

It is associated with decreased maximal oxygen uptake, particularly during heat stress. Consequently, the increased heart rate reflects an increased relative metabolic intensity during prolonged exercise in the heat when cardiovascular drift occurs, which has implications for exercise prescription.

It is characterized by
-A progressive decline in stroke volume (SV)
-Decreease pulmonary and systemic mean arterial pressures (MAPs) and
-Increase in heart rate (HR),
-Cardiac output is maintained nearly constant.
-Dehydration(maintained with saline infusion), Although CV drift can occur without dehydration,
-Raising temperature within the muscle
-Slightly elevated core temperature

CV drift is a phenomenon, classically observed in non endurance trained persons working in thermo neutral environments, that is associated with progressive but small increases in core temperature.

SV reductions after the first 10-to 15-min period of exercise probably provide the single best index of CV drift.

Suggestions must be adhered to in order to prevent physical damages and injuries during strength training.

1. Do not perform strength training with weight without qualified supervision.

2. To reduce chance of injury, keep head and limbs clear of weights and moving parts at all times.

3. Proper skill is needed while working with heavy apparatus during each session of strength training. In the beginning the strength exercise should be correctly learnt with lighter weights and as the skill improves, the resistance should be gradually increased.

4. A variety of exercises should be performed. The weak joints of the body namely, hand, foot and elbow should not be loaded with heavy weights.

5. In all the strength training exercises, the spine should be kept straight and avoid frequent stress on the spine during one training session.

6. While performing strength exercises, the normal breathing should continue. Avoid holding of breath for too long.

7. Each strength training session must be preceded by a good session of warming up and must end with limbering down.

8. As soon as pain is experienced in muscles and joints, the exercises should be stopped. This way prevents in protecting serious injuries.

9. Take preventive measures in order to protect muscles, ligaments and joints from injuries. Steps should be taken to accelerate recovery after each session of strength training.

10. While working with heavy weights take help of assistants and use proper footwear in order to stabilize the foot joints.

11. Strength training equipment to be used must be free from defects.

12 Observe proper discipline and follow safety rules in each strength training sess

Suggestions for reducing over weight

1.Eat less than what you normally eat and in case you cannot cut down on your eating, participate regularly and religiously in a programme of physical exercise so that you burn up more calories.

2. In case you are non- vegetarian eat more fish and chicken. Avoid animal fat in meat because this fat is harmful.

3. Reduce intake of sugar because it is high in calories. Take eat and coffee with an approved artificial sweetener or no sweetener at all. Reduce consumption of canned foods. Avoid intake of deserts, chocolates, nuts and soft drinks.

4. Reduce intake of excess of fats. A gram of fat contains twice as many calories as a gram of protein.

5. Avoid intake of snacks between the meals.

6.According to Dr. Jeen Mayor, one of the worlds most respected nutritionist, a safe and effective method of controlling weight is eating smaller protions at more frequent intervals e.g. divide your three meals into six small ones.

7. Consume salt in moderate quantities. Decreased salt intake helps boost your morale since the body will retain less water and you will appear to have less weight. Do not reduce your salt too far in case you do vigorous exercise.

8. Avoid crash diets. They are bad for health if continued for long time because they are not balanced.

9. Avoid eating very late at night. Prefer to eat early at night (between 7:00 PM to 7:30 PM). Involvement in some kind of task after night’s meal helps in digestion.

10. Eat more baked, boiled and steamed foods. Avoid consuming fats which result from cooking.

11. Go for skimmed milk and also curd made from skimmed milk. Skimmed milk products have low fat content.

13. Raw salad should form a part of your daily meal.

Pulmonary ventilation during Exercise

Exercise affects Oxygen consumption & carbon- dioxide production. With exercise large amount of oxygen diffuse from the alveoli into the venous blood returning to the lungs, conversely considerable quantities of CO_2 move from blood to alveoli.

Ventilation in steady rate exercise:

In light to moderate steady rate exercise ventilation increases linearly with O_2 consumption and Co2 production. About 20-25 liter of air breathed per liter of O_2 consumption. So we can say ventilation is mainly increased by increasing tidal volume. Whereas at higher exercise level breathing frequency take on more important role.

Ventilation in non steady rate exercise:

In more intense sub maximal exercise the minute ventilation takes a sharp upswing and increase disproportionately with increase in O_2 consumption. As a result ventilator equivalent is greater than during steady rate exercise and may increase to 35-40 lit of air per lit of o2 consumed.

Adaptations in breathing with training:

1. Maximal exercise: Maximal exercise ventilation will be increased with the improvements in maximal O_2 uptake. This values serves Physiologically because any increase in aerobic capacity results in a larger O_2 requirement & correspondingly larger production of O_2 that must be eliminated through increase alveolar ventilation.

2. Sub maximal exercise: Following only four weeks of training, a considerable reduction in the ventilatory equivalent is observed in sub maximal exercise consequently a smaller amount of air is breathed at a particular rate of sub maximal oxygen consumption. This reduces the percentages of total oxygen cost of exercise attribute to breathing. Theoretically this would be important in performing prolonged vigorous exercise for two reasons:

i) It would reduce fatiguing effects of exercise on the ventilator musculature.

ii) Any O_2 freed from use by the respiratory muscles becomes available to the exercising muscle.

- In general tidal volume becomes larger & breathing frequenay is considerably reduced.

- Air remains in the lungs for a longer period of time between breaths. The result is an increase in the amount of O_2 extracted from the inspired air.

- Ventilatory adaptations appear to be specific to the type of exercise used in the training. When subjects performed either arm or leg exercise the ventilation equivalent was always greater during arm than during leg work.

- The ventilator adjustment to training results from local neural or chemical adaptation in the specific muscle trained through exercise.

Long term effect of physical Training

The training effects are broadly classified as follows

1. Biochemical changes (cellular changes)
2.Systemic changes (changes at various system)
3.Other changes

Practical

Height & weight
HR –palpation
HR- telemetric
Recovery HR
ECG
Fat%
VO2 max
Blood pressure
Lung function test
Physical fitness index