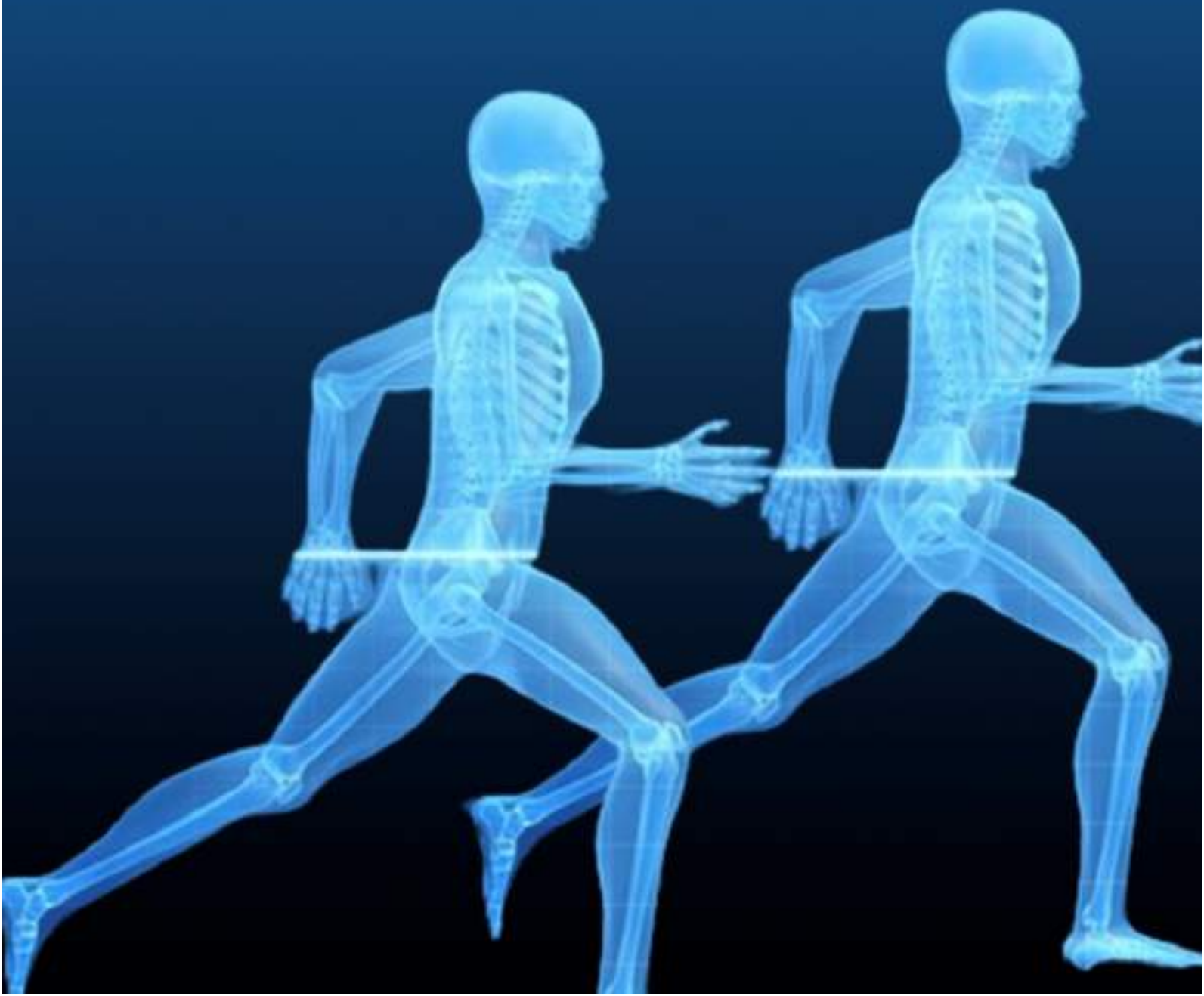
PHYSIOLOGICAL ASPECTS OF PHYSICAL EDUCATION

Dr. Surjeet Singh Kaswan



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Preface

The physiological aspects of physical education delve into the intricate mechanisms of the human body's response to exercise and physical activity. One fundamental area of study within this field is cardiovascular physiology, which examines how the heart and blood vessels respond to increased demands during exercise. As individuals engage in physical activity, the heart rate and stroke volume typically rise to meet the heightened oxygen requirements of working muscles. Over time, regular exercise can lead to improvements in cardiovascular fitness, characterized by a more efficient heart and enhanced circulation.

Respiratory physiology is another key aspect, focusing on the lungs' capacity to exchange oxygen and carbon dioxide during exercise. With increased physical exertion, breathing rate and depth typically increase to supply oxygen to active tissues and remove metabolic waste products. Through regular exercise, individuals can improve respiratory function and enhance overall pulmonary efficiency.

Muscular physiology is also central to understanding physical education, encompassing the mechanisms of muscle contraction and adaptation. As muscles are repeatedly stressed through exercise, they adapt by becoming stronger, more flexible, and better able to sustain prolonged activity. Moreover, resistance training stimulates muscle growth and increases muscle mass, contributing to improvements in strength, power, and endurance.

Metabolic physiology explores the energy systems utilized by the body during exercise to generate adenosine triphosphate (ATP), the primary source of cellular energy. Depending on the intensity and duration of activity, the body may rely on anaerobic metabolism, aerobic metabolism, or a combination of both to meet energy demands. Understanding these metabolic pathways is crucial for optimizing

performance and designing effective training programmes. In addition to physiological responses, physical education also considers individual differences in fitness levels, age, sex, and genetics. These factors influence an individual's capacity to tolerate and adapt to exercise, highlighting the importance of personalized exercise prescriptions. By tailoring physical activity recommendations to each individual's unique physiological profile, educators can maximize the health benefits and performance outcomes of exercise.

Furthermore, knowledge of physiological principles guides the development of safe and effective exercise protocols, minimizing the risk of injury and promoting long-term adherence to physical activity. By emphasizing the importance of gradual progression, proper technique, and adequate recovery, physical educators can create supportive environments that foster optimal health and well-being.

Overall, an understanding of the physiological aspects of physical education provides a solid foundation for promoting lifelong fitness and wellness. By integrating physiological principles into educational curricula and exercise programming, educators can empower individuals to achieve their health and fitness goals, leading to improved quality of life and enhanced overall well-being.

The book on Physiological Aspects of Physical Education provides a comprehensive exploration of the body's responses to exercise, offering insights into optimizing athletic performance and promoting lifelong fitness.

–Author

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Roles of the Muscular System

STRUCTURE OF SKELETAL MUSCLE

A whole skeletal muscle is considered an organ of the muscular system. Each organ or muscle consists of skeletal muscle tissue, connective tissue, nerve tissue, and blood or vascular tissue. Skeletal muscles vary considerably in size, shape, and arrangement of fibres. They range from extremely tiny strands such as the stapedium muscle of the middle ear to large masses such as the muscles of the thigh. Some skeletal muscles are broad in shape and some narrow. In some muscles the fibres are parallel to the long axis of the muscle, in some they converge to a narrow attachment, and in some they are oblique. Each skeletal muscle fibre is a single cylindrical muscle cell. An individual skeletal muscle may be made up of hundreds, or even thousands, of muscle fibres bundled together and wrapped in a connective tissue covering. Each muscle is surrounded by a connective tissue sheath called the epimysium. Fascia, connective tissue outside the epimysium, surrounds and separates the muscles. Portions of the epimysium project inward to divide the muscle into compartments. Each compartment contains a bundle of muscle fibres. Each bundle of muscle fibre is called a fasciculus and is surrounded by a layer of connective tissue called the perimysium. Within the fasciculus, each individual muscle cell, called a muscle fibre, is surrounded by connective tissue called the endomysium. Skeletal muscle cells (fibres), like other body cells, are soft and fragile.

The connective tissue covering furnish support and protection for the delicate cells and allow them to withstand the forces of contraction. The coverings also provide pathways for the passage of blood vessels and nerves. Commonly, the

epimysium, perimysium, and endomysium extend beyond the fleshy part of the muscle, the belly or gaster, to form a thick ropelike tendon or a broad, flat sheet-like aponeurosis. The tendon and aponeurosis form indirect attachments from muscles to the periosteum of bones or to the connective tissue of other muscles.

Typically a muscle spans a joint and is attached to bones by tendons at both ends. One of the bones remains relatively fixed or stable while the other end moves as a result of muscle contraction.

Skeletal muscles have an abundant supply of blood vessels and nerves. This is directly related to the primary function of skeletal muscle, contraction. Before a skeletal muscle fibre can contract, it has to receive an impulse from a nerve cell.

Generally, an artery and at least one vein accompany each nerve that penetrates the epimysium of a skeletal muscle. Branches of the nerve and blood vessels follow the connective tissue components of the muscle of a nerve cell and with one or more minute blood vessels called capillaries.

MUSCLE TYPES

In the body, there are three types of muscle: skeletal (striated), smooth, and cardiac.

Skeletal Muscle

Skeletal muscle, attached to bones, is responsible for skeletal movements. The peripheral portion of the central nervous system (CNS) controls the skeletal muscles. Thus, these muscles are under conscious, or voluntary, control. The basic unit is the muscle fibre with many nuclei. These muscle fibres are striated (having transverse streaks) and each acts independently of neighbouring muscle fibres.

Smooth Muscle

Smooth muscle, found in the walls of the hollow internal organs such as blood vessels, the gastrointestinal tract, bladder, and uterus, is under control of the autonomic nervous system. Smooth muscle cannot be controlled consciously and thus acts involuntarily. The non-striated (smooth) muscle cell is spindle-shaped and has one central nucleus. Smooth muscle contracts slowly and rhythmically.

Cardiac Muscle

Cardiac muscle, found in the walls of the heart, is also under control of the autonomic nervous system. The cardiac muscle cell has one central nucleus, like smooth muscle, but it also is striated, like skeletal muscle. The cardiac muscle cell is rectangular in shape. The contraction of cardiac muscle is involuntary, strong, and rhythmical.

SKELETAL MUSCLE GROUPS

There are more than 600 muscles in the body, which together account for about 40 per cent of a person's weight. Most skeletal muscles have names that describe some feature of the muscle. Often several criteria are combined into one name. Associating the muscle's characteristics with its name will help you learn and remember them. The following are some terms relating to muscle features that are used in naming muscles.

- *Size:* Vastus (huge); maximus (large); longus (long); minimus (small); brevis (short).
- *Shape:* Deltoid (triangular); rhomboid (like a rhombus with equal and parallel sides); latissimus (wide); teres (round); trapezius (like a trapezoid, a four-sided figure with two sides parallel).
- *Direction of fibres:* Rectus (straight); transverse (across); oblique (diagonally); orbicularis (circular).
- *Location:* Pectoralis (chest); gluteus (buttock or rump); brachii (arm); supra- (above); infra- (below); sub- (under or beneath); lateralis (lateral).
- *Number of origins:* Biceps (two heads); triceps (three heads); quadriceps (four heads).
- *Origin and insertion:* Sternocleidomastoideus (origin on the sternum and clavicle, insertion on the mastoid process); brachioradialis (origin on the brachium or arm, insertion on the radius).
- *Action:* Abductor (to abduct a structure); adductor (to adduct a structure); flexor (to flex a structure); extensor (to extend a structure); levator (to lift or elevate a structure); masseter (a chewer).

Listed below are some significant and obvious muscles arranged in groups according to location and/or function. Click one of the hyper-links to explore a specific muscle group listed below.

- Muscles of the Head and Neck
- Muscles of the Trunk
- Muscles of the Upper Extremity
- Muscles of the Lower Extremity.

MUSCLES OF THE HEAD AND NECK

Humans have well-developed muscles in the face that permit a large variety of facial expressions. Because the muscles are used to show surprise, disgust, anger, fear, and other emotions, they are an important means of non-verbal communication. Muscles of facial expression include frontalis, orbicularis oris, laris oculi, buccinator, and zygomaticus. These muscles of facial expressions are identified in the illustration below. There are four pairs of muscles that are responsible for chewing movements or mastication. All of these muscles connect to the mandible and they are some of the strongest muscles in the body. Two of the muscles, temporalis and masseter are identified in the illustration above. There are numerous muscles associated with the throat, the hyoid bone and the vertebral column, only two of the more obvious and superficial neck muscles are identified in the illustration. They are sternocleidomastoid and trapezius.

MUSCLES OF THE TRUNK

The muscles of the trunk include those that move the vertebral column, the muscles that form the thoracic and abdominal walls, and those that cover the pelvic outlet. The erector spinae group of muscles on each side of the vertebral column is a large muscle mass that extends from the sacrum to the skull. These muscles are primarily responsible for extending the vertebral column to maintain erect posture. The deep back muscles occupy the space between the spinous and transverse processes of adjacent vertebrae. The muscles of the thoracic wall are involved primarily in the process of breathing. The intercostal muscles are located in spaces between the ribs. They contract during forced expiration. External intercostal muscles contract to elevate the ribs during the inspiration phase of breathing. The diaphragm is a dome-shaped muscle that forms a partition between the thorax and the abdomen. It has three openings in it for structures that have to pass from the thorax to the abdomen. The abdomen, unlike the thorax and pelvis, has no bony reinforcements or protection. The wall consists entirely of four muscle pairs, arranged in layers, and the fascia that envelops them. The abdominal wall muscles are identified in the illustration below. The pelvic outlet is formed by two muscular sheets and their associated fascia.

MUSCLES OF THE UPPER EXTREMITY

The muscles of the upper extremity include those that attach the scapula to the thorax and generally move the scapula, those that attach the humerus to the scapula and generally move the arm, and those that are located in the arm or forearm that move the forearm, wrist, and hand. The illustration below shows some of the muscles of the upper extremity. Muscles that move the shoulder and arm include the trapezius and serratus anterior. The pectoralis major, latissimus dorsi, deltoid, and rotator cuff muscles connect to the humerus and move the arm. The muscles that move the forearm are located along the humerus, which include the triceps brachii, biceps brachii, brachialis, and brachioradialis. The 20 or more muscles that cause most wrist, hand, and finger movements are located along the forearm.

MUSCLES OF THE LOWER EXTREMITY

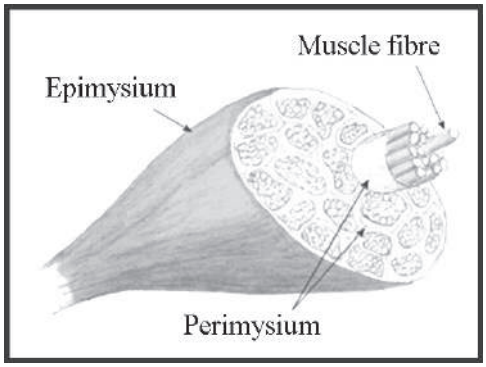
The muscles that move the thigh have their origins on some part of the pelvic girdle and their insertions on the femur. The largest muscle mass belongs to the posterior group, the gluteal muscles, which, as a group, abduct the thigh. The iliopsoas, an anterior muscle, flexes the thigh. The muscles in the medial compartment adduct the thigh. The illustration below shows some of the muscles of the lower extremity. Muscles that move the leg are located in the thigh region. The quadriceps femoris muscle group straightens the leg at the knee. The hamstrings are antagonists to the quadriceps femoris muscle group, which are used to flex the leg at the knee. The muscles located in the leg that move the ankle and foot are divided into anterior, posterior, and lateral compartments. The tibialis anterior, which dorsiflexes the foot, is antagonistic to the gastrocnemius and soleus muscles, which plantar flex the foot.

SKELETAL MUSCLE CELL STRUCTURE

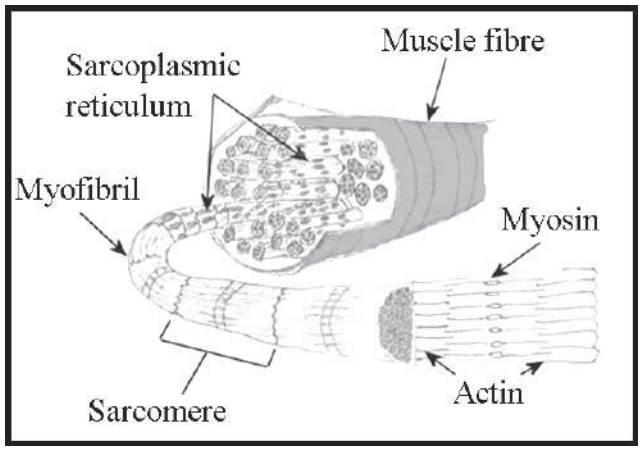
Although skeletal muscle cells come in different shapes and sizes the main structure of a skeletal muscle cell remains the same.

MUSCLE ANATOMY

If you were to take one whole muscle and cut through it, you would find the muscle is covered in a layer of connective muscle tissue known as the Epimysium. The Epimysium protects the muscle from friction against other muscles and bones. It also continues at the end of the muscle to form (along with other connective tissues) the muscles tendon. Looking at the cross section of the muscle you can see bundles of fibres/fibres, known as Fasciculi, which are surrounded by another connective tissue, called the Perimysium. Each Fasciculi contains anywhere between 10 and 100 muscle fibres, depending on the muscle in question.



A large strong muscle, such as thoses forming your Quadriceps would have a large number of fibers within each bundle. A smaller muscle used for precision movement, such as those in the hand would contain far fewer fibres per Fasciculi.



Looking at each muscle fibre in detail, you can see they too are covered in a fibrous connective tissue, known as Endomysium which insulates each muscle fibre. Muscle fibers can range from 10 to 80 micrometers in diameter and may be up to 35cm long.

Beneath the Endomysium and surrounding the muscle fibre is the Sarcolemma which is the fibres cell membrane and beneath this is the Sarcoplasm, which is the cells cytoplasm, a gelatinous fluid which fills most cells.

This contains Glycogen and Fats for energy and also Mitochondria which are the cells powerhouses, inside which the cells energy is produced.

Each muscle fibre itself contains cylindrical organelles known as Myofibrils. Each muscle fibre contains hundreds to thousands of Myofibrils. These are bundles of Actin and Myosin proteins which run the length of the muscle fibre and are important in muscle contraction.

Surrounding the Myofibril there is a network of tubules and channels called the Sarcoplasmic Reticulum in which Calcium is stored which is important in muscle contraction. Transverse tubules pass inwards from the Sacrolemma throughout the Myofibril, through which nerve impulses travel.

SLIDING FILAMENT THEORY

When a muscle contracts, the actin is pulled along myosin towards the center of the sarcomere until the actin and myosin filaments are completely overlapped. The H zone becomes smaller and smaller due to the increasing overlap of actin and myosin filaments, and the muscle shortens. Thus when the muscle is fully contracted, the H zone is no longer visible (as in the bottom diagram, left). Note that the actin and myosin filaments themselves do not change length, but instead slide past each other.

Cellular Action of Skeletal Muscles

During cellular respiration the mitochondria, within skeletal muscle cells, convert glucose from the blood to carbon dioxide and water in the process of producing ATP. ATP is needed for all muscular movement. When the need of ATP in the muscle is higher than the cells can produce with aerobic respiration, the cells will produce extra ATP in a process called anaerobic respiration. The first step of aerobic respiration(glycolysis) produces two ATP per glucose molecule. When the rest of the aerobic respiration pathway is occupied the pyruvate molecule can be converted to lactic acid. This method produces much less ATP than the aerobic method, but it does it faster and allows the muscles to do a bit more than if they relied solely on ATP production from aerobic respiration.

The drawback to this method is that lactic acid accumulates and causes the muscles to fatigue. They will eventually stop contracting until the breakdown of lactic acid is sufficient to allow for movement once again. People experience this most noticeably when they repeatedly lift heavy things such as weights or sprint for a long distance. Muscle soreness sometimes occurs after vigorous activity, and is often misunderstood by the general public to be the result of lactic acid buildup. This is a misconception because the muscle does fatigue from lactic acid buildup, but it does not stay in the muscle tissue long enough to cause tissue breakdown or soreness. During heavy breathing, following exercise,

the cells are converting the lactic acid either back into glucose or converting it to pyruvate and sending it through the additional steps of aerobic respiration. By the time a person is breathing normally again the lactic acid has been removed. The soreness is actually from small tears in the fibers themselves. After the fibers heal they will increase in size. The number of mitochondria will also increase if there is continued demand for additional ATP. Hence, through exercise the muscles can increase in both strength and endurance.

Another misconception is that as the muscle increases in size it also gains more fibers. This is not true. The fibers themselves increase in size rather than in quantity. The same holds true for adipose tissue—fat cells do not increase in number, but rather the amount of lipids (oil) in the cells increase.

Muscle fibers are also genetically programmed to reach a certain size and stop growing from there, so after awhile even the hardest working weightlifter will only reach a certain level of strength and endurance. Some people will get around this by taking steroids. The artificial steroids cause all sorts of trouble for the person.

They can cause the adrenal glands to stop producing corticosteroids and glucosteroids. This leads to the atrophy of the gland's medulla and causes permanent loss of the production of these hormones. The testicles may also atrophy in response to steroids. Eventually the testes will stop making testosterone and sperm, rendering the male infertile.

One of the more serious problems associated with abnormal gain of muscle mass is heart failure. While for most people gaining muscle and losing fat is desirable, a body builder is at risk of producing more muscle mass than the heart can handle.

One pound of fat contains about 3.5 miles of blood vessels, but one pound of muscle has about 6.5 miles. Hence, additional muscle causes the heart to pump more blood. Some people that have too much muscle will be very strong but will not have a healthy aerobic endurance, in part because of the difficulty of providing oxygenated blood to so much tissue.

Sliding filament theory: This link shows the animation of the sliding filament theory.

Explanation and image of sliding filament theory: This link gives a better demonstration of the theory with the explanation.

INVOLUNTARY MUSCLE MOVEMENT

Spasms

When Smooth and skeletal muscles go through multiple spasms it is referred either as seizure or convulsion.

Cramps

Strenuous activities can cause painful spasms that are long, this is referred to as cramps.

INJURY

Sprain

An injury to a joint that involves a stretched or torn ligament.

Muscle Strain

A strain occurs when a muscle or the tendon that attaches it to the bone is overstretched or torn. Muscle strains are also called pulled muscles. Who gets it? Anyone can strain a muscle.

However, people involved in sports or other forms of strenuous exercise are more likely to strain a muscle. *What causes it?*

Muscles are bunches of fibers that can contract. Muscle strains usually occur during activities that require the muscle to tighten forcefully. The muscle is strained either because it is not properly stretched, or warmed up, before the activity; it is too weak; or because the muscle is already injured and not allowed time to recover. So, many muscle strains occur during exercise or sports activities. They can also occur when lifting heavy objects. What are the symptoms?

When a muscle is strained, it hurts and is difficult to move. You may also feel a burning sensation in the area of the injured muscle, or feel as though something has "popped."

Sometimes the area of the strained muscle looks bruised or swells. A strained muscle might spasm, which means it contracts suddenly and involuntarily, causing severe pain. How is it diagnosed?

To diagnose a muscle strain, your doctor will examine the painful area, and ask how and when the injury happened. He or she may order other diagnostic tests, such as x-rays, to rule out any injury to the bone.

What is the Treatment

Muscle strains are treated with rest, ice, compression, and elevation, or RICE. You will be told to rest the injured area to reduce pain and swelling. If the strain is in the leg or foot area, you may need to use crutches. Ice packs are recommended at regular intervals (as recommended by your doctor) over the first few days after the injury. Ice causes the blood vessels to constrict, which reduces inflammation and pain. Anti-inflammatory medications might also be used to relieve pain. Compression and elevation help to reduce swelling. Your doctor may also recommend physical therapy to speed your recovery. You should avoid the type of activity that caused the injury until the muscle is completely healed. Self-care tips

You can prevent muscle strains by warming up for at least 10 minutes before participating in any strenuous exercise or heavy lifting. When you warm up, you increase the blood circulation to the muscle and prepare it for exercise. When starting any new exercise programme or sport, it's important to begin gradually so your muscles are conditioned for the activity.

STEROIDS

Anabolic steroids, which are synthetic versions of the primary male sex hormone testosterone, can be injected, taken orally, or used transdermally. These drugs are Controlled Substances that can be prescribed to treat conditions such as body wasting in patients with AIDS, and other diseases that occur when the body produces abnormally low amounts of testosterone. However, the doses prescribed to treat these medical conditions are 10 to 100 times lower than the doses that are used for performance enhancement.

Let me be clear:- while anabolic steroids can enhance certain types of performance or appearance,they are dangerous drugs, and when used inappropriately, they can cause a host of severe, long-lasting, and often irreversible negative health consequences. These drugs can stunt the height of growing adolescents, masculinize women, and alter sex characteristics of men. Anabolic steroids can lead to premature heart attacks, strokes, liver tumors, kidney failure and serious psychiatric problems. In addition, because steroids are often injected, users risk contracting or transmitting HIV or hepatitis.

Abuse of anabolic steroids differs from the abuse of other illicit substances because the initial use of anabolic steroids is not driven by the immediate euphoria that accompanies most drugs of abuse, such as cocaine, heroin, and marijuana, but by the desire of the user to change their appearance and performance, characteristics of great importance to adolescents. These effects of steroids can boost confidence and strength leading the user to overlook the potential serious long-term damage that these substances can cause.

Government agencies such as NIDA support research that increases our understanding of the impact of steroid use and improves our ability to prevent abuse of these drugs. For example, NIDA funding led to the development of two highly effective programmes that not only prevent anabolic steroid abuse among male and female high school athletes, but also promote other healthy behaviours and attitudes. The ATLAS (targeting male athletes) and ATHENA (targeting female athletes) programmes have been adopted by schools in 29 states and Puerto Rico. Both Congress and the Substance Abuse and Mental Health Services Administration have endorsed ATLAS and ATHENA as model prevention programmes, which could and should be implemented in more communities throughout the country.

In addition to these prevention programmes and other research efforts, also has invested in public education efforts to increase awareness about the dangers of steroid abuse. We have material on our web site about steroid abuse at www.steroidabuse.gov and in April 2005 we again will distribute a “Game Plan” public service announcement designed to bring attention to abuse of anabolic steroids.

Research has shown that the inappropriate use of anabolic steroids can have catastrophic medical, psychiatric and behavioural consequences.

I hope that students, parents, teachers, coaches and others will take advantage of the information on our web site about anabolic steroids abuse and join us in

our prevention and education efforts. Participating in sports offers many benefits, but young people and adults shouldn't take unnecessary health risks in an effort to win.(Nora D. Volkow, M.D.)

Human-made substances related to male sex hormones. Some athletes abuse anabolic steroids to enhance performance. Abuse of anabolic steroids can lead to serious health problems, some of which are irreversible.

Major side effects can include liver tumors and cancer, jaundice, high blood pressure, kidney tumors, severe acne, and trembling. In males, side effects may include shrinking of the testicles and breast development. In females, side effects may include growth of facial hair, menstrual changes, and deepened voice. In teenagers, growth may be halted prematurely and permanently.

The therapeutic use of steroids can be realized by patients and their doctors by using them in a manner that is beneficial to the person.

MyoD and other Muscular Factors

MyoD is a protein and a transcription factor that activates muscle cell differentiation by turning on transcription of specific regulatory genes. It turns stem cells into myoblasts, a cell that can turn into many muscle cell, also called "muscle stem cell". MyoD belongs to a family of proteins knowns as myogenic regulatory factor(MRFs). MyoD can also turn on transcription of it's own regulatory genes (MyoD protein coding genes), and this means that it can produce more of itself. The positive feedback turns on transcription of other muscle proteins, cell cycle blockers, and microRNA-206. One of the main actions of MyoD is to remove cells from the cell cycle by enhancing the transcription of p21The function of MyoD is to commit mesoderm cells to a skeletal lineage. MyoD can also regulate muscle repair. One of the main actions of MyoD is to remove cells from the cell cycle by enhancing the transcription of p21. Bidirectional Signalling- muscle cells and nerves cells send signals back and forth to each other. Amyotrophic Lateral Sclerosis(ALS) is a loss of motor neuron and this blocks the formation of neuromuscular junctions. Therefore, no muscle growth which means a potential of leading to paralysis. Stephen Hawking suffers from this disease.

Muscle Homeostasis

MicroRNA-206 indirectly forms neuromuscular junctions with motor neurons. Neuromuscular junction sends synaptic signals to MyoD and this blcoks MyoD and stops or limits muscle development. Myostatin is a protein that also blocks MyoD. Without myostatin, muscle development increases.

Myostatin Mutations In Sheep: they can have a mutant myostatin that causes microRNA-206 to block myostatin translation

Myostatin Mutations In Humans: humans with mutant myostatin will develop lots of muscle (like a body builder) is possible to create a drug that blocks myostatin production.

SMOOTH MUSCLE CONTRACTION

- Contractions are initiated by an influx of calcium which binds to calmodulin.
- The calcium-calmodulin complex binds to and activates myosin light-chain kinase.
- Myosin light-chain kinase phosphorylates myosin light-chains using ATP, causing them to interact with actin filaments.
- Powerstroke.
- Calcium is actively pumped out of the cell by receptor regulated channels. A second messanger, IP3, causes the release.
- As calcium is removed the calcium-calmodulin complex breaks away from the myosin light-chain kinase, stopping phosphorylation.
- Myosin phophatase dephosphorylates the myosin. If the myosin was bound to an actin molecule, the release is slow, this is called a latch state. In this manner, smooth muscle is able to stay contracted for some time without the use of much ATP. If the myosin was not bound to an actin chain it loses its affinity for actin.

It should be noted that ATP is still needed for crossbridge cycling, and that there is no reserve, such as creatine phosphate, available. Most ATP is created from aerobic metabolism, however anaerobic production may take place in times of low oxygen concentrations.

CARDIAC MUSCLE

Cardiac muscle is found in the heart and lungs of humans

ATP IN THE HUMAN BODY

Muscles cells, like all cells, use ATP as an energy source. The total quantity of ATP in the human body at any one time is about 0.1 Mole. The energy used by human cells requires the hydrolysis of 200 to 300 moles of ATP daily. This means that each ATP molecule is recycled 2000 to 3000 times during a single day. ATP cannot be stored, hence its consumption must closely follow its synthesis. On a per-hour basis, 1 kilogram of ATP is created, processed and then recycled in the body. Looking at it another way, a single cell uses about 10 million ATP molecules per second to meet its metabolic needs, and recycles all of its ATP molecules about every 20-30 seconds.

LACTIC ACID

Catabolized carbohydrates is known as glycolysis. The end product of glycolysis, pyruvate can go into different directions depending on aerobic or anaerobic conditions. In aerobic it goes through the Krebs cycle and in anaerobic it goes through the Cori cycle. In the Cori cycle pyruvate is converted to lactate, this forms lactic acid, lactic acid causes muscle fatigue. In the aerobic conditions pyruvate goes through the Krebs cycle.

MUSCLE DISORDERS

Dermatomyositis and Polymyositis

Dermatomyositis and polymyositis cause inflammation of the muscles. They are rare disorders, affecting only about one in 100,000 people per year. More women than men are affected. Although the peak age of onset is in the 50s, the disorders can occur at any age.

Signs and symptoms — Patients complain of muscle weakness that usually worsens over several months, though in some cases symptoms come on suddenly. The affected muscles are close to the trunk (as opposed to in the wrists or feet), involving for example the hip, shoulder, or neck muscles. Muscles on both sides of the body are equally affected. In some cases, muscles are sore or tender. Some patients have involvement of the muscles of the pharynx (throat) or the esophagus (the tube leading from the throat to the stomach), causing problems with swallowing. In some cases, this leads to food being misdirected from the esophagus to the lungs, causing severe pneumonia.

In dermatomyositis, there is a rash, though sometimes the rash resolves before muscle problems occur. A number of different types of rash can occur, including rashes on the fingers, the chest and shoulders, or on the upper eyelids (show picture 1-3). In rare cases, the rash of dermatomyositis appears but myopathy never develops.

Other problems sometimes associated with these diseases include fever, weight loss, arthritis, cold-induced colour changes in the fingers or toes (Raynaud phenomenon), and heart or lung problems.

Muscle Atrophy

Alternative names: Atrophy of the muscles, Muscle wasting, Wasting

The majority of muscle atrophy in the general population results from disuse. People with sedentary jobs and senior citizens with decreased activity can lose muscle tone and develop significant atrophy. This type of atrophy is reversible with vigorous exercise. Bed-ridden people can undergo significant muscle wasting. Astronauts, free of the gravitational pull of Earth, can develop decreased muscle tone and loss of calcium from their bones following just a few days of weightlessness.

Muscle atrophy resulting from disease rather than disuse is generally one of two types, that resulting from damage to the nerves that supply the muscles, and disease of the muscle itself. Examples of diseases affecting the nerves that control muscles would be poliomyelitis, amyotrophic lateral sclerosis (ALS or Lou Gehrig's disease), and Guillain-Barre syndrome. Examples of diseases affecting primarily the muscles would include muscular dystrophy, myotonia congenita, and myotonic dystrophy as well as other congenital, inflammatory or metabolic myopathies.

Even minor muscle atrophy usually results in some loss of mobility or power.

Common Causes:

- Some atrophy that occurs normally with ageing
- Cerebrovascular accident (stroke)

- Spinal cord injury
- Peripheral nerve injury (peripheral neuropathy)
- Other injury
- Prolonged immobilization
- Osteoarthritis
- Rheumatoid arthritis
- Prolonged corticosteroid therapy
- Diabetes (diabetic neuropathy)
- Burns
- Poliomyelitis
- Amyotrophic lateral sclerosis (ALS or Lou Gehrig's disease)
- Guillain-Barre syndrome
- Muscular dystrophy
- Myotonia congenita
- Myotonic dystrophy
- Myopathy

Muscular Dystrophy

Muscular dystrophy (MD) is a group of rare inherited muscle diseases in which muscle fibers are unusually susceptible to damage. Muscles, primarily voluntary muscles, become progressively weaker. In the late stages of muscular dystrophy, muscle fibers are often replaced by fat and connective tissue. In some types of muscular dystrophy, heart muscles, other involuntary muscles and other organs are affected. The most common types of muscular dystrophy appear to be due to a genetic deficiency of the muscle protein dystrophin. There's no cure for muscular dystrophy, but medications and therapy can slow the course of the disease.

SMOOTH MUSCLE TISSUE

Smooth muscle is an involuntary non-striated muscle. It is divided into two subgroups; the single-unit (unitary) and multiunit smooth muscle. Within single-unit cells, the whole bundle or sheet contracts as a syncytium (*i.e.*, a multinucleate mass of cytoplasm that is not separated into cells). Multiunit smooth muscle tissues innervate individual cells; as such, they allow for fine control and gradual responses, much like motor unit recruitment in skeletal muscle.

Smooth muscle is found within the walls of blood vessels (such smooth muscle specifically being termed vascular smooth muscle) such as in the tunica media layer of large (aorta) and small arteries, arterioles and veins. Smooth muscle is also found in lymphatic vessels, the urinary bladder, uterus (termed uterine smooth muscle), male and female reproductive tracts, gastrointestinal tract,respiratory tract, arrector pili of skin, the ciliary muscle, and iris of the eye. The structure and function is basically the same in smooth muscle cells in different organs, but the inducing stimuli differ substantially, in order to perform individual effects in the body at individual times. In addition, the glomeruli of the kidneys contain smooth muscle-like cells called mesangial cells.

STRUCTURE

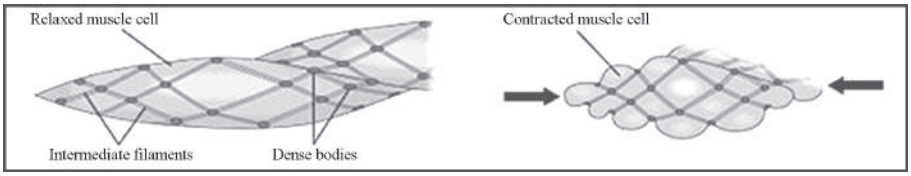


Fig. The dense bodies and intermediate filaments are networked through the sarcoplasm, which cause the muscle fibre to contract.

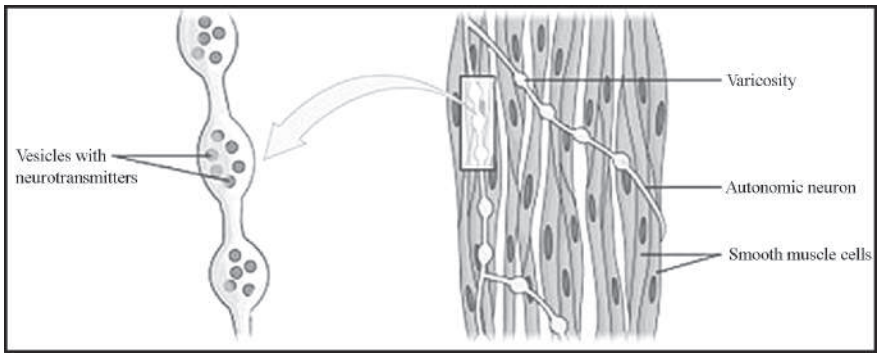
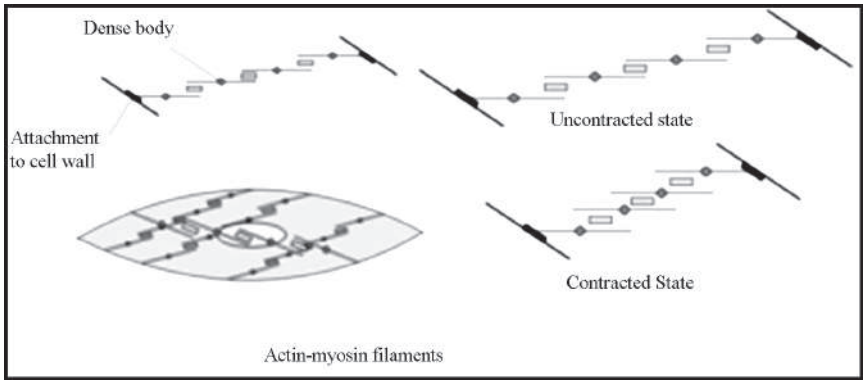


Fig. A series of axon-like swelling, called varicosities or "boutons," from autonomic neurons form motor units through the smooth muscle.

Most smooth muscle is of the single-unit variety, that is, either the whole muscle contracts or the whole muscle relaxes, but there is multiunit smooth muscle in the trachea, the large elastic arteries, and the iris of the eye. Single unit smooth muscle, however, is most common and lines blood vessels (except large elastic arteries), the urinary tract, and the digestive tract.

Smooth muscle is fundamentally different from skeletal muscle and cardiac muscle in terms of structure, function, regulation of contraction, and excitation-contraction coupling.



Smooth muscle cells known as myocytes, have a fusiform shape and, like striated muscle, can tense and relax. However, smooth muscle tissue tends to demonstrate greater elasticity and function within a larger length-tension curve

than striated muscle. This ability to stretch and still maintain contractility is important in organs like the intestines and urinary bladder. In the relaxed state, each cell is spindle-shaped, 20-500 micrometers in length.

Molecular structure

A substantial portion of the volume of the cytoplasm of smooth muscle cells are taken up by the molecules myosin and actin, which together have the capability to contract, and, through a chain of tensile structures, make the entire smooth muscle tissue contract with them.

Myosin

Myosin is primarily of class II in smooth muscle.

- Myosin II contains two *heavy chains* which constitute the head and tail domains. Each of these heavy chains contains the N-terminal head domain, while the C-terminal tails take on a coiled-coil morphology, holding the two heavy chains together (imagine two snakes wrapped around each other, such as in a caduceus). Thus, myosin II has two heads. In smooth muscle, there is a single gene (MYH11) that codes for the heavy chains myosin II, but there are splice variants of this gene that result in four distinct isoforms. Also, smooth muscle may contain MHC that is not involved in contraction, and that can arise from multiple genes.
- Myosin II also contains 4 *light chains*, resulting in 2 per head, weighing 20 (MLC_{20}) and 17 (MLC_{17}) kDa. These bind the heavy chains in the "neck" region between the head and tail.
- The MLC_{20} is also known as the *regulatory light chain* and actively participates in muscle contraction. Two MLC_{20} isoforms are found in smooth muscle, and they are encoded by different genes, but only one isoform participates in contraction.
- The MLC_{17} is also known as the *essential light chain*. Its exact function is unclear, but it's believed that it contributes to the structural stability of the myosin head along with MLC_{20}. Two variants of MLC_{17} ($MLC_{17a/b}$) exist as a result of alternate splicing at the MLC_{17} gene.

Different combinations of heavy and light chains allow for up to hundreds of different types of myosin structures, but it is unlikely that more than a few such combinations are actually used or permitted within a specific smooth muscle bed. In the uterus, a shift in myosin expression has been hypothesized to avail for changes in the directions ofuterine contractions that are seen during the menstrual cycle.

Actin

The super thin filaments that form part of the contractile machinery are predominantly composed of α- and γ-actin. Smooth muscle α-actin (alpha actin) is the predominant isoform within smooth muscle. There are also lots of actin

(mainly β-actin) that does not take part in contraction, but that polymerizes just below the plasma membrane in the presence of a contractile stimulant and may thereby assist in mechanical tension. Alpha actin is also expressed as distinct genetic isoforms such as smooth muscle, cardiac muscle and skeletal muscle specific isoforms of alpha actin. (ref The actin gene family: function follows isoform.Perrin BJ, Ervasti JM.Cytoskeleton (Hoboken). 2010 Oct;67(10):630-4. Review.)

The ratio of actin to myosin is between 2:1 and 10:1 in smooth muscle, compared to ~6:1 in skeletal muscle and 4:1 in cardiac muscle.

Other Proteins of the Contractile Apparatus

Smooth muscle does not contain the protein troponin; instead calmodulin (which takes on the regulatory role in smooth muscle), caldesmon and calponin are significant proteins expressed within smooth muscle.

- Tropomyosin is present in smooth muscle, spanning seven actin monomers and is laid out end to end over the entire length of the thin filaments. In striated muscle, tropomyosin serves to block actin–myosin interactions until calcium is present, but in smooth muscle, its function is unknown.
- Calponin molecules may exist in equal number as actin, and has been proposed to be a load-bearing protein.
- Caldesmon has been suggested to be involved in tethering actin, myosin and tropomyosin, and thereby enhance the ability of smooth muscle to maintain tension.

Also, all three of these proteins may have a role in inhibiting the ATPase activity of the myosin complex that otherwise provides energy to fuel muscle contraction.

Other Tensile Structures

The myosin and actin are the contractile parts of continuous chains of tensile structures that stretch both across and between smooth muscle cells.

The actin filaments of contractile units are attached to *dense bodies*. Dense bodies are rich in α-actinin, and also attach intermediate filaments (consisting largely of vimentinand desmin), and thereby appear to serve as anchors from which the thin filaments can exert force. Dense bodies also are associated with β-actin, which is the type found in the cytoskeleton, suggesting that dense bodies may coordinate tensions from both the contractile machinery and the cytoskeleton. Dense bodies appear darker under an electron microscope, and so they are sometimes described as electron dense.

The intermediate filaments are connected to other intermediate filaments via dense bodies, which eventually are attached to adherens junctions (also called focal adhesions) in the cell membrane of the smooth muscle cell, called the sarcolemma.

The adherens junctions consist of large number of proteins including α-actinin, vinculin and cytoskeletal actin. The adherens junctions are scattered

around *dense bands* that are circumfering the smooth muscle cell in a rib-like pattern. The dense band (or dense plaques) areas alternate with regions of membrane containing numerous caveolae. When complexes of actin and myosin contract, force is transduced to the sarcolemma through intermediate filaments attaching to such dense bands.

During contraction, there is a spatial reorganization of the contractile machinery to optimize force development. part of this reorganization consists of vimentin being phosphorylated at Ser by a p21 activated kinase, resulting in some disassembly of vimentin polymers.

Also, the number of myosin filaments is dynamic between the relaxed and contracted state in some tissues as the ratio of actin to myosin changes, and the length and number of myosin filaments change.

Smooth muscle cells have been observed contracting in a spiral corkscrew fashion, and contractile proteins have been observed organizing into zones of actin and myosin along the axis of the cell.

Smooth muscle-containing tissue needs to be stretched often, so elasticity is an important attribute of smooth muscle. Smooth muscle cells may secrete a complex extracellular matrix containing collagen (predominantly types I and III), elastin, glycoproteins, and proteoglycans. Smooth muscle also has specific elastin and collagen receptors to interact with these proteins of the extracellular matrix. These fibers with their extracellular matrices contribute to the viscoelasticity of these tissues. For example, the great arteries are viscolelastic vessels that act like a Windkessel, propagating ventricular contraction and smoothing out the pulsatile flow, and the smooth muscle within the tunica mediacontributes to this property.

Caveolae

The sarcolemma also contains caveolae, which are microdomains of lipid rafts specialized to cell signaling events and ion channels. These invaginations in the sarcoplasma contain a host of receptors (prostacyclin, endothelin, serotonin, muscarinic receptors, adrenergic receptors), second messenger generators (adenylate cyclase, phospholipase C), G proteins (RhoA, G alpha), kinases (rho kinase-ROCK, protein kinase C, protein Kinase A), ion channels (L type calcium channels, ATP sensitive potassium channels, calcium sensitive potassium channels) in close proximity. The caveolae are often close to sarcoplasmic reticulum or mitochondria, and have been proposed to organize signaling molecules in the membrane.

EXCITATION-CONTRACTION COUPLING

A smooth muscle is excited by external stimuli, which causes contraction.

Inducing Stimuli and Factors

Smooth muscle may contract spontaneously (via ionic channel dynamics) or as in the gut special pacemakers cells interstitial cells of Cajal produce rhythmic

contractions. Also, contraction, as well as relaxation, can be induced by a number of physiochemical agents (*e.g.*, hormones, drugs, neurotransmitters - particularly from the autonomic nervous system).

Smooth muscle in various regions of the vascular tree, the airway and lungs, kidneys and vagina is different in their expression of ionic channels, hormone receptors, cell-signaling pathways, and other proteins that determine function.

External Substances

For instance, blood vessels in skin, gastrointestinal system, kidney and brain respond to norepinephrine and epinephrine (from sympathetic stimulation or the adrenal medulla) by producing vasoconstriction (this response is mediated through alpha-1 adrenergic receptors. However, blood vessels within skeletal muscle and cardiac muscle respond to these catecholamines producing vasodilation because the smooth muscle possess beta-adrenergic receptors. So there is a difference in the distribution of the various adrenergic receptors that explains the difference in why blood vessels from different areas respond to the same agent norepinephrine/epinephrine differently as well as differences due to varying amounts of these catecholamines that are released and sensitivities of various receptors to concentrations..

Generally, arterial smooth muscle responds to carbon dioxide by producing vasodilation, and responds to oxygen by producing vasoconstriction. Pulmonary blood vessels within the lung are unique as they vasodilate to high oxygen tension and vasoconstrict when it falls. Bronchiole, smooth muscle that line the airways of the lung, respond to high carbon dioxide producing vasodilation and vasoconstrict when carbon dioxide is low.

These responses to carbon dioxide and oxygen by pulmonary blood vessels and bronchiole airway smooth muscle aid in matching perfusion and ventilation within the lungs. Further different smooth muscle tissues display extremes of abundant to little sarcoplasmic reticulum so excitation-contraction coupling varies with its dependence on intracellular or extracellular calcium.

Recent research indicates that sphingosine-1-phosphate (S1P) signaling is an important regulator of vascular smooth muscle contraction. When transmural pressure increases,sphingosine kinase 1 phosphorylates sphingosine to S1P, which binds to the S1P2 receptor in plasma membrane of cells.

This leads to a transient increase in intracellular calcium, and activates Rac and Rhoa signaling pathways. Collectively, these serve to increase MLCK activity and decrease MLCP activity, promoting muscle contraction. This allows arterioles to increase resistance in response to increased blood pressure and thus maintain constant blood flow. The Rhoa and Rac portion of the signaling pathway provides a calcium-independent way to regulate resistance artery tone.

Spread of Impulse

To maintain organ dimensions against force, cells are fastened to one another by adherens junctions. As a consequence, cells are mechanically coupled to

one another such that contraction of one cell invokes some degree of contraction in an adjoining cell. Gap junctions couple adjacent cells chemically and electrically, facilitating the spread of chemicals (*e.g.*, calcium) or action potentials between smooth muscle cells. Single unit smooth muscle displays numerous gap junctions and these tissues often organize into sheets or bundles which contract in bulk.

Contraction

Smooth muscle contraction is caused by the sliding of myosin and actin filaments (a sliding filament mechanism) over each other. The energy for this to happen is provided by the hydrolysis of ATP. Myosin functions as an ATPase utilizing ATP to produce a molecular conformational change of part of the myosin and produces movement.

Movement of the filaments over each other happens when the globular heads protruding from myosin filaments attach and interact with actin filaments to form crossbridges. The myosin heads tilt and drag along the actin filament a small distance (10-12 nm). The heads then release the actin filament and then changes angle to relocate to another site on the actin filament a further distance (10-12 nm) away. They can then re-bind to the actin molecule and drag it along further. This process is called crossbridge cycling and is the same for all muscles. Unlike cardiac and skeletal muscle, smooth muscle does not contain the calcium-binding protein troponin. Contraction is initiated by a calcium-regulated phosphorylation of myosin, rather than a calcium-activated troponin system.

Crossbridge cycling causes contraction of myosin and actin complexes, in turn causing increased tension along the entire chains of tensile structures, ultimately resulting in contraction of the entire smooth muscle tissue.

Phasic or Tonic

Smooth muscle may contract phasically with rapid contraction and relaxation, or tonically with slow and sustained contraction. The reproductive, digestive, respiratory, and urinary tracts, skin, eye, and vasculature all contain this tonic muscle type. This type of smooth muscle can maintain force for prolonged time with only little energy utilization. There are differences in the myosin heavy and light chains that also correlate with these differences in contractile patterns and kinetics of contraction between tonic and phasic smooth muscle.

Activation of Myosin Heads

Crossbridge cycling cannot occur until the myosin heads have been activated to allow crossbridges to form. When the light chains are phosphorylated, they become active and will allow contraction to occur. The enzyme that phosphorylates the light chains is called myosin light-chain kinase (MLCK), also called MLC_{20} kinase. In order to control contraction, MLCK will work only when the muscle is stimulated to contract. Stimulation will increase the intracellular concentration of calcium ions. These bind to a molecule called

calmodulin, and form a calcium-calmodulin complex. It is this complex that will bind to MLCK to activate it, allowing the chain of reactions for contraction to occur.

Activation consists of phosphorylation of a serine on position 19 (Ser^{19}) on the MLC_{20} light chain, which causes a conformational change that increases the angle in the neck domain of the myosin heavy chain, which corresponds to the part of the cross-bridge cycle where the myosin head is unattached to the actin filament and relocates to another site on it. After attachment of the myosin head to the actin filament, this serine phosphorylation also activates the ATPase activity of the myosin head region to provide the energy to fuel the subsequent contraction. Phosphorylation of a threonine on position 18 (Thr^{18}) on MLC_{20} is also possible and may further increase the ATPase activity of the myosin complex.

Sustained Maintenance

Phosphorylation of the MLC_{20} myosin light chains correlates well with the shortening velocity of smooth muscle. During this period there is a rapid burst of energy utilization as measured by oxygen consumption. Within a few minutes of initiation the calcium level markedly decrease, MLC_{20} myosin light chains phosphorylation decreases, and energy utilization decreases and the muscle can relax. Still, smooth muscle has the ability of sustained maintenance of force in this situation as well. This sustained phase has been attributed to certain myosin crossbridges, termed latch-bridges, that are cycling very slowly, notably slowing the progression to the cycle stage whereby dephosphorylated myosin detaches from the actin, thereby maintaining the force at low energy costs. This phenomenon is of great value especially for tonically active smooth muscle.

Isolated preparations of vascular and visceral smooth muscle contract with depolarizing high potassium balanced saline generating a certain amount of contractile force. The same preparation stimulated in normal balanced saline with an agonist such as endothelin or serotonin will generate more contractile force.

This increase in force is termed calcium sensitization. The myosin light chain phosphatase is inhibited to increase the gain or sensitivity of myosin light chain kinase to calcium. There are number of cell signalling pathways believed to regulate this decrease in myosin light chain phosphatase: a RhoA-Rock kinase pathway, a Protein kinase C-Protein kinase C potentiation inhibitor protein 17 (CPI-17) pathway, telokin, and a Zip kinase pathway. Further Rock kinase and Zip kinase have been implicated to directly phosphorylate the 20kd myosin light chains.

Other Contractile Mechanisms

Other cell signaling pathways and protein kinases (Protein kinase C, Rho kinase, Zip kinase, Focal adhesion kinases) have been implicated as well and actin polymerization dynamics plays a role in force maintenance. While myosin light chain phosphorylation correlates well with shortening velocity, other cell

signaling pathways have been implicated in the development of force and maintenance of force. Notably the phosphorylation of specific tyrosine residues on the focal adhesion adapter protein-paxillin by specific tyrosine kinases has been demonstrated to be essential to force development and maintenance.

For example, cyclic nucleotides can relax arterial smooth muscle without reductions in crossbridge phosphorylation, a process termed force suppression. This process is mediated by the phosphorylation of the small heat shock protein, hsp20, and may prevent phosphorylated myosin heads from interacting with actin.

Relaxation

The phosphorylation of the light chains by MLCK is countered by a myosin light-chain phosphatase, which dephosphorylates the MLC_{20} myosin light chains and thereby inhibits contraction. Other signaling pathways have also been implicated in the regulation actin and myosin dynamics. In general, the relaxation of smooth muscle is by cell-signaling pathways that increase the myosin phosphatase activity, decrease the intracellular calcium levels, hyperpolarize the smooth muscle, and/or regulate actin and myosin muscle can be mediated by the endothelium-derived relaxing factor-nitric oxide, endothelial derived hyperpolarizing factor (either an endogenous cannabinoid, cytochrome P450 metabolite, or hydrogen peroxide), or prostacyclin (PGI2). Nitric oxide and PGI2 stimulate soluble guanylate cyclase and membrane bound adenylate cyclase, respectively.

The cyclic nucleotides (cGMP and cAMP) produced by these cyclases activate Protein Kinase G and Protein Kinase A and phosphorylate a number of proteins.

The phosphorylation events lead to a decrease in intracellular calcium (inhibit L type Calcium channels, inhibits IP3 receptor channels, stimulates sarcoplasmic reticulum Calcium pump ATPase), a decrease in the 20kd myosin light chain phosphorylation by altering calcium sensitization and increasing myosin light chain phosphatase activity, a stimulation of calcium sensitive potassium channels which hyperpolarize the cell, and the phosphorylation of amino acid residue serine 16 on the small heat shock protein (hsp20)by Protein Kinases A and G.

The phosphorylation of hsp20 appears to alter actin and focal adhesion dynamics and actin-myosin interaction, and recent evidence indicates that hsp20 binding to 14-3-3 protein is involved in this process.

An alternative hypothesis is that phosphorylated Hsp20 may also alter the affinity of phosphorylated myosin with actin and inhibit contractility by interfering with crossbridge formation. The endothelium derived hyperpolarizing factor stimulates calcium sensitive potassium channels and/or ATP sensitive potassium channels and stimulate potassium efflux which hyperpolarizes the cell and produces relaxation.

INVERTEBRATE SMOOTH MUSCLE

In invertebrate smooth muscle, contraction is initiated with the binding of calcium directly to myosin and then rapidly cycling cross-bridges, generating

force. Similar to the mechanism of vertebrate smooth muscle, there is a low calcium and low energy utilization catch phase. This sustained phase or catch phase has been attributed to a catch protein that has similarities to myosin light-chain kinase and the elastic protein-titin called twitchin. Clams and other bivalve mollusks use this catch phase of smooth muscle to keep their shell closed for prolonged periods with little energy usage.

SPECIFIC EFFECTS

Although the structure and function is basically the same in smooth muscle cells in different organs, their specific effects or end-functions differ.

The contractile function of vascular smooth muscle regulates the lumenal diameter of the small arteries-arterioles called resistance vessels, thereby contributing significantly to setting the level of blood pressure and blood flow to vascular beds. Smooth muscle contracts slowly and may maintain the contraction (tonically) for prolonged periods in blood vessels, bronchioles, and some sphincters. Activating arteriole smooth muscle can decrease the lumenal diameter 1/3 of resting so it drastically alters blood flow and resistance. Activation of aortic smooth muscle doesn't significantly alter the lumenal diameter but serves to increase the viscoelasticity of the vascular wall.

In the digestive tract, smooth muscle contracts in a rhythmic peristaltic fashion, rhythmically forcing foodstuffs through the digestive tract as the result of phasic contraction. A non-contractile function is seen in specialized smooth muscle within the afferent arteriole of the juxtaglomerular apparatus, which secretes renin in response to osmotic and pressure changes, and also it is believed to secrete ATP in tubuloglomerular regulation of glomerular filtration rate. Renin in turn activates the renin-angiotensin system to regulate blood pressure.

GROWTH AND REARRANGEMENT

The mechanism in which external factors stimulate growth and rearrangement is not yet fully understood. A number of growth factors and neurohumoral agents influence smooth muscle growth and differentiation. The Notch receptor and cell-signaling pathway have been demonstrated to be essential to vasculogenesis and the formation of arteries and veins. The proliferation is implicated in the pathogenesis of atherosclerosis and is inhibited by nitric oxide.

The embryological origin of smooth muscle is usually of mesodermal origin, after the creation of muscle fibers in a process known as myogenesis. However, the smooth muscle within the Aorta and Pulmonary arteries (the Great Arteries of the heart) is derived from ectomesenchyme of neural crest origin, although coronary artery smooth muscle is of mesodermal origin.

RELATED DISEASES

"Smooth muscle condition" is a condition in which the body of a developing embryo does not create enough smooth muscle for the gastrointestinal system. This condition is fatal.

Anti-smooth muscle antibodies (ASMA) can be a symptom of an auto-immune disorder, such as hepatitis, cirrhosis, or lupus. Vascular smooth muscle tumors are very rare.

They can be malignant or benign, and morbidity can be significant with either type. Intravascular leiomyomatosis is a benign neo-plasm that extends through the veins; angioleiomyoma is a benign neo-plasm of the extremities; vascular leiomyosarcomas is a malignant neo-plasm that can be found in theinferior vena cava, pulmonary arteries and veins, and other peripheral vessels.

FUNCTIONS OF THE MUSCULAR SYSTEM TYPES OF MUSCLES AND THEIR FUNCTIONS

Different types of muscles in the body perform different functions according to their type and location.

Muscles are the contractile tissues [Tissue that is able to contract] that are responsible for performing various voluntary and involuntary functions. Muscles can be regarded as motors of the body.

Muscles are so named because, many of them resemble a mouse, with their tendons representing the tail.

TYPES OF MUSCLES

The muscles are of three types, skeletal, smooth and cardiac. Fourth type is myoepithelial cells which are specialized cells in sweat glands.

The characters of each type are summarized below.

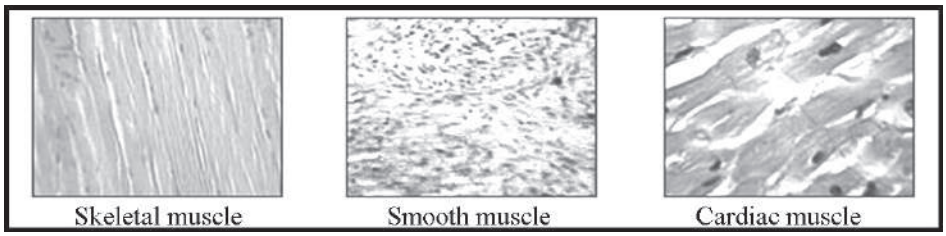


Fig. Different Types of Muscles, Image Credit: Wikipedia, Public Domain.

SKELETAL MUSCLES

Skeletal muscles are types of muscles which are most abundant and are found attached to skeleton. They are also called striped, striated, somatic, or voluntary muscles.

They exhibit cross-striations under microscope, and are considered to be the best differentiated form of muscle.

They are supplied by somatic (cerebrospinal) nerves, and, therefore, are under voluntary control, with certain exceptions.

They respond quickly to stimuli, being capable of rapid contractions, and help in adjusting the individual to external environment. They also get fatigued very easily.

Each muscle fibre of skeletal muscle is a multinucleated cylindrical cell, containing groups of myofibrils. Myofibrils are made up of myofilaments of three types (myosin, actin and tropomyosin). These are the actual contractile elements of the muscle.

Skeletal muscles are under highest nervous control of cerebral cortex.

Examples of these types of muscles are muscles of limbs and body wall, and bronchial muscles are examples of skeletal muscles.

GROSS ANATOMY OF A SKELETAL MUSCLE

Most of the skeletal muscles are attached to two bones, one is called origin and other is called insertion. Muscles attach to the bones by tendons which are tough bands of connective tissue. Tendons very strong and are woven into the coverings of both muscles and bones.

Muscles act by contraction which results in their shortening and pull on tendons. This transfers the force to bone attached and desired movement results between the bones muscle is attached. The muscle attachement on the stationery bone is called origin and the one on the other bone [which moved] is called insertion.

In between the origin and the insertion lies the muscle belly.

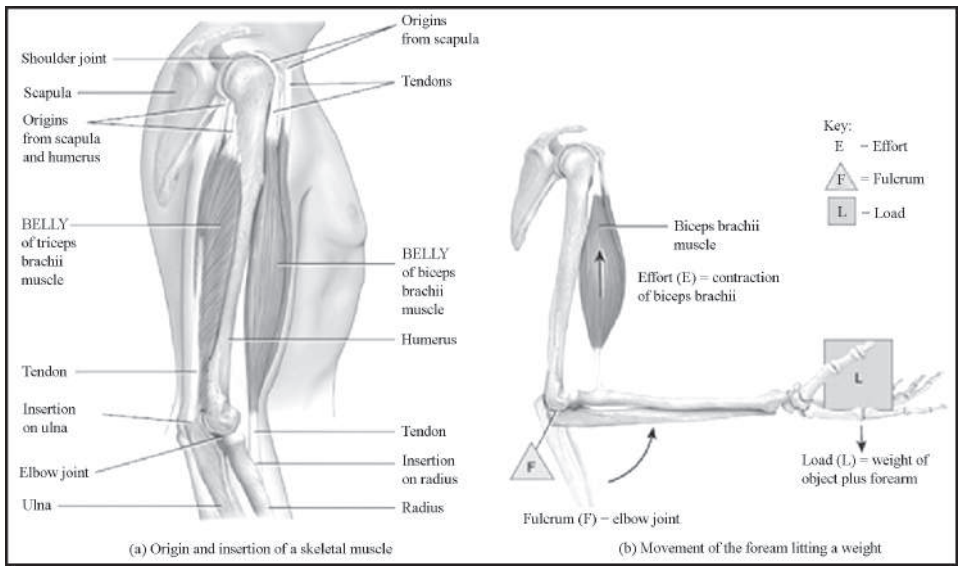


Fig. Higheredbcs.

Skeletal muscle may be named on based on their location [tibialis anterior], site of origin and insertion [sternocleidomastoid], number of Origins[quadriceps], shape [serratus anterior], and function [supinator].

Most of the time, for producing a movement, many muscles act together. The muscle that produces any particular movement of the body is known as an agonist or prime mover. The agonist always pairs with an antagonist muscle that produces the opposite effect on the same bones. For example, the biceps

brachii muscle flexes the arm and the triceps brachii muscle extends the arm at the elbow. So biceps is agonist when arm is flexed and tricpes is anatagonist. Reverse happens in extension of arm.

When the triceps is extending the arm, the biceps would be considered the antagonist.

Synergists are muscles that help to stabilize a movement and reduce extraneous movements to produce smooth functioning. They are usually found in regions near the agonist and often connect to the same bones.

SKELETAL MUSCLE HISTOLOGY

Skeletal muscle fibers are highly specialized and contains many unique organelles.

Cell membrane of muscle fibers is called the sarcolemma and acts as a conductor for electrochemical signals. T tubules are transverse tubules that help carry these electrochemical signals into the middle of the muscle fibre.

Calcium ions are vital to muscle contraction and are stored in the sarcoplasmic reticulum. Muscle cells are very rich in mitochondria are which function to provide ATP [energy] to active muscles.

Most of the muscle fiber's structure is made up of myofibrils, which are the contractile structures of the cell. Myofibrils are made up of many proteins fibers arranged into repeating subunits called sarcomeres. The sarcomere is the functional unit of muscle fibers.

Sarcomeres are made of two types of protein fibers: thick filaments made of myosin protein and thin filaments actin, tropomyosin and troponin.

PHYSIOLOGY OF MUSCLE CONTRACTION

Motor neurons control the movement of muscles. Each motor neuron controls several muscle cells in a group known as a motor unit. When a motor neuron receives stimulates all of the muscles cells in its motor unit at the same time.

Nummber of muscle fibers in a motor unit may very with muscle. For example fine muscles like those of fingers have very few muscle fibers in each motor unit to improve the and the muscles that need a lot of strength to perform their function—like leg or arm muscles—have many muscle cells in each motor unit. Body can control number of motor units to activate or employ for a given function.

Neuromuscular junction is place where neurons bond with the motor end plate, a specialized part of sarcolemma, and cause release of ions creating an electrochemical gradient inside of the cell, which further opens more ion channels.

When the positive ions reach the sarcoplasmic reticulum, Ca2+ ions are released and allowed to flow into the myofibrils and bind to troponin. This binding leads to change in shape of troponin molecule and move tropomyosin away from myosin binding sites on actin. This allows actin and myosin to bind together.

Using ATP molecules myosin proteins in the thick filaments bend and pull on actin molecules in the thin filaments.. As the thin filaments are pulled together, the sarcomere shortens and contracts. Contraction of many sarcomeres in a row [myofibril], cause shortening of muscle cells.

When a motor neuron stops the release of the neurotransmitter, the process of contraction reverses itself. Calcium returns to the sarcoplasmic reticulum, troponin and tropomyosin return to their resting positions; and actin and myosin are prevented from binding and sarcomeres return to their elongated resting state. Muscles stay partially contracted in normal state to maintain tone which helps to prevent damage to the muscle and joints and maintains the body's posture.

MUSCLE METABOLISM

Muscles use aerobic respiration when we call on them to produce a low to moderate level of force. However they switch to aanaerobic respiration, a less efficient form of respiration when demand is higher.

Myoglobin is a pigment found in muscles, contains iron and stores oxygen in a manner similar to hemoglobin in the blood enabling muscle to continue aerobic respiration in oxygen deficiency.

Creatine phosphate and glycogen are other energy providing sources of muscle.

CARDIAC MUSCLE

This type of muscles, as the name suggests are found in the heart. It is intermediate in structure, being striated and at the same time involuntary.

It is meant for automatic and rhythmic-contractions and each muscle fibre. These fibers have a single nucleus placed centrally which branches and anastomoses with the neighbouring fibers at intercalated discs (apposed cell membranes). The cross-striations are less prominent than those in the skeletal muscle. These muscles are found only in the heart and are responsible for pumping blood. Cardiac muscles are also involuntary muscles. Cardiac muscle is unique as it stimulates itself to contract by virtue of pacemaker which is also made of cardiac muscle tissue. Because of this property, cardiac muscle is considered to be autorhythmic or intrinsically controlled.

The cells of cardiac muscle tissue are striated—that is, they appear to have light and dark stripes when viewed under a light microscope. The arrangement of protein fibers inside of the cells causes these light and dark bands. Striations indicate that a muscle cell is very strong, unlike visceral muscles.

The cells of cardiac muscle are branched X or Y shaped cells tightly connected together by f fingerlike projections from two neighbouring cells [called intercalated discs] that interlock and provide a strong bond between the cells.

The branched structure and intercalated discs allow the muscle cells to resist high blood pressures and the strain continuous working. These features also help to spread electrochemical signals quickly from cell to cell so that the heart can beat as a unit.

MYOEPITHELIAL CELLS

These are present at the bases of secretary acini of sweat gland, *etc.* These help in expulsion of secretion from the acini.

Out of the four kinds of muscles, the skeletal muscles are most abundant in the body. These are the only muscles which are dissected out in the dissection hall and studies individually.

FUNCTIONS OF MUSCLES

Movement and Locomotion

The main function of the muscular system is movement. Skeletal muscles work together with bones and joints to form lever. The muscle acts as the effort force; the joint acts as the fulcrum; the bone acts as the lever; and the object being moved acts as the load. {Second diagram explains the motion}

Posture and Position

Another important function of muscles. The muscles responsible for the body's posture have the greatest endurance of all muscles in the body as they hold up the body throughout the day without becoming tired.

Movement of Body Substances

The cardiac and visceral muscles are primarily responsible for transporting substances like blood or food from one part of the body to another.

Regulation of Function

They provide motor power for regulating the internal environment related to digestion, circulation, secretion and excretion.

Generation of Body Heat

Due to high metabolic rate of contracting muscle, heat is produced as byproduct. This helps to maintain body temperature. Remember shivering in winters. Muscles are working to produce heat.

Incoming search terms:

- Types of muscles and their functions (130)
- Muscle types and functions (92)
- Muscles and their functions (83)
- Different types of muscles and their functions (63)
- 3 types of muscles and their functions (53)
- Types of muscles (48)
- Types of Muscles and Functions (38)
- Classification of muscles according to function (23)
- Types of muscles and their function (17)
- Different types of muscles and their function (16)

THE NEUROMUSCULAR SYSTEM

The brain, nerves and skeletal muscles work together to cause movement. This is collectively known as the neuromuscular system. A typical muscle is serviced by anywhere between 50 and 200 (or more) branches of specialised nerve cells called motor neurones. These plug directly into the skeletal muscle. The tip of each branch is called a presynaptic terminal. The point of contact between the presynaptic terminal and the muscle is called the neuromuscular junction.

To move a particular body part:

- The brain sends a message to the motor neurones.
- This triggers the release of the chemical acetylcholine from the presynaptic terminals.
- The muscle responds to acetylcholine by contracting.

SHAPES OF SKELETAL MUSCLE

Generally speaking, skeletal muscles come in four main shapes, including:

- *Spindle:* Wide through the middle and tapering at both ends, such as the biceps on the front of the upper arm.
- *Flat:* Like a sheet, such as the diaphragm that separates the chest from the abdominal cavity.
- *Triangular:* Wider at the bottom, tapered at the top, such as the deltoid muscles of the shoulder.
- *Circular:* A ring-shape like a doughnut, such as the muscles that surround the mouth, the pupils and the anus. These are also known as sphincters.

MUSCLE DISORDERS

Muscle disorders may cause weakness, pain, loss of movement and even paralysis. The range of problems that affect muscles are collectively known as myopathy. Common muscle problems include:

- Injury or overuse, including- sprains or strains, cramps, tendonitis and bruising
- Genetic problems, such as muscular dystrophy
- Inflammation, such as myositis
- Diseases of nerves that affect muscles, such as multiple sclerosis
- Conditions that cause muscle weakness, such as metabolic, endocrine or toxic disorders; for example, thyroid, and adrenal diseases, alcoholism, pesticide poisoning, medications (steroids, statins) and myasthenia gravis
- Cancers, such as soft tissue sarcoma.

2

Physical Education

It can be seen that through the fulfillment of its objectives of physical skill and mental and social development, physical education can contribute a great deal to the whole development and growth process. It is important, however, to be able to see more clearly how this phase contributes to each of the objectives set forth for education in general. For purposes of organization, such a discussion may be grouped under the four headings, which represent the objectives of general education as set forth by the Educational Policies Commission.

By realizing how physical education, as an integral part of education, contributes to the fulfillment of each of there objectives, the teacher will have a clearer conception of how physical education fits into a total integrated educational pattern.

The objectives of Self-realization. The objectives of self-realization are aimed at developing the individual so that he realizes his potentialities and becomes a well-adjusted member of society. Physical education can contribute to the objectives of self-realization in many ways.

Contributing to an Inquiring Mind: New and interesting phases of living are opened up to the child through activity. His motor mechanism enables him to explore, to cruise, and to see and discover the nature of many phases of his environment. It stimulates his curiosity.

Contributing to Family and Community Health: Physical education can create, within the student, a realization of his responsibilities for his own health and for the health of others. He comes to realize that health is a product that increases as it is shared with other individuals. He has a responsibility for the health of others in school, at home, and in the community of which he is a part.

Contributing to Knowledge of Health and Disease: Physical education contributes to knowledge by giving the child information as to the importance of such things as nutrition, rest, sleep, and exercise; by instructing him in measures that should be taken to guard against disease; by developing an understanding of why the body needs vigorous outdoor activity; by instilling an appreciation of wholesome health attitudes and habits; by giving him knowledge about the correction of physical defects; by stressing safety factors for the preveation of accidents; and by showing the importance of adequate health services.

Contributing to Resources for Utilizing Leisure Hours in Mental Pursuits: Education is concerned with developing mental resources for the utilization of leisure hours. Physical education contributes by providing the material for interesting sports stories and biographies of great athletes, such as Bob Feller, Jackie Robinson, and Ben Hogan. In addition to motivating reading, sports can contribute to many interesting hobbies such as designing, building, and caring for equipment, research on the many statistics involved in sports, and a study of various aspects of nature which would be aroused by an interest in sports.

Contributing to Skill As a Participant and Spectator in Sports: Physical education develops skill in many activities. The child, as a result, can enjoy and derive the many advantages that come from actually engaging in a game or other similar experiences. At the same time, an interest and knowledge of other activities is presented so that the value of spectator enjoyment is also enhanced.

Contributing to an Appreciation of Beauty: The educated person develops an appreciation of the beautiful which can be fostered in early childhood. In addition to beauty of architecture, painting, and music, the child should also appreciate the beauty of trees, animals, the sky, and other aspects of the environment which he meets in his play. He should develop an appreciation for the beauty of his body, and physical movement, which can in sports situations produce the ultimate in grace, rhythm, and coordination.

Contributing to the Direction of One's Life Towards Worth-while Goals: The educated person conscientiously attempts to guide his life in the proper direction. Physical education can contribute to the child's direction during the early formative years by giving guidance as to what is right and proper, which goals are worth competing for, the difference between intrinsic and extrinsic values, autocratic and democratic procedures, antisocial and acceptable conduct. The child is a great imitator, and the beliefs, actions, and conduct of the teacher are often reflected in the beliefs, actions, and conduct of the student.

THE OBJECTIVES OF HUMAN RELATIONSHIPS

Human relationships may be defined as the manner in which individuals get along with each other.

Good human relations imply that people live together, work together, and play together harmoniously. Physical education can make a worth-while contribution in this area in the following ways.

Enabling Each Child to Enjoy a Rich Social Experience Through Play: Such an experience can help develop a child's personality by teaching him to adapt to the group situation, by developing proper standards of conduct, by creating a feeling of belonging, and by developing a sound code of ethics. There are limitless possibilities for social experiences in "tag" and "it" games. Here the child learns behaviour traits which are characteristic of a democratic society. Because of his drive for play, he will be more willing to abide by the rules, accept responsibility, contribute to the welfare of the group, and respect the rights of others.

Placing Human Relations First: Activities are planned with the needs and interests of children in mind; rules and regulations exist for the benefit of the players' welfare; the less skilled are given due attention; and the programme is child-centered. If human relations come first, a spirit of good will, fellowship, and cooperation exist.

Teaching Courtesy, Fair Play, and Good Sports-manship: The amenities of social behaviour are a part of the repertoire of every educated person. Such characteristics as courtesy, fair play, and good sportsmanship can be developed in the child as he plays with his classmates and others in game situations.

Helping Children To Play Cooperatively: The physical education programme should stress cooperation as the basis for achieving the goals an individual or group desires. It should also stress leadership and followership traits. The success of any venture depends on good leadership and good workers or followers. Everyone cannot be captain of the relay team. Everyone does not have leadership ability. Those who are good leaders should also be good followers.

A leader in one activity might possibly make a better follower in another activity. The important thing is that both leaders and followers are needed for the accomplishment of any enterprise. All contribute to the undertaking. All deserve commendation for work well done. Cooperation be every member of the group in whatever way each one is best equipped to contribute will insure success for the group endeavor.

Contributing to Family and Home Living: The teacher of physical education is often the individual in whom a child puts his trust and confidence and whom he desires to emulate. The nature of physical education work and its appeal to youth are probably the major reasons for this tendency. Consequently, the teacher in charge of the physical education class should utilize his advantageous position to become better acquainted with the youth and his home and family life. Many times a child's home and parent problems can be helped through such knowledge. Proper counseling and guidance, helping children to experience success in play activities, talks with parents, and home visits are often useful.

THE OBJECTIVES OF ECONOMIC EFFICIENCY

A third objective of education deals with the production and consumption of goods and services. Education has the opportunity of informing children in respect to both the vocational aspects of living and the consumer aspects. Both

are important and are necessary for a happy and successful life. Physical education can aid in more efficient production of goods and services and also can aid in the establishment of certain standards which will guide the public in the wise consumption of certain goods.

Recognition of the Need for Good Workmanship: Work is an essential for all individuals. Through work one contributes goods and services to the community of which he is a part. Children should have opportunities to work. As part of their educational training children should be assigned tasks in the home and also in school. In physical education, children could help develop playfields, care for equipment, and instruct those with less skill. Through regular duties, they can discover that they are contributing to the welfare of the group and are providing services, which will help others to enjoy their activity experiences more fully.

Recognition of the Need for Professional Growth: The teacher of physical education should be continually interested in developing new skills, understandings, and an appreciation of the contribution that his area of education can make to child growth and development. Physical education is a growing profession. New awareness and knowledge in the fields of biology, psychology, and sociology are continually evolving which have implications for helping the physical education teacher do the best job possible. Only if the teacher is constantly studying such new developments can he make the greatest contribution to children.

Recognition of the Need for Successful Work: The success of any job depends to a great degree upon the health and physical fitness of the worker. Experience in physical education activities contributes to physical health, mental health, human relations, and other social assets which help to contribute to better work. As each child develops a strong organic base for future years, he becomes prepared to do a better job.

Recognition of the Need for Wise Consumption of Goods and Services: The educated person buys his goods and services with wisdom. He is well informed as to the worth and utility of various goods and services. Physical education helps to develop in children the relative values of goods and services that influence their health and physical fitness. Such things as the need to seek qualified advice in health matters, the dangers of self-medication, and the importance of critical evaluation of advertisements and other material on health cures can be discussed.

THE OBJECTIVES OF CIVIC RESPONSIBILITY

Civic responsi-bility falls upon each member of society. Only as each individual assumes his civic responsibility and contributes to group welfare will democratic ties be strengthened.

Recognition of the Need for Tolerance: It is the prerogative of every person to think out solutions to various problems, form his own opinions, and attempt to bring other around to his point of view. The physical education class can be a

placed where tolerance is developed in regard to other people's opinions in the various activities they conduct. Children may be educated to participate intelligently in the discussion of common problems that develop in a game situation. All can be encouraged to contribute their thinking. Thoughts and ideas are respected by all and final settlement of the problem can be made by the group.

Recognition of the Need for Humanitarianism: Children should be well informed as to the needs of mankind everywhere. A humanitarian view of the conditions of mankind should become a part of every student. Physical education can, within limits, provide democratic play experiences in which, children see the importance and value of cooperative living a contributing to the welfare of all. Here is an ideal setting for developing humanitarian values. Children from all walks of life, all creeds, colours, and races are brought together for a social experience. Interest and natural drive for activity provide a laboratory for actual practice in developing these values.

Recognition of the Need for the Conservation of Natural Resources: Physical education should be especially interested in preserving the natural resources of the nation such as forests, soil, scenic beauty, water and wild life. They have implications for active forms of recreation. Children should understand the value of such resources to the health and physical fitness of the country. Through an educational programme which points out that natural resources are directly related to the welfare of each resident of this country, much good can be done in conserving this form of the nation's wealth.

Recognition of the Need for Civic Responsibility: It is the responsibility of every citizen to have a clear under-standing of his civic duties and to see that they are carried out in an intelligent manner. Physical education can show how games and various aspects of the school programme are analogous in many ways to what the child's responsibilities will be in an adult community. The importance of selecting good leaders, living according to high standards of conduct, abiding by the rules, and contributing to the welfare of the group are a few examples.

Recognition of the Need for Conformance with the Law. In a democracy laws are made by the people and for their benefit. Obedience is essential to a well-ordered society. Physical education can contribute to the development of a law-abiding attitude in youth. The rules of the game and the rules of safety that have been established for the playground, gymnasium, and other places where activities are held should be made clear to each student. Furthermore, the purpose behind such rules and the individual's responsibility in each case should be understood.

Recognition of the Need for Democratic Living: The educated citizen believes in the democratic way of life and his every action is symbolic of his loyalty to its ideals. Physical education can contribute, together with other areas of the school programme, to making experiences on the playground or in the gymnasium ones where democratic principles prevail and where such important concepts as respect for the individual, the rights of others, and freedom of action are honored.

FUNCTIONS OF DEVELOPMENTAL AND ADAPTED PHYSICAL EDUCATION

In the efforts to physical educators to plan programmes that will be completely effective in realizing educational objectives, the necessity of meeting individual needs of boys and girls becomes readily apparent. Children differ in innumerable ways. For example: their muscular strength varies from weak and puny to physically powerful; their ability to learn skills ranges from neuromuscularly inept to well-coordinated and highly skilled; their nutritional status ranges widely from undernourished to obese; their somatotypes are of many variations; some individuals have serious handicaps of various kinds while others are free from all defects; the differences in social adjustment and mental health are obvious to any astute observer. Programme adaptations for such factors must be provided if physical education is to be fully effective in the lives of all individuals.

As a consequence of these realisations, developmental and adapted processes were devised—not as a separate entity, but evolving from this complex situation. This programme should be a vital phase of the total physical education programme. Its justification should be in terms of basic growth and development of the individual. Simply stated, then, *the purpose of developmental and adapted physical education is to meet, through physical education methods and activities, the individual needs of boys and girls who are handicapped in some respect, who have functional defects or deficiencies amenable to improvement through exercise, or who possess other inadequacies which interfere with their successful participation in the diversified and vigorous activities of the general physical education programme.*

In presenting specific functions of developmental and adapted physical education, the many related developments affecting physical education from all sources should be brought together and applied. This process should include the early experiences of physical education, the basic concept of the unity of the individual, and the relationship of the physical aspect to that entity, the successful practices of physical education since its inception in the United States, and the broad utilization of physical education as therapy during and following World War II. Specific procedures should be devised and materials selected in accordance with the needs of school and college populations. As will be discussed later, the capabilities of physical education personnel to practice therapy must necessarily constitute a limitation to the programme attempted at particular institutions.

Based on these considerations, then, the specific functions of the developmental and adapted programme in school and college physical education include the following factors.

General developmental and conditioning activities for individuals free of handicaps but of low physical fitness status. Many individuals in any school or college population who are organically and structurally sound and who are well nourished, are still deficient in basic strength and endurance elements. These

individuals should be identified by tests and examinations, studied for causes of their low fitness status, and provided with individual programmes to eliminate such causes and improve their general fitness.

Mild, progressing to vigorous exercise regimens should be provided for boys and girls returning to school after devitalizing illnesses and operations before they are permitted to participate in the strenuous activities of the general physical education programme. In this way, such students can gradually and systematically return to desirable physical fitness levels without the danger of over-exertion from prematurely vigorous athletic activities. Where feasible, pre-operative general body conditioning would prove beneficial. In some colleges, too, it would be possible to provide bed and ambulatory exercises for convalescent students in health-service infirmaries.

Body mechanics training for individuals with non-pathological conditions. Among the demonstrated accomplishments of physical education is the development of correct body mechanics and the prevention and correction of postural and bodily defects. The responsibility for improving postural and weak foot conditions has long been recognised by this field in schools and colleges.

The extent of the need for posture training, proper use of the feet, and body mechanics teaching is widespread. Fundamentally, posture work should be included in childhood education, as it is during these formative years of life that proper attitudes and habits can best be developed. Also, during this period, the detection and correction of slight deviations from normal may be most effective, often resulting in the prevention of structional deformities. General agreement, therefore, places emphasis on this phase of developmental and adapted physical education in the elementary school. However, functional postural defects and weakened foot conditions should be treated at any level where found.

Adaptation of physical education and recreation activities for the handicapped. Although physical educators for many years have conducted "restricted" activities for students with all sorts of physical handicaps, the experiences with reconditioning in the hospitals of the armed forces and in corrective therapy in Veterans Administration hospitals have added a new chapter in understanding the potentialities of this phase of the programme. Basically, physical education should strive to accomplish the following with handicapped individuals: to develop strength, stamina, and skill within the limits of individual disabilities; to provide and adapt sports and recreational activities for use during leisure time in accordance with individual capabilities; to aid these students in the acceptance of their disabilities and to motivate them to live most effectively with their handicaps.

In this statement, the use of therapeutic exercise is not included, primarily for the following three reasons: First, schools and colleges are not now generally established as medical treatment centers; second, physical therapy training, or its equivalent in foundations and practices of therapeutic exercise, is essential for this function; third, the functions proposed are primarily educational and

are within the capabilities of properly trained physical educators. It should not be forgotten that developmental and adapted physical education in schools and colleges is not primarily therapeutic, although there will be therapeutic values realized from the programme, but is basically educational in nature.

Psychological and social adjustments of "normal" individuals with atypical tendencies. Studies of the childhood backgrounds of psychiatric casualties in World War I emphasize the need for certain personality traits, without which men find it difficult to stand the rigours of war. Emmanuel Miller presented data which show that those who lacked psychological stamina in the first World War were characterized by childhood backgrounds of nervousness, fussiness, over-evaluation of their egos, sensitive dispositions, over-attachment to their mothers, rigid personalities, and marked lack of aggressiveness. Our accelerated mode of living, the emotional pressures of everyday life, and the change from interesting and challenging to monotonous and routine employment which generally involves small-muscle rather than large-muscle activity, necessitates less psychological stamina than was demanded during war.

These same conditions have resulted in placing a premium on social adjustment. Not only must the individual in our civilization be conscious of his obligations to society, but he must be able to work co-operatively and well with other for the common good. In developmental and adapted physical education it is imperative to consider the psychological and social deviates. The programme itself should provide activities in which individuals can participate together and in which they are afforded opportunities for expression, thus helping to diminish physical and emotional tensions. Physical activities should be conducted to improve the psychological and social condition of maladjusted individuals. This programme should also develop, create, or recreate a positive mental attitude towards the use of activities as a means for further total growth and development of the individual.

Relaxation activities for individuals suffering from chronic fatigue and neuromuscular hypertension. Chronic fatigue and neuromuscular hypertension are closely associated, and are recognisable, as is true fatigue, by a definite increase of tension in the neuromuscular system. This tension is reflected in the tenseness of the skeletal muscles of the individual. Rest and specially devised relaxation activities are needed to counteract and alleviate this condition. Similar programmes are needed for post-operative cases, tuberculosis suspects, and undernourished students. Rest and relaxation are also frequently desirable for many low-fitness individuals at the start of, and at different times during their developmental and conditioning process.

Counselling, guidance, and assistance with physical fitness, personal adjustment, and social problems. Permeating the developmental and adapted physical education programme is the need for counselling, guidance, and assistance for individuals with physical fitness, personal adjustment, and other problems. The handicapped must understand the nature of and be motivated to accept his disability; the socially maladjusted may need guidance towards

desirable inter-personal and democratic relationships; the individual with a personality conflict needs considerate help. In his counselling relationships, the physical educator will frequently need the assistance of other school personnel. For example: the home economics teacher may help if serious dietary problems are encountered; the school doctor is essential if organic drains are present; the school nurse is invaluable when parental co-operation in dealing with health problems is desired; the guidance officer will be needed if personality conflicts need study and counsel. As a consequence, relationships with many other school personnel will be necessary in conducting developmental and adapted physical education. If an all-school guidance programme exists, the physical educator may logically become a participant; it may even be feasible to merge his counselling function with this over all institutional programme.

Developmental and adapted physical education, thus, undertakes the difficult task of dealing with the individual and with individual needs far more specifically and intensively than do other phases of physical education. As aptly expressed by Rosalind Cassidy: "Research has shown this to be a necessity if democratic values and the facts of biology are to be respected." Physical educators do not disagree on the principle that individual needs should be met; however, they may not all accept the manner in which this goal is to be accomplished. In this book, details relative to a basic approach to this problem are presented.

PREPARATION OF PERSONNEL

As intimated before, the amount and nature of developmental and adapted education attempted in any school or college should depend upon the qualifications of the physical educators involved. The basic training of these individuals should be the four-year major in physical education. Inasmuch as undergraduate programmes in this field vary considerably within the several hundred colleges and universities throughout the country, however, the prospective teacher should select an institution offering a strong sequence of studies for this work. The following training programme is proposed from recommendations made by Blesh and may be considered desirable in accordance with present thought and best practice (reference to the usual liberal arts or general education requirements for the bachelor's degree is omitted):

1. Foundation sciences, including biology, human anatomy, kinesiology, human physiology, and physiology of exercise.
2. General psychology.
3. Professional education, including history of education, principles of education, educational psychology, methods of teaching, and student teaching.
4. Technical training, including measurement and evaluation, physical examinations, corrective exercise, normal growth and development, nature and function of play, training and first aid, school programmes in physical education, recreation leadership, camping, administration of physical education, and physical skills and coaching techniques.

The well-trained physical educator must have a thorough grounding in foundation sciences, must understand the learning process and the effective application of his activities to the education and development of the individual, must have great versatility in teaching many activities in a physical education programme, and must be able to administer, supervise, and evaluate a varied programme of physical education and athletics. That it is difficult to achieve the objective of preparing physical educators adequately within the limits of a four-year college programme and still provide for the liberal-cultural education of the student is not to be denied. As a consequence, specialisation in developmental and adapted physical education is not feasible in the four-year programme under these circumstances. To be sure, related courses (basic sciences, correctives, measurement, *etc.*) are included, to provide the physical educator with an initial acquaintance with this specialty.

Physical educators who wish to become fully qualified to carry on the developmental and remedial functions in hospitals and rehabilitation centers should have postgraduate study at institutions providing specialised programmes in this field. The trained physical educator should take more courses in anatomy, kinesiology, physiology, physiology of exercise, and psychology than he had as an undergraduate and must know their relationships to pathological conditions. He needs to understand the pathology of the various disabilities he will encounter and the utilisation of physical activity in surgical, orthopedic, neurologic, and psychiatric conditions. He must be thoroughly acquainted with the modalities of exercise, adapted sports, aquatics, and recreational activities and should have extensive supervised clinical and field experience.

Although physical educators in schools and colleges do not work with patients *per se* and although their objectives and programme of activities are largely educational in nature, nevertheless, specialised training is advantageous if they are to be completely effective in their efforts to meet the individual needs of boys and girls. However, until the need for such training is generally recognised and provided, physical educators must, necessarily, perform only those functions for which they are specifically qualified. They definitely need to recognise their professional limitations in this respect.

TERMINOLOGY OF PHYSICAL EDUCATION

The multiplicity of terms that are sometimes used synonymously for physical education makes it imperative that the meaning of these various terms be clarified.

Hygiene: Hygiene comes from the Greek word *hygieinos*, meaning healthful. This refers to the science of preserving one's health. It often refers to rules or principles which are prescribed for the purpose of developing and maintaining health. In past years many school physical education departments were known as departments of hygiene. A few still use this term. It appears that this term became popular as a result of legislation in various states which sought to have the effects of tobacco and alcohol brought to the attention of all students through

a course which was often known by the name of hygiene. There are still many laws on the statute books prescribing such instruction. Since World War I, this term has become more or less obsolete. Newer terminology is being used, such as health education and personal and community health.

Physical Culture: The term "physical culture" is an obsolete term in education, having been used in the late nineteenth century to parallel the use of other names of courses which at times were called religious culture, social culture, and intellectual culture. This term is still used by some faddists in commercial ventures to popularize the beneficial effects of exercise. Such men as Bernarr Macfadden have, through their publications and business enterprises, done a great deal spread the use of such terminology. Physical culture has been used synonymously for physical training. It implies that through various physical activities health may be promoted. It is a term, however, which is not in use today in our institutions of learning.

Athletics: The term "athletics" refers to the games or sports which are usually engaged in the individuals who are strong, robust, skilled, and able to participate in vigorous exertions. The interest in athletics in the United States has been largely inherited from Great Britain. With the introduction of athletics into colleges and universities, there has been a rapid growth in all sports which were engaged in on an intercollegiate basis. The first intercollegiate meet was a boat race in 1852 between the crews of Harvard University and Yale University. The first intercollegiate football game is believed to have been played between Rutgers University and Princeton University in 1869. These rivalries still exist today.

Many lay persons frequently think of athletics and physical education as being similar in meaning. However, most physical education personnel think of athletics as one phase of a broad physical education programme, namely, that division of the programme which is concerned with interscholastic or intercollegiate sports competition. A director of athletics in a school has as his primary responsibility the direction of this competitive programme.

Gymnastics: The word "gymnastics" refers to exercises that are adaptable to or are performed in a gymnasium. It is the art of performing various types of physical exercises and feats of skill. The term has been and still is used extensively in the various physical education programmes on the continent of Europe. Anyone trained in physical education has heard mention of such programmes as the German and Swedish systems of gymnastics. Formal drills, such as calisthenics, were until recently utilized extensively in many physical education programmes in the United States. Today, when one thinks of gymnastics, formal drills come to mind which are conducted either with or without the use of apparatus. Americans do not use the term synonymously with physical education but, instead, with just that phase of the physical education programme which is concerned with formal drills. Physical express himself in various types of games rather than through formal drill. This is believed to be more in keeping with the democratic way of life.

Physical Training: The term "physical training" to many individuals has a military tinge. It is a term that has been used in school programmes of physical activity and also a term that has been used in the Armed Forces. Hetherington used the term to connote big-muscle activity in the school programme of physical education. On the other hand, both during World War II and at the present time its use refers to the entire programme of physical conditioning which the Armed Forces require men to go through as preparation for their rigorous duties. Most individuals agree that, because of the military connection, the term is used to imply training. This term has become rather outmoded for the modern-day physical education programmes that are found in the public schools. Today, physical education programmes realize outcomes other than just those that are concerned with the physical aspects. For example, there are sociological outcomes which result in an individual's better adaptation to group living. The term "physical education" also implies that physical activity serves the field of education in a much broader aspect than physical training does.

Physical Education: The term "physical education" is much broader and much more meaningful for day-to-day living than any of those terms that have been discussed previously. It is more closely allied to the larger area of education, of which it is a vital part. It implies that its programme consists of something other than mere exercises done at command. A physical education programme under qualified leadership aids in the enrichment of an individual's life. Before formulating a definition of physical education, it is interesting to note how a few of the leaders in the field of physical education define this term.

Hetherington listed two things with which physical education is concerned. First, physical education is concerned with big-muscle activity and the benefits which may be derived therefrom and, second, with its contribution to the health and growth of the child so that he may realize as much as possible from the educational process without having growth handicaps.

Nash points out that physical education is one phase of the total education process, and that it utilizes activity drives that are inherent in each individual to develop a person organically, neuromuscularly, intellectually, and emotionally. These outcomes are realized whenever physical education activities are conducted in such places as the playground, gymnasium, and swimming pool.

Nixon and Cozens describe physical education as that phase of the total education process which pertains to vigorous activities involving the muscular system and the learnings that result from participation in these activities.

Sharman points out that physical education is that part of education which takes place through activities which involve the motor mechanism of the human body and which results in the individual's formulating behaviour patterns.

Williams, Brownell, and Vernier point to the fact that physical education implies selected physical activities which are conducted with reference to the benefits that may be derived from participation in these activities.

Voltmer and Esslinger refer to physical education as that phase of education which takes place through physical activity. From these various definitions of physical education, it can be seen that any definition of the term should incorporate such concepts as selected physical activities and related learnings that are realized through participation in these activities and should show that it is a part of the educational process.

The author proposes the following as a definition of physical education:

Physical education, an integral part of the total education process, is a field of endeavor which has as its aim the development of physically, mentally, emotionally, and socially fit citizens through the medium of physical activities which have been selected with a view to realizing these outcomes.

In a larger sense, this definition of physical education means that the leadership in this field must develop a programme of activities in which participants will realize results beneficial to their growth and development; that they will develop, through participation, such physical characteristics as endurance, strength, and the ability to resist and recover from fatigue; that neuromuscular skill will become a part of their motor mechanism so that they may have proficiency in performing physical acts; that, socially, they will become educated to play an effective part in democratic group living; and that they will be better able to interpret new situations in a more meaningful and purposeful manner as a result of these physical education experiences.

PHYSICAL EDUCATION - OVERVIEW, PREPARATION OF TEACHERS

"Physical education is the study, practice, and appreciation of the art and science of human movement". While movement is both innate and essential to an individual's growth and development, it is the role of physical education to provide instructional activities that not only promote skill development and proficiency, but also enhance an individual's overall health. Physical education not only fulfills a unique role in education, but is also an integral part of the schooling process.

HISTORICAL PERSPECTIVES

From the late 1700s to the mid-1800s, three nations–Germany, Sweden, and England–influenced the early development of physical education in the United States. German immigrants introduced the Turner Societies, which advocated a system of gymnastics training that utilized heavy apparatus (*e.g.*, side horse, parallel and horizontal bars) in the pursuit of fitness. In contrast, the Swedish system of exercise promoted health through the performance of a series of prescribed movement patterns with light apparatus (*e.g.*, wands, climbing ropes). The English brought sports and games to America with a system that stressed moral development through participation in physical activities. The influence of these three nations laid the foundation for sport and physical education in America.

The 1800s were an important time for the inclusion of physical education in schools across America. The Round Hill School, a private school established in 1823 in Northampton, Massachusetts, was the first to include physical education as an integral part of the curriculum.

In 1824 Catherine Beecher, founder of the Hartford Female Seminary, included calisthenics in her school's curriculum and "was the first American to design a programme of exercise for American children". She also advocated the inclusion of daily physical education in public schools. However, physical education was not offered in the public schools until 1855, when Cincinnati, Ohio, became the first city school system to offer this type of programme to children.

In 1866 California became the first state to pass a law requiring twice-per-day exercise periods in public schools. Beecher's influence started the American system of exercise, and, along with her contemporaries Dio Lewis, Edward Hitchcock, and Dudley Allen Sargent, she was an early leader in physical education. In the profession's early years, between 1855 and 1900, there were several debates, referred to as the *Battle of the Systems,* regarding which system (American, Swedish, German, or English) could best provide a national physical education programme for America.

During the 1890s traditional education was challenged by John Dewey and his colleagues, whose educational reforms led to the expansion of the "three R's" to include physical education. It was also during this time that several *normal schools* (training schools for physical education teachers) were established. All of these schools offered a strong background in the sciences that included courses in anatomy and physiology, with many of the early professors holding medical degrees.

In 1893 Thomas Wood stated that "the great thought of physical education is not the education of the physical nature, but the relation of physical training to complete education, and then the effort to make the physical contribute its full share to the life of the individual" (National Education Association, p. 621).

During the early twentieth century, several educational psychologists, including Dewey, Stanley G. Hall, and Edward Thorndike, supported the important role of children's play in a child's ability to learn. In line with the work of Wood in physical education, and the theoretical work of prominent educational psychologists, *The New Physical Education*was published in 1927 by Wood and Rosalind Cassidy, who advocated *education through the physical.*

This position supported the thesis that physical education contributed to the physical well-being of children, as well as to their social, emotional, and intellectual development. However, Charles McCloy argued against this expanded role of physical education, arguing that *education of the physical,* which emphasized the development of skills and the maintenance of the body, was the primary objective of physical education. The testing of motor skills was a part of McCloy's contribution to physical education, and his philosophy of testing paralleled the scientific movement in education.

The evolution of physical education, along with other educational professions, reflected contemporary changes in society. Throughout the early twentieth century, into the 1950s, there was a steady growth of physical education in the public schools. During the early 1920s many states passed legislation requiring physical education. However, shifts in curricular emphasis were evident when wars occurred and when the results of national reports were published. For example, as a result of the bombing of Pearl Harbor and the United States' entrance into World War II, the emphasis in physical education shifted from games and sport to physical conditioning. Similar curricular shifts were noted in 1953 when the Kraus-Weber study found that American children were far less fit than their European counterparts. As a result of this report, the President's Council on Physical Fitness was established to help combat the falling fitness levels of America's youth.

During the 1950s and the 1960s, physical education at the elementary level experienced tremendous growth. Today, many physical education programmes emphasize overall fitness, referred to as *wellness,* as well as skill development. However, since the 1970s the number of schools offering daily physical education has drastically decreased–1995 statistics from the Centres for Disease Control and Prevention (CDC) show a drop from 43 percent in 1991 to 25 percent in 1995.

RATIONALE

In the 1990s three national reports–*The Surgeon General's Report on Physical Activity and Health* (1996), *Healthy People 2000* (1990), and the CDC's *Guidelines for School and Community Programmes* (1997)–have focused on the deplorable physical condition of Americans. These reports cited physical inactivity as a national health risk, based on statistics such as: (1) 13 percent of young people are classified as overweight; (2) only half of all youths are physically active on a regular basis (and this percentage decreases with age); and (3) inactivity and poor diet cause at least 300,000 deaths per year.

These reports advocated the need for daily physical activity, citing the following health benefits from moderate participation: improved strength and endurance, healthier bones and muscles, weight control, reduced anxiety and increased self-esteem, and, often, improved blood pressure and cholesterol levels. Physical education is the major vehicle for improving the health and fitness of the nations' youth. *Healthy People 2000* recommended the increase of daily physical education to a level of at least 50 percent of students in public schools by the year 2000.

In addition to the health benefits, cognitive performance can also be enhanced through physical education. There is a growing body of research that supports the important relationship between physical activity and brain development and cognitive performance. C. Edwin Bencraft (1999) found that "sensory and motor experiences play a prominent role in reinforcing … synaptic connections and neural pathways". Eric Jensen's 1998 research revealed that the cerebellum

is not solely dedicated to motor activity, but includes both cognitive and sensory operations. Further, Jensen points out the strong relationship of the cerebellum to memory, perception, language, and decision-making, citing physical activity as a way to enhance cognition. In a summary of research findings, Bencraft suggests providing the following applications that could increase cognitive performance: (1) challenging motor tasks before the age of ten can increase cognitive ability due to a heavier, more dendrite-rich brain;(2) aerobic exercise improves cognitive functioning by increasing the number of capillaries serving the brain through the delivery of more oxygen and glucose and removal of carbon dioxide; (3) cross-lateral movements increase the communication ability between the brain's hemispheres; and (4) physical activity reduces the production of stress chemicals that inhibit cognitive processing.

From the mounting evidence favouring physical activity, it appears that physical education in schools plays a dual role in serving both mind and body. The challenge to physical educators will be to implement programmes that address the health crisis while building the child's mind through physical activity.

CURRICULUM

According to the American Alliance for Health, Physical Education, Recreation and Dance (AAHPERD), a quality physical education programme for grades K–12 includes instructional periods totaling at least 150 minutes per week at the elementary level and 225 minutes at the secondary level, qualified physical education specialists, and adequate equipment and facilities. In general, the curriculum should consist of: (a) instruction in a variety of developmentally appropriate motor skills that challenge students to develop physically, cognitively, socially, and emotionally; (b) fitness activities that educate and help students understand and improve or maintain optimal fitness levels; (c) instruction in concepts that lead to a better understanding of motor skills and fitness development; (d) opportunities to engage in experiences that enhance cooperation and develop multicultural awareness; and (e) experiences that foster the desire for lifelong participation in physical activity.

More specifically, the elementary curriculum should include many enjoyable activities that lead to the acquisition and refinement of fundamental motor patterns (*e.g.*, running, skipping, jumping, catching, throwing, striking, balancing) that can be applied in game, sport, dance, and gymnastics contexts. The *movement-based curriculum* proposed and adapted by George Graham, Shirley Ann Holt/Hale, and Melissa Parker in 1998 introduces skill themes (fundamental motor patterns) and movement concepts that describe how a movement is performed (*e.g.*, speed, direction, relationship). This curriculum pattern teaches children to move while challenging them to explore, modify, and refine motor patterns, and it can be used as a vehicle for teaching physical education. The *activity based* approach is the most common curriculum pattern used in both middle schools and high schools. This curricular pattern uses activity units in sport, fitness, and dance (*e.g.*, volleyball, aerobic dance, swimming) to

teach physical education. Middle school curriculums should include a wide variety of team and individual sports utilizing motor skills introduced and refined at the elementary level. High school curriculums should focus on lifetime sports skills (*e.g.*, golf, tennis, aerobic dance), with a secondary emphasis on team sports. During the high school years, students should become highly proficient in one (or more) sport and/or fitness activity of their own choosing. However, regardless of the level of schooling, fitness forms the base of the curriculum and it is an integral part of the programme.

TRENDS, ISSUES, AND CONTROVERSIES

School accountability, a major trend of the 1990s, has driven the need for national assessment (testing) and standards. This trend has become an issue and has created debate throughout education, including physical education. Proponents on both sides have valid points to make. Those who oppose national testing point out the need for people to enjoy physical activity. They believe that testing does not foster the desire for lifelong participation. In contrast, proponents of testing think it would parallel work completed in other disciplines, such as math and science, while helping students gauge their progress towards a national standard for fitness and/or skill competence.

The National Association for Sport and Physical Education has provided guidelines in the form of grade-level benchmarks, as well as an operational definition of the *physically educated person.* Such a person is skilful in a variety of physical activities, physically fit, participates regularly in physical activity, knows the benefits of physical activity, values physical activity and its contributions to a healthy lifestyle, respects diversity, and acts in a socially responsible manner. The question remains, however, of how much direction and specificity in the form of standards and assessment are needed.

In many school programmes and business settings, the term *wellness* has replaced *fitness* and *health.* In general, this term refers to optimal health and well-being, but it has been broadened to include the dimensions of emotional, mental, spiritual, social, and environmental well-being.

There are many issues that are of interest to all educators, issues that pose a challenge to all of those who seek to teach children. These include discipline problems, student drug abuse, violence, insufficient resources, lack of parental support for education, large classes, teacher burnout, and perhaps most importantly, a concern for the health and well-being of all children.

By far the greatest issue facing physical education in K–12 institutions is the reduction of time in the curriculum allotted to this important subject. The need for daily physical education is obviously important for the well-being of students, but it presents a dilemma for those who must balance academics, accountability, and what is best for the child's overall education. Given the support for the physical and psychological contributions of exercise, along with the health risks associated with inactivity, it is clear that daily physical education plays a crucial and unique role in each child's cognitive, psychological, and physical development.

EDUCATION OF INDIVIDUALS WITH PHYSICAL DISABILITIES

In special education, physical disabilities are physical limitations or health problems that interfere with school attendance or learning to such an extent that special services, training, equipment, materials, or facilities are required. In the early twenty-first century, approximately 500,000 school children in the United States were classified as having physical disabilities or other health impairments for special education purposes.

Since 1975, federal law (under the Education for All Handicapped Children Act, and since 1990, the Individuals with Disabilities Education Act [IDEA]) has mandated special education and related services for all students with physical disabilities that interfere with their education. Major classifications include neurological conditions, musculoskeletal conditions, and other health impairments.

TYPES AND CAUSES OF PHYSICAL DISABILITIES

Neurological conditions involve damage to the central nervous system (brain or spinal cord). In 1990 traumatic brain injury became a separate category of disability under IDEA.

Other major neurological conditions include cerebral palsy, seizure disorder (or epilepsy), and spina bifida, a congenital condition in which the spinal cord protrudes through the backbone resulting in partial or total paralysis below the site of the nerve damage. Disabilities associated with neurological conditions vary from very mild to severe and may involve physical, cognitive, speech-language, or sensory abilities, or a combination thereof.

Musculoskeletal conditions include muscular dystrophy, juvenile rheumatoid arthritis, limb deficiencies or amputations, and a wide variety of other deformities or degeneration of muscles or bones affecting the ability to move, walk, stand, sit, or use the hands or feet normally. Other health impairments include a wide variety of infectious diseases and chronic problems such as diabetes, asthma, cystic fibrosis, immunodeficiency (including HIV and AIDS), hemophilia, fetal alcohol syndrome, and the malfunction or failure of vital organs.

Causes include infectious disease, congenital conditions or malformations, and developmental problems or chronic health problems that are poorly understood. A wide variety of disabilities, especially those associated with traumatic brain injury, result from vehicular accidents, gunshot wounds, burns, falls, and poisoning. Substance abuse and physical abuse by caretakers, infectious diseases, and substance abuse by the child or by the mother during pregnancy cause some disabilities. Advances in medicine and related treatments are reducing or eliminating physical disabilities resulting from some diseases, injuries, and chronic conditions. Advances in medicine, however, also increase the number of children surviving congenital anomalies, accidents, and diseases with severe disabilities.

THE BASICS AND HISTORY OF SPECIAL EDUCATION

Special education includes helping students have as normal an experience as possible in school. Much depends on access to the typical curriculum and use of adaptive devices when necessary.

Emphasis is on overcoming attitudinal barriers among persons without disabilities to participation of students with physical disabilities in school and the community. Special educators must understand the operation of prostheses (artificial body parts), orthotics (braces and other corrective devices), and adaptive devices (wheelchairs, communication boards, and other gadgets enabling people to accomplish tasks).

Special education in public schools dates from the early twentieth century. Programmes have emphasized major health problems of the era. In the first half of the twentieth century the focus was on crippling conditions and the effects of infectious diseases, particularly tuberculosis and polio. After antibiotic drugs and vaccines dramatically reduced or eliminated many infectious diseases in the mid-twentieth century, the focus changed to cerebral palsy, spina bifida, and other congenital conditions or chronic health problems. In the late twentieth century, increasing attention was given to traumatic brain injury, spinal cord injuries, and AIDS.

TRENDS AND CONTROVERSIES

Trends in the field are determined largely by changes in epidemiology and advances in medicine. The number of students needing special education and the focus of programmes may change because of a resurgence of an infectious disease (*e.g.*, tuberculosis), an advance in immunology (*e.g.*, an effective vaccine for AIDS), or medical advances such as gene therapy, transplants, artificial organs, or extremely effective new treatments that reduce or eliminate a chronic health problem (as may occur for such conditions as diabetes, cystic fibrosis, and asthma).

Advances in medicine and related services, such as physical therapy, technological applications, and adaptive devices that allow more normal functioning, may reduce or eliminate the need for special education or make education in a typical classroom feasible.

Issues and controversies include the extent to which placement in typical school environments is appropriate. Many students with even severe physical disabilities can attend regular schools and classes, given improved accessibility of school buildings, the use of technologies of treatment and adaptive devices, and improved attitudes of acceptance of disabilities in the school. Some students need highly specialized medical care and are thought to need education in the hospital where they are being treated or in a special class or school. A controversial issue is whether to include in regular schools and classes students who are near death or who have extreme physical and cognitive disabilities that leave them unresponsive to typical instruction.

DEVELOPING FUNCTIONAL SKILLS THROUGH PHYSICAL EDUCATION

The FUN Pack provides task cards for pupils and the lesson rotation plan for teachers to switch teams through the different subject areas for the next lesson. Teams of pupils rotate on a weekly basis and take on the roles identified above. Within the lesson, pupils take part as performers within a structured game either as players or officials. Other pupils act as scorers, timekeepers, coaches or match analysts recording the number of passes or shots. Using video and still cameras other pupils record the game and download the footage or visual images whilst another group provides recorded match commentary and match reports all of which can contribute to the production of a newsletter or added to the school's website.

The West Kent e-learning group has provided eight schools with the essential ICT equipment including camcorders, MP3 voice recorders and digital cameras to enable them to develop the lessons. The FUN resources are also available for use with Rugby and with new curriculum links for year eight.

GAMES CONSOLES IN SCHOOLS

Games consoles are being used in schools to encourage disaffected pupils in physical education lessons in order to increase fitness levels. Some schools are using the consoles to simulate actions of certain activities to improve pupils' behaviour and teamwork skills through tennis, baseball, snowboarding and skiing for example.

Whilst some may think that the use of virtual reality games is contradictory in raising activity levels and attainment there is anecdotal evidence to suggest that, with rigid structures in place using specific games, pupils can be physically active without releasing the console. In one case study project teachers identified pupils between the ages of fourteen and sixteen who had often missed physical education lessons.

NINTENDO WII FIT AND VIDEO GAME

The Wii Fit is a video game that has been designed by Nintendo for the Wii console. The game focuses on exercise which involves an individual using a Wii balance board. The board is a wireless accessory and contains multiple pressure sensors used to measure an individual's centre of balance. This can be applied to activity games such as skiing, for example. The 'Wii Fit' package includes a 'Wii Fit' game disk for the Nintendo Wii console containing fitness training related games and activities.

The balance board measures a user's mass and centre of balance. The software can then calculate the user's body mass index when told of his or her height. The game consists of different sub-games and activitie – some of which are not available until being unlocked by building up credits in the 'Fit Bank', including yoga poses, strength training, aerobics, balance games and other exercises.

MULTI-PLAYER WIRELESS AND DANCE MAT SYSTEMS

There a number of multi-player wireless dance mat systems where pupils can activate panels on a dance platform in sequence with four arrows on a screen and the beat of music. DanceMachine offer a twenty mat system for schools. It has been developed to improve fitness levels through hi-tech sound and visual equipment and is suitable for all key stages. This interactive range of equipment is designed to improve fitness through a large video screen and the latest hi-tech sound equipment.

This system tests both mental and physical activity through the many games and music to choose from and offers unlimited hours of physical activity. Interactive fitness equipment offers many benefits to the growing concerns of pupil's participation in physical activity. Amongst the many benefits to pupils is that they will burn off energy, boost their overall fitness, improve coordination and cardiovascular health. Dance steps are projected on to a wall or screen; users follow the steps displayed by arrows on their individual dance mat. At the end of song or session, users and instructors can see instant feedback on how well they performed, along with a leadership board for motivational competitiveness. Physical activity can therefore be more enjoyable and fitness and coordination is improved. Each dance mat is easily transported to different location by a storage cart that can hold up to sixteen dance mats.

GENERATION PEDOMETERS

The FitLinxx ActiPed is a next generation pedometer that clips to a shoe and records the wearer's walking, running or jumping as well as measures the distance travelled, calories burnt and total time of active minutes. This data can be stored and sent wirelessly and securely to an ActiPed account for the wearer to view their achievement and compare with their peer group.

Other innovative developments using ICT in physical education is the Nike Plus programme. This programme allows pupils to monitor their progress with regards to their levels of exercise in a similar way to other pedometers. This requires an iPod or Nike Plus sport band, sensor for shoes, sensor case to attach to shoe and a receiver for an iPod Nano. As pupils run, an iPod indicates their time, distance, pace and calories burned. And it gives you feedback at the halfway point and in the final lead-up to your goal. You can also see the details of your workout on your iPod. On selected workouts when using it with a Nano/iPod sporting legends such as Lance Armstrong and Venus Williams give periodic motivational help.

Pupils can download all the run information on to the Nike Plus website where they can see a timescale indicating all the information about their run and review their workout. Pupils can store all the runs completed so they can compare them and gain advice and help with training/coaching for any distances. The website also has a whole interactive community all over the world. This allows a person to challenge people, view other racing times and interact with

other runners. The Nike Plus website motivates pupils to access learning outside school; increases their running and fitness; improves ICT skills; motivates their learning through self-pacing calculations and estimating distances; undertake courses appropriate to their levels of skill and fitness; set targets to challenge themselves; assess their learning; supports the teaching of appropriate techniques.

DESIGNED OF PUPIL RESPONSE SYSTEMS

Interactive pupil response systems are designed to engage and motivate pupils whilst giving the teacher the tools to monitor and record pupil progress.

They are sometimes referred to as classroom voting systems, utilising advanced radio frequency technology and integrating with curriculum software. Pupil response systems add increased interactivity into classrooms through interactive writing tablets or wireless slates which presents a cost effective alternative to interactive whiteboard technology.

Pupil response systems are essentially a series of handsets that interact with additional software for Windows PowerPoint which allows pupils to interact with the teacher's presentation. This could be in the form of a quiz or formal assessment. Each pupil has access to a handset and if required can remain anonymous throughout the activity, or it can relate to each pupil individually. The results from each question can be highlighted to the group, via a graph or table, and pupils can compete against one another with a marking system, or a time limit, that can be adopted by the teacher.

Qwizdom is one interactive pupil response system. At Seaford Head Community College in East Sussex, Qwizdom has been used to develop material from both the GCSE and BTEC syllabi. It has also captivated pupils' interest, particularly in areas that may be more academic or literature based. It has been used with all Key Stage 4 pupils to evaluate the BTEC physical education course.

This has allowed physical education staff to make changes to the curriculum throughout the year in order to enhance the learning environment for each pupil. In addition, Qwizdom has been used within an orienteering unit of work.

The lessons were designed to include a strong theme of numeracy and literacy and included clues that pupils could answer using the handsets. The teacher was able to collate and save results, as well as observe the progress of the pupils as the handsets interact with the laptop used on-site by the member of staff.

ARCHOS: MP4 MASS STORAGE

Archos is an MP4 mass storage unit that has the capability of accessing the web, transmitting video, still images and music through an external source such as a speaker system or interactive whiteboard. The main function within physical education lessons is its ability to record video footage. The player has a small camera attachment that can film any type of activity, such as a dance performance, and it can be instantly played back on the Archos's 4-inch screen. The screen size allows for students to observe theirs or others' technique and

make comment, or watch the performance. During the playback mode there is also the opportunity to slow the action down to several variable speeds, as well as pause the footage. This is ideal when illustrating areas for improvement, or highlighting good technique and also incredibly visual for the pupils observing. Playback can instantly be transferred to a PC or laptop, and therefore be viewed on the 'big screen', or even edited to make into a video. It is a reliable back up for pupils' written assignments and can make the course content far more interesting and challenging. At Seaford Head Community College, pupils have created videos of good technique during outdoor and adventurous activities whilst using the climbing wall using the Archos to capture the footage. They have then used the school's ICT suite to edit their footage together to make a short film. The physical education department has also used the Archos equipment to film evidence of completion of BTEC National Diploma work with the Year 12 pupils. It has provided a reliable back up for the pupils' written assignments and has made the course content far more interesting and challenging.

Archos can save video footage which can be used for starter material at the beginning of a lesson. For example, footage taken from the previous lesson, or information from the internet, or digital television. Clips can be related to the lesson focus, or learning objectives. Information can be stored on the device that will relate to the lesson planned such as a good technique or performance. This could be observed at any stage throughout the lesson by pupils in order for them to enhance and compare their own work against the work of others. Music can be used at any stage and can play whilst the Archos is performing another feature. For example, it would be possible for the Archos to be plugged into speakers for a dance or gymnastics performance as well as film the performance itself.

Wireless internet (wifi) is also a feature as pupils can access the web in wifi areas to aid their research within accredited courses at key stage four and beyond by searching for items related to the work being covered. This does require a licence from Archos and involves a fee. Filming is easy with the 'Head camera'. Pupils can gain instant feedback on what they have performed and develop work as a result. They can use the slow motion tool on the device to illustrate an action or to evaluate their own and others performance. This information can then be stored on any computer system that has the software installed (this will take three minutes to install). Footage is stored via USB and takes moments to save minutes of work. This can then be used in various ways. For example, it can be added to Movie Maker and edited into a movie. It can also be added to presentations (PowerPoint). To view the footage on a larger scale it takes moments to plug the device in and illustrate the work on the interactive whiteboard. This works via USB again (similar to a memory stick) and can be watched and paused a number of times. Slow motion is not available at a larger scale as the footage is being played through the computer, rather than the Archos unit itself.

Other recordings can be taken from digital TV, terrestrial, video and DVD by linking the device up to a DVR station (also a charger). Using a DVR station alongside the wifi allows the teacher to set a timer on the Archos to record programmes. Data is stored directly onto the device and can be played back. Alternatively, highlights of programmes can be recorded by hand once plugged in using the record and pause functions.

THE USE OF IPODS

An iPod is a brand of portable media players designed and marketed by Apple Inc. The products includes the hard drive based iPod Classic, the touchscreen iPod Touch, the video-capable iPod Nano and the compact iPod Shuffle. The iPhone can function as an iPod but is generally treated as a separate product. iPod Classic models store media on an internal hard drive, while all other models use flash memory to enable their smaller size. As with many other digital music players, iPods, excluding the iPod Touch, can also serve as external data storage devices. Storage capacity varies by model.

The iTunes software can be used to transfer music to the devices from computers using certain versions of Apple Macintosh and Microsoft Windows operating systems. The use of iTunes and its alternatives may also transfer photographs, videos, games, contact information, e-mail settings, Web bookmarks and calendars to iPod models supporting those features. There are a number of potential benefits of using gadgets such as iPods which can engage and motivate pupils through analysis of performance. Pupils can rip and upload videos to their own. A dictaphone can allow pupils to provide commentary to moving images. For teachers it allows practical forms of assessment to take place and provide immediate results and feedback. Clips can be stored in pupil files allowing for reduced marking and paperwork for both teachers and pupils. The iPod shuffle is a digital audio player that uses flash memory which can provide teachers with quick and easy access to music playlists for dance lessons and can be played through a docking station using speakers. Other applications include the iPhone which is an internet and multimedia enabled 'Smartphone' designed and marketed by Apple Inc. Functions include a camera phone, portable media player similar to a video iPod and full internet access including web browsing.

PODCASTING: SERIES OF AUDIO OR VIDEO DIGITAL MEDIA

A podcast is a series of audio or video digital media files which are distributed over the internet by download, through web feeds, to portable media players and personal computers. A podcast is distinguished from most other digital media formats by its ability to be syndicated, subscribed to and downloaded automatically when new content is added. Like the term *broadcast*, *podcast* refers either to the series of content itself or to the method by which it is syndicated; the latter is also called podcasting. The host or author of a podcast is often called a podcaster. Podcasting is becoming increasingly popular in education and is currently being used at Hayesbrook Specialist Sports College,

which has enabled pupils and teachers to share information at any time. An absent pupil can download the podcast of the recorded lesson and it is being used as a tool for teachers or administrators to communicate curriculum, assignments and other information with parents and the community. Teachers can record trampolining and gymnastic routines, dance performances, swimming techniques, post-match interviews and pupil debates for example. Podcasting can be a publishing tool for pupil oral presentations within accredited physical education courses at Key Stage 4 and beyond.

THE VIRTUAL LEARNING ENVIRONMENT (VLE)

The virtual learning environment (VLE) has transformed the way in which pupils learn and teachers teach. The virtual learning environment is a global website that allows pupils to access their work and their curriculum from anywhere in the world. It is rights-protected and therefore only parents, students and staff will be able to log in. Pupils work can be set, collected and marked via the VLE, saving on a great deal of paperwork and collection and deadline dates. This, in turn, can empower pupils and inform their own learning. Pupils are able to make more decisions, as tasks will be completed at their own pace and potentially in their own time.

There are many ways in which physical education teachers can optimise pupil's knowledge and understanding through the use of this technology, which has significant advantages.

For example, pupils are able to join subjects (known as courses) and from there they will see the tasks, homework, quizzes and forums linked to the teacher, from home and school. As a teacher you are able to post work for your pupils that will be available around the clock. Your pupils will be able to submit work online and you can feedback to them from anywhere in the world. This allows teachers, parents and pupils to monitor their work and current attainment in physical education. Using the VLE pupils are able to post their work for others to see and comment on; parents will be able to participate more fully in their children's learning; learning can continue outside the school day; pupils will be able to participate in collaborative work involving other schools locally and internationally involving external experts; and learning can be more personalised to suit pupil needs. As many pupils make use of interactive online services (such as blogs, messaging and virtual worlds) at home, the VLE allows them to make use of these services in a controlled and safe on line environment.

At Hailsham Specialist Sports College in East Sussex, the VLE is being piloted to enhance collaboration with feeder primary schools by having online mentoring of Year 6 pupils by current Year 7 pupils, helping to ease the transition to secondary school. Cross-curricular learning is also facilitated through use of the VLE. Current examples of this working are the science and physical education project run in Year 7 by physical education teachers. Pupils are able interact online with teachers and each other to discuss and formulate answers to questions relating to learning objectives from lessons 'out of school time'.

This type of learning environment and this specific cross-curricular work has been recognised as a model of good practice and is growing rapidly. With many schools moving towards a more interactive way of teaching and learning it is likely that these types of practices will be commonplace in many schools by the start of the next decade.

3

Respiratory Responses to Exercise

Two of the major functions of the respiratory system (the lungs and the tubes through which air pass into and out of the body) are to:

- Provide oxygen (O_2) to the tissues of body via the lungs
- Eliminate carbon dioxide (CO_2) from the tissues of the body via the lungs

As with the cardiovascular system (heart, blood and blood vessels) greater demand is placed on these key functions with certain types of exercise.

As exercise commences pulmonary ventilation (breathing) increases in direct proportion to the intensity and metabolic needs of the exercise. This is shown on the adjacent graph. Note that pulmonary ventilation is expressed in terms of litres of air inhaled and exhaled per minute (L/min)).

Ventilation increases to meet the demands of exercise through the following two methods:

- An increase in 'tidal volume' which refers to the quantity of air that is inhaled and exhaled with every breath. This is similar to 'stoke volume' in the cardiovascular system.
- An increase in the 'respiration or breathing rate' which refers to how many times a person completes an inhalation and exhalation every minute. This is similar to 'heart rate' in the cardiovascular system.

If the exercise is intense, breathing rates may increase from a typical resting rate of 15 breaths per minute up to 40 – 50 breaths per minute.

The most commonly used measure of respiratory function with exercise is known as VO_2 (volume of oxygen uptake). VO_2 refers to the amount of oxygen taken up and used by the body. With continuous exercise (≥ 1 minute in duration)

such as aerobic fitness, longer duration anaerobic fitness and to a lesser degree muscular endurance training, VO_2 increases linearly with increases in exercise intensity. This is due to an increasing reliance on oxygen to help provide energy as exercise continues.

As the intensity of exercise continues to increase a person reaches a maximum point above which oxygen consumption will not increase any further. This point is known as VO2 max and is shown on the following graph.

Training types with moderate – high intensity, longer duration (≥ 1 minute) and have short or no rests throughout create what is known as 'EPOC'. EPOC stands for 'Excess Post-exercise Oxygen Consumption', and relates to the bodies need to keep consuming oxygen at a greater than resting rate once exercise has finished to make up for an oxygen 'debt' that is created when exercise commences. We'll explain this a little more in relation to the following graph.

As longer duration exercise commences an oxygen deficit is created (remember that it takes awhile for the aerobic energy system to kick in).

The size of the deficit largely determines the time that will be spent in recovery to 're-pay' the oxygen debt.

Respiration rate and depth remain elevated during this recovery period in order to expel carbon dioxide and return the acid–base balance of the muscles to neutral.

The higher the intensity of longer duration training the bigger the oxygen deficit and the longer the respiration rate and depth will stay elevated after the workout has finished.

During intense sessions focusing on muscular endurance and/or anaerobic fitness respiration rate and depth may remain elevated for 20-40 minutes after the workout.

When it comes to exercise the respiratory and cardiovascular systems are largely geared to the intake and supply of oxygen for energy and removal of the waste products carbon dioxide and lactate.

For these reasons we expect the greatest response of these systems to occur with training that relies on oxygen for energy and produces significant amounts of carbon dioxide and lactate.

High intensity short duration (≥ 30 seconds) training with long recovery intervals (≥ 2 minutes) such as strength or power and speed training are primarily reliant on stored ATP-PC energy.

For this reason the response of the respiratory system to these training types will be minimal. Breathing rates will rise slightly during a warm up, there may be a slight peak in breathing rate shortly after each set and breathing rate will return to normal within a few minutes of finishing the training session.

The respiratory system response becomes greater as exercise increases in duration and the demand for oxygen becomes more prevalent

With muscular hypertrophy training we will see greater peaks in breathing rates at the end of each set than we would for strength training as lactate starts to accumulate requiring oxygen to help metabolise it.

It may take 10-20 minutes post exercise for the breathing rate to return to normal with hypertrophy training because of this. Muscular endurance training has a greater reliance on oxygen for energy than hypertrophy training, the work intervals are longer and the rest periods are shorter allowing a minimum of recovery, so the response of the respiratory system is much greater than for hypertrophy training.

Breathing rates will have larger peaks at the end of each work interval due to limited recovery time. Breathing rates will compound over the total duration of the session and stay elevated for longer post workout. Similar responses will occur for anaerobic fitness training.

Training to improve aerobic fitness results in responses from the respiratory system that are very similar to the responses of the cardiovascular system for aerobic fitness.

Breathing increases up to 'steady state' where the supply of oxygen and expulsion of carbon dioxide meets the demands of the exercise.

Breathing rates remain relatively constant once steady state has been reached (as long as the intensity of the exercise remains constant), or fluctuate if the intensity fluctuates, much like the heart rate response to fluctuating intensities.

Breathing rates return to normal within 10-20 minutes after a primarily aerobic fitness session, as the respiratory system is not 'overstressed'.

The largest peaks in breathing rate and the longest periods of EPOC will occur with training for muscular endurance and anaerobic fitness.

These types of training with prolonged periods of high intensity work and limited recovery put the greatest demands on the respiratory and cardiovascular systems, and therefore have the greatest acute response.

AEROBIC EXERCISE

Aerobic exercise (also known as cardio) is physical exercise of low to high intensity that depends primarily on the aerobic energy-generating process. Aerobic literally means "relating to, involving, or requiring free oxygen", and refers to the use of oxygen to adequately meet energy demands during exercise via aerobic metabolism. Generally, light-to-moderate intensity activities that are sufficiently supported by aerobic metabolism can be performed for extended periods of time.

When practiced in this way, examples of cardiovascular/aerobic exercise are medium to long distance running/jogging, swimming,cycling, and walking, according to the first extensive research on aerobic exercise, conducted in the 1960s on over 5,000 U.S., Air Force personnel by Dr. Kenneth H. Cooper.

AEROBIC VERSUS ANAEROBIC EXERCISE

Aerobic exercise and fitness can be contrasted with anaerobic exercise, of which strength training and short-distance running are the most salient examples. The two types of exercise differ by the duration and intensity of muscular contractions involved, as well as by how energy is generated within the muscle.

New research on the endocrine functions of contracting muscles has shown that both aerobic and anaerobic exercise promote the secretion of myokines, with attendant benefits including growth of new tissue, tissue repair, and various anti-inflammatory functions, which in turn reduce the risk of developing various inflammatory diseases. Myokine secretion in turn is dependent on the amount of muscle contracted, and the duration and intensity of contraction. As such, both types of exercise produce endocrine benefits.

In almost all conditions, anaerobic exercise is accompanied by aerobic exercises because the less efficient anaerobic metabolism must supplement the aerobic system due to energy demands that exceed the aerobic system's capacity. What is generally called aerobic exercise might be better termed "solely aerobic", because it is designed to be low-intensity enough not to generate lactate via pyruvate fermentation, so that all carbohydrate is aerobically turned into energy.

Initially during increased exertion, muscle glycogen is broken down to produce glucose, which undergoes glycolysis producing pyruvate which then reacts with oxygen (Krebs cycle, Chemiosmosis) to produce carbon dioxide and water and releases energy. If there is a shortage of oxygen (anaerobic exercise, explosive movements), carbohydrate is consumed more rapidly because the pyruvate ferments into lactate. If the intensity of the exercise exceeds the rate with which the cardiovascular system can supply muscles with oxygen, it results in buildup of lactate and quickly makes it impossible to continue the exercise. Unpleasant effects of lactate buildup initially include the burning sensation in the muscles, and may eventually include nausea and even vomiting if the exercise is continued without allowing lactate to clear from the bloodstream.

As glycogen levels in the muscle begin to fall, glucose is released into the bloodstream by the liver, and fat metabolism is increased so that it can fuel the aerobic pathways. Aerobic exercise may be fueled by glycogen reserves, fat reserves, or a combination of both, depending on the intensity. Prolonged moderate-level aerobic exercise at 65 per cent VO_2 max (the heart rate of 150 bpm for a 30-year-old human) results in the maximum contribution of fat to the total energy expenditure. At this level, fat may contribute 40 per cent to 60 per cent of total, depending on the duration of the exercise. Vigorous exercise above 75 per cent VO_2max (160 bpm) primarily burns glycogen.

Major muscles in a rested, untrained human typically contain enough energy for about 2 hours of vigorous exercise. Exhaustion of glycogen is a major cause of what marathonrunners call "hitting the wall". Training, lower intensity levels, and carbohydrate loading may allow postponement of the onset of exhaustion beyond 4 hours.

Aerobic exercise comprises innumerable forms. In general, it is performed at a moderate level of intensity over a relatively long period of time. For example, running a long distance at a moderate pace is an aerobic exercise, but sprinting is not. Playing singles tennis, with near-continuous motion, is generally considered aerobic activity, while golf or two person team tennis, with brief bursts of activity punctuated by more frequent breaks, may not be predominantly aerobic.

Some sports are thus inherently "aerobic", while other aerobic exercises, such as fartlek training or aerobic dance classes, are designed specifically to improve aerobic capacity and fitness. It is most common for aerobic exercises to involve the leg muscles, primarily or exclusively. There are some exceptions. For example, rowing to distances of 2,000 m or more is an aerobic sport that exercises several major muscle groups, including those of the legs, abdominals, chest, and arms. Common kettlebell exercises combine aerobic and anaerobic aspects.

Among the recognized benefits of doing regular aerobic exercise are:

- Strengthening the muscles involved in respiration, to facilitate the flow of air in and out of the lungs
- Strengthening and enlarging the heart muscle, to improve its pumping efficiency and reduce the resting heart rate, known as aerobic conditioning
- Improving circulation efficiency and reducing blood pressure
- Increasing the total number of red blood cells in the body, facilitating transport of oxygen
- Improved mental health, including reducing stress and lowering the incidence of depression, as well as increased cognitive capacity.
- Reducing the risk for diabetes. One meta-analysis has shown, from multiple conducted studies, that aerobic exercise does help lower Hb A_{1C}levels for type 2 diabetics.

As a result, aerobic exercise can reduce the risk of death due to cardiovascular problems. In addition, high-impact aerobic activities (such as jogging or using a skipping rope) can stimulate bone growth, as well as reduce the risk of osteoporosis for both men and women.

In addition to the health benefits of aerobic exercise, there are numerous performance benefits:

- Increased storage of energy molecules such as fats and carbohydrates within the muscles, allowing for increased endurance
- Neovascularization of the muscle sarcomeres to increase blood flow through the muscles
- Increasing speed at which aerobic metabolism is activated within muscles, allowing a greater portion of energy for intense exercise to be generated aerobically
- Improving the ability of muscles to use fats during exercise, preserving intramuscular glycogen
- Enhancing the speed at which muscles recover from high intensity exercise
- Neurobiological effects: improvements in brain structural connections and increased gray matter density, new neuron growth, improved cognitive function (cognitive controland various forms of memory), and improvement or maintenance of mental health

Some downfalls of aerobic exercise include:

- Overuse injuries because of repetitive, high-impact exercise such as distance running.
- Is not an effective approach to building muscle.
- Only effective for fat loss when used consistently.

Both the health benefits and the performance benefits, or "training effect", require a minimum duration and frequency of exercise. Most authorities suggest at least twenty minutes performed at least three times per week.

AEROBIC CAPACITY

Aerobic capacity describes the functional capacity of the cardiorespiratory system, (the heart, lungs and blood vessels). Aerobic capacity refers to the maximum amount of oxygen consumed by the body during intense exercises, in a given time frame. It is a function both of cardiorespiratory performance and the maximum ability to remove and utilize oxygen from circulating blood. To measure maximal aerobic capacity, an exercise physiologist or physician will perform a VO_2 max test, in which a subject will undergo progressively more strenuous exercise on a treadmill, from an easy walk through to exhaustion.

The individual is typically connected to a respirometer to measure oxygen consumption, and the speed is increased incrementally over a fixed duration of time. The higher the measured cardiorespiratory endurance level, the more oxygen has been transported to and used by exercising muscles, and the higher the level of intensity at which the individual can exercise. More simply put, the higher the aerobic capacity, the higher the level of aerobic fitness. The Cooper and multi-stage fitness tests can also be used to assess functional aerobic capacity for particular jobs or activities. The degree to which aerobic capacity can be improved by exercise varies very widely in the human population: while the average response to training is an approximately 17 per cent increase in VO_2max, in any population there are "high responders" who may as much as double their capacity, and "low responders" who will see little or no benefit from training. Studies indicate that approximately 10 per cent of otherwise healthy individuals cannot improve their aerobic capacity with exercise at all. The degree of an individual's responsiveness is highly heritable, suggesting that this trait is genetically determined.

ALTERNATIVES

Higher intensity exercise, such as High-intensity interval training (HIIT), increases the resting metabolic rate (RMR) in the 24 hours following high intensity exercise, ultimately burning more calories than lower intensity exercise; low intensity exercise burns more calories during the exercise, due to the increased duration, but fewer afterwards.

COMMERCIAL SUCCESS

Aerobic exercise has long been a popular approach to achieving weight loss and physical fitness, often taking a commercial form.

- In the 1970s Judi Sheppard Missett helped create the market for commercial aerobics with her Jazzercise programme
- In the 1980s Richard Simmons hosted an aerobic exercise show on television, and also released a series of exercise videos
- In the 1990s Billy Blanks's Tae Bo helped popularize cardio-boxing workouts that incorporated martial arts movements

OXYGEN DEBT AND RECOVERY

WHAT IS IT ALL ABOUT THEN?

When you have a short intense burst of exercise such as sprinting you generate energy for this anaerobically or without oxygen. When you stop exercising you are still breathing heavily.

This is your body taking in extra oxygen to 'repay' the oxygen debt. Well, that is the simple solution but there is a little more to it if you want to look a bit deeper.

True, your body has worked anaerobically and will have produced energy without some of the oxygen it would normally have used performing low intensity exercise such as slow steady running. The difference between the oxygen the body required and what it actually managed to take in during the sudden sprint is called oxygen deficit.

When you stop sprinting and start to recover you will actually need more oxygen to recover than your body would have liked to use had enough been available. This is called Excess Post Exercise Oxygen Consumption.

So why does it take more oxygen to recover then?

- You needed to replace the oxygen the body needed but couldnt get (oxygen deficit).
- Breathing rate and heart rate are elevated (to remove CO2) and this needs more oxygen.
- Body temperature and metabolic rate is increased and this needs more oxygen.
- Adrenaline and Noradrenaline are increased which increases oxygen consumption.

So after exercise there are other factors causing an increase in oxygen needs as well as repaying the lack of oxygen during exercise.

The chart below is often seen and shows how the amount of oxygen used by the body changes over time. At the beginning the body works anaerobically leaving an oxygen deficit. Over time the oxygen consumption levels out to a steady state. After exercise the oxygen is pain back (oxygen debt). Notice the area of oxygen debt is greater than the area of oxygen deficit for the reasons stated above.

WHAT HAS LACTIC ACID GOT TO DO WITH IT?

Lactic acid is a by product of exercising without using oxygen (anaerobially). It is essential this is removed but it is not necessarily a waste product. It is recycled into other useful chemicals:

- During prolonged intensive exercise (*e.g.*, 800m race) the heart may get half its energy from lactic acid. It is converted back to pyruvic acid and used as energy by the heart and other muscles.

- It is thought that 70 per cent of lactic acid produced is oxidised, 20 per cent is converted to glucose (energy) in the liver.
- 10 per cent is converted to protein.

How long does it take to remove lactic acid?

- About 1 hour if cooling down with gentle exercise.

It can take 2 hours or more if you dont warm down with gentle exercise.

EXCESS POST-EXERCISE OXYGEN CONSUMPTION

Excess post-exercise oxygen consumption (EPOC, informally called afterburn) is a measurably increased rate of oxygen intake following strenuous activity intended to erase the body's "oxygen deficit". In historical context the term "oxygen debt" was popularized to explain or perhaps attempt to quantify anaerobic energy expenditure, particularly as regards lactic acid/lactate metabolism; in fact, the term "oxygen debt" is still widely used to this day. However, direct and indirect calorimeter experiments have definitively disproven any association of lactate metabolism as causal to an elevated oxygen uptake.

In recovery, oxygen (EPOC) is used in the processes that restore the body to a resting state and adapt it to the exercise just performed. These include: hormone balancing, replenishment of fuel stores, cellular repair, innervation and anabolism. Post-exercise oxygen consumption replenishes the phosphagen system. New ATP is synthesized and some of this ATP donates phosphate groups to creatine until ATP and creatine levels are back to resting state levels again. Post-exercise oxygen is also used to oxidize lactic acid. Lactic acid is produced during exercise and then travels via the blood stream to the kidneys, cardiac muscle, and liver. An increased amount of oxygen is necessary to convert the lactic acid back to pyruvic acid at these locations. Another use of EPOC is to fuel the body's increased metabolism from the increase in body temperature which occurs during exercise.

EPOC is accompanied by an elevated consumption of fuel. In response to exercise, fat stores are broken down and free fatty acids (FFA) are released into the blood stream. In recovery, the direct oxidation of free fatty acids as fuel and the energy consuming re-conversion of FFAs back into fat stores both take place.

DURATION OF THE EFFECT

The EPOC effect is greatest soon after the exercise is completed and decays to a lower level over time. One experiment found EPOC increasing metabolic rate to an excess level that decays to 13 per cent three hours after exercise, and 4 per cent after 16 hours. Another study, specifically designed to test whether the effect existed for more than 16 hours, conducted tests for 48 hours after the conclusion of the exercise and found measurable effects existed up to the 38 hour post-exercise measurement.

SIZE OF THE EPOC EFFECT

Studies show that the EPOC effect exists after both anaerobic exercise and aerobic exercise. Such comparisons are problematic, however, in that it is difficult to equalize and subsequently compare workloads between the two types of exercise. For exercise regimens of comparable duration and intensity, aerobic exercise burns more calories during the exercise itself, but the difference is partly offset by the higher increase in caloric expenditure that occurs during the EPOC phase after anaerobic exercise.

Anaerobic exercise in the form of high-intensity interval training was also found in one study to result in greater loss of subcutaneous fat, even though the subjects expended fewer than half as many calories during exercise. Whether this result was caused by the EPOC effect has not been established, and the caloric content of the participants' diet was not controlled during this particular study period.

In a 1992 Purdue study, results showed that high intensity, anaerobic type exercise resulted in a significantly greater magnitude of EPOC than aerobic exercise of equal work output.

Most researchers use a measure of EPOC as a natural part of the quantification or measurement of exercise and recovery energy expenditure; to others this is not deemed necessary. After a single bout or set of weight lifting, Scott et al. found considerable contributions of EPOC to total energy expenditure.

In their 2004 survey of the relevant literature, Meirelles and Gomes found: "In summary, EPOC resulting from a single resistance exercise *session* (*i.e.*, many lifts) does not represent a great impact on energy balance; however, its cumulative effect may be relevant".

This is echoed by Reynolds and Kravitz in their survey of the literature where they remarked: "the overall weight-control benefits of EPOC, for men and women, from participation in resistance exercise occur over a significant time period, since kilocalories are expended at a low rate in the individual post-exercise sessions."

The EPOC effect clearly increases with the intensity of the exercise, and (at least in the case of aerobic exercise, perhaps also for anaerobic) the duration of the exercise.

Studies comparing intermittent and continuous exercise consistently show a greater EPOC response for higher intensity, intermittent exercise.

OXYGEN DEBT

During muscular exercise, blood vessels in muscles dilate and blood flow is increased in order to increase the available oxygen supply. Up to a point, the available oxygen is sufficient to meet the energy needs of the body. However, when muscular exertion is very great, oxygen cannot be supplied to muscle fibres fast enough, and the aerobic breakdown of pyruvic acid cannot produce all the ATP required for further muscle contraction.

LACTIC ACID

During such periods, additional ATP is generated by anaerobic glycolysis. In the process, most of the pyruvic acid produced is converted to lactic acid. Although about 80 per cent of the lactic acid diffuses from the skeletal muscles and is transported to the liver for conversion back to glucose or glycogen.

OXYGEN

Ultimately, once adequate oxygen is available, lactic acid must be catabolized completely into carbon dioxide and water. After exercise has stopped, extra oxygen is required to metabolize lactic acid; to replenish ATP, phosphocreatine, and glycogen; and to pay back any oxygen that has been borrowed from hemoglobin, myoglobin (an iron-containing substance similar to hemoglobin that is found in muscle fibres), air in the lungs, and body fluids.

The additional oxygen that must be taken into the body after vigorous exercise to restore all systems to their normal states is called oxygen debt (Hill 1928).

Eventually, muscle glycogen must also be restored. This is accomplished through diet and may take several days, depending on the intensity of exercise. The maximum rate of oxygen consumption during the aerobic catabolism of pyruvic acid is called "maximal oxygen uptake".

It is determined by sex (higher in males), age (highest at about age 20) and size (increases with body size).

Highly trained athletes can have maximal oxygen uptakes that are twice that of average people, probably owing to a combination of genetics and training. As a result, they are capable of greater muscular activity without increasing their lactic acid production, and their oxygen debts are less. It is for these reasons that they do not become short of breath as readily as untrained individuals.

OXYGEN CONSUMPTION FOLLOWING EXERCISE

After a strenuous exercise there are four tasks that need to be completed:

- Replenishment of ATP
- Removal of lactic acid
- Replenishment of myoglobin with oxygen
- Replenishment of glycogen

The need for oxygen to replenish ATP and remove lactic acid is referred to as the "Oxygen Debit" or "Excess Post-exercise Oxygen Consumption" (EPOC) - the total oxygen consumed after exercise in excess of a pre-exercise baseline level.

In low intensity, primarily aerobic exercise, about one half of the total EPOC takes place within 30 seconds of stopping the exercise and complete recovery can be achieved within several minutes (oxygen uptake returns to the pre-exercise level).

Recovery from more strenuous exercise, which is often accompanied by increase in blood lactate and body temperature, may require 24 hours or more before re-establishing the pre-exercise oxygen uptake. The amount of time will depend on the exercise intensity and duration.

The two major components of oxygen recovery are:

- Alactacid oxygen debit (fast component)
  - The portion of oxygen required to synthesise and restore muscle phosphagen stores (ATP and PC)
- Lactacid oxygen debit (slow component)
  - The portion of oxygen required to remove lactic acid from the muscle cells and blood

The replenishment of muscle myoglobin with oxygen is normally completed within the time required to recover the Alactacid oxygen debit component.

The replenishment of muscle and liver glycogen stores depends on the type of exercise: short distance, high intensity exercise (*e.g.*, 800 metres) may take up to 2 or 3 hours and long endurance activities (*e.g.*, marathon) may take several days. Replenishment of glycogen stores is most rapid during the first few hours following training and then can take several days to complete. Complete restoration of glycogen stores is accelerated with a high carbohydrate diet.

4

Exercise Physiology

Exercise physiology is the physiology of physical exercise. It is the study of the acute responses and chronic adaptations to a wide range of exercise conditions.

Exercise physiologists study the effect of exercise on pathology, and the mechanisms by which exercise can reduce or reverse disease progression.

ENERGY EXPENDITURE

Humans have a high capacity to expend energy for many hours during sustained exertion. For example, one individual cycling at a speed of 26.4 km/h (16.4 mph) through 8,204 km (5,098 mi) over 50 consecutive days expended a total of 1,145 MJ (273,850 kcal; 273,850 dieter calories) with an average power output of 182.5 W.

Skeletal muscle burns 90 mg (0.5 mmol) of glucose each minute during continuous activity (such as when repetitively extending the human knee), generating ≈ 24 W of mechanical energy, and since muscle energy conversion is only 22–26 per cent efficient, ≈ 76 W of heat energy. Resting skeletal muscle has a basal metabolic rate (resting energy consumption) of 0.63 W/kg making a 160 fold difference between the energy consumption of inactive and active muscles. For short duration muscular exertion, energy expenditure can be far greater: an adult human male when jumping up from a squat can mechanically generate 314 W/kg. Such rapid movement can generate twice this amount in non-human animals such as bonobos, and in some small lizards.

This energy expenditure is very large compared to the basal resting metabolic rate of the adult human body. This rate varies somewhat with size, gender and age but is typically between 45 W and 85 W. Total energy expenditure (TEE)

due to muscular expended energy is much higher and depends upon the average level of physical work and exercise done during a day. Thus exercise, particularly if sustained for very long periods, dominates the energy metabolism of the body. Physical activity energy expenditure correlates strongly with the gender, age, weight, heart rate, and VO_2 max of an individual, during physical activity.

METABOLIC CHANGES

Rapid Energy Sources

Energy needed to perform short lasting, high intensity bursts of activity is derived from anaerobic metabolism within the cytosol of muscle cells, as opposed to aerobic respiration which utilizes oxygen, is sustainable, and occurs in the mitochondria. The quick energy sources consist of the phosphocreatine (PCr) system, fast glycolysis, and adenylate kinase. All of these systems re-synthesize adenosine triphosphate (ATP), which is the universal energy source in all cells. The most rapid source, but the most readily depleted of the above sources is the PCr system which utilizes the enzyme creatine kinase. This enzyme catalyzes a reaction that combines phosphocreatineand adenosine diphosphate (ADP) into ATP and creatine. This resource is short lasting because oxygen is required for the resynthesis of phosphocreatine via mitochondrial creatine kinase.

Therefore, under anaerobic conditions, this substrate is finite and only lasts between approximately 10 to 30 seconds of high intensity work. Fast glycolysis, however, can function for approximately 2 minutes prior to fatigue, and predominately uses intracellular glycogen as a substrate. Glycogen is broken down rapidly via glycogen phosphorylase into individual glucose units during intense exercise.

Glucose is then oxidized to pyruvate and under anaerobic condition is reduced to lactic acid. This reaction oxidizes NADH to NAD, thereby releasing a hydrogen ion, promoting acidosis. For this reason, fast glycolysis can not be sustained for long periods of time. Lastly, adenylate kinase catalyzes a reaction by which 2 ADP are combined to form ATP and adenosine monophosphate (AMP). This reaction takes place during low energy situations such as extreme exercise or conditions of hypoxia, but is not a significant source of energy. The creation of AMP resulting from this reaction stimulates AMP-activated protein kinase (AMP kinase) which is the energy sensor of the cell. After sensing low energy conditions, AMP kinase stimulates various other intracellular enzymes geared towards increasing energy supply and decreasing all anabolic, or energy requiring, cell functions.

Plasma Glucose

Plasma glucose is said to be maintained when there is an equal rate of glucose appearance (entry into the blood) and glucose disposal (removal from the blood). In the healthy individual, the rates of appearance and disposal are essentially equal during exercise of moderate intensity and duration; however, prolonged

exercise or sufficiently intense exercise can result in an imbalance leaning towards a higher rate of disposal than appearance, at which point glucose levels fall producing the onset of fatigue. Rate of glucose appearance is dictated by the amount of glucose being absorbed at the gut as well as liver (hepatic) glucose output. Although glucose absorption from the gut is not typically a source of glucose appearance during exercise, the liver is capable of catabolizing stored glycogen (glycogenolysis) as well as synthesizing new glucose from specific reduced carbon molecules (glycerol, pyruvate, and lactate) in a process called gluconeogenesis.

The ability of the liver to release glucose into the blood from glycogenolysis is unique, since skeletal muscle, the other major glycogen reservoir, is incapable of doing so. Unlike skeletal muscle, liver cells contain the enzyme glycogen phosphatase, which removes a phosphate group from glucose-6-P to release free glucose. In order for glucose to exit a cell membrane, the removal of this phosphate group is essential. Although gluconeogenesis is an important component of hepatic glucose output, it alone can not sustain exercise. For this reason, when glycogen stores are depleted during exercise, glucose levels fall and fatigue sets in. Glucose disposal, the other side of the equation, is controlled by uptake of glucose at the working skeletal muscles. During exercise, despite decreased insulin concentrations, muscle increases GLUT4 translocation of and glucose uptake. The mechanism for increased GLUT4 translocation is an area of ongoing research.

- *Glucose control:* As mentioned above, insulin secretion is reduced during exercise, and does not play a major role in maintaining normal blood glucose concentration during exercise, but its counter-regulatory hormones appear in increasing concentrations. Principle among these are glucagon, epinephrine, and growth hormone. All of these hormones stimulate liver (hepatic) glucose output, among other functions. For instance, both epinephrine and growth hormone also stimulate adipocyte lipase, which increases non-esterified fatty acid (NEFA) release. By oxidizing fatty acids, this spares glucose utilization and helps to maintain blood sugar level during exercise.
- *Exercise for diabetes:* Exercise is a particularly potent tool for glucose control in those who have diabetes mellitus. In a situation of elevated blood glucose (hyperglycemia), moderate exercise can induce greater glucose disposal than appearance, thereby decreasing total plasma glucose concentrations. As stated above, the mechanism for this glucose disposal is independent of insulin, which makes it particularly well-suited for people with diabetes. In addition, there appears to be an increase in sensitivity to insulin for approximately 12–24 hours post-exercise. This is particularly useful for those who have type II diabetes and are producing sufficient insulin but demonstrate peripheral resistance to insulin signaling. However, during extreme hyperglycemic episodes, people with diabetes should avoid exercise due to potential

complications associated withketoacidosis. Exercise could exacerbate ketoacidosis by increasing ketone synthesis in response to increased circulating NEFA's.

Type II diabetes is also intricately linked to obesity, and there may be a connection between type II diabetes and how fat is stored within pancreatic, muscle, and liver cells. Likely due to this connection, weight loss from both exercise and diet tends to increase insulin sensitivity in the majority of people. In some people, this effect can be particularly potent and can result in normal glucose control. Although nobody is technically cured of diabetes, individuals can live normal lives without the fear of diabetic complications; however, regain of weight would assuredly result in diabetes signs and symptoms.

Oxygen

Vigorous physical activity (such as exercise or hard labour) increases the body's demand for oxygen. The first-line physiologic response to this demand is an increase in heart rate, breathing rate, and depth of breathing.

Oxygen consumption (VO_2) during exercise is best described by the Fick Equation: VO_2=Q x (a-vO_2diff), which states that the amount of oxygen consumed is equal to cardiac output (Q) multiplied by the difference between arterial and venous oxygen concentrations. More simply put, oxygen consumption is dictated by the quantity of blood distributed by the heart as well as the working muscle's ability to take up the oxygen within that blood; however, this is a bit of an oversimplification. Although cardiac output is thought to be the limiting factor of this relationship in healthy individuals, it is not the only determinant of VO_2 max.

That is, factors such as the ability of the lung to oxygenate the blood must also be considered. Various pathologies and anomalies cause conditions such as diffusion limitation, ventilation/perfusion mismatch, and pulmonary shunts that can limit oxygenation of the blood and therefore oxygen distribution. In addition, the oxygen carrying capacity of the blood is also an important determinant of the equation. Oxygen carrying capacity is often the target of exercise (ergogenic aids) aids used in endurance sports to increase the volume percentage of red blood cells (hematocrit), such as through blood doping or the use of erythropoietin (EPO). Furthermore, peripheral oxygen uptake is reliant on a rerouting of blood flow from relatively inactive viscera to the working skeletal muscles, and within the skeletal muscle, capillary to muscle fibre ratio influences oxygen extraction.

Dehydration

Dehydration refers both to hypohydration (dehydration induced prior to exercise) and to exercise-induced dehydration (dehydration that develops during exercise). The latter reduces aerobic endurance performance and results in increased body temperature, heart rate, perceived exertion, and possibly increased reliance on carbohydrate as a fuel source. Although the negative effects of exercise-

induced dehydration on exercise performance were clearly demonstrated in the 1940s, athletes continued to believe for years thereafter that fluid intake was not beneficial. More recently, negative effects on performance have been demonstrated with modest (<2 per cent) dehydration, and these effects are exacerbated when the exercise is performed in a hot environment.

The effects of hypohydration may vary, depending on whether it is induced through diuretics or sauna exposure, which substantially reduce plasma volume, or prior exercise, which has much less impact on plasma volume. Hypohydration reduces aerobic endurance, but its effects on muscle strength and endurance are not consistent and require further study. Intense prolonged exercise produces metabolic waste heat, and this is removed bysweat-based thermoregulation. A male marathon runner loses each hour around 0.83 L in cool weather and 1.2 L in warm (losses in females are about 68 to 73 per cent lower).People doing heavy exercise may lose two and half times as much fluid in sweat as urine. This can have profound physiological effects. Cycling for 2 hours in the heat (35 °C) with minimal fluid intake causes body mass decline by 3 to 5 per cent, blood volume likewise by 3 to 6 per cent, body temperature to rise constantly, and in comparison with proper fluid intake, higher heart rates, lower stroke volumes and cardiac outputs, reduced skin blood flow, and higher systemic vascular resistance. These effects are largely eliminated by replacing 50 to 80 per cent of the fluid lost in sweat.

Other

- Plasma catecholamine concentrations increase 10-fold in whole body exercise.
- Ammonia is produced by exercised skeletal muscles from ADP (the precursor of ATP) by purine nucleotide deamination and amino acid catabolism of myofibrils.
- Interleukin-6 (IL-6) increases in blood circulation due to its release from working skeletal muscles. This release is reduced if glucose is taken, suggesting it is related to energy depletion stresses.
- Sodium absorption is affected by the release of interleukin-6 as this can cause the secretion of arginine vasopressin which, in turn, can lead to exercise-associated dangerously low sodium levels (hyponatremia). This loss of sodium in blood plasma can result in swelling of the brain. This can be prevented by awareness of the risk of drinking excessive amounts of fluids during prolonged exercise.

BRAIN

At rest, the human brain receives 15 per cent of total cardiac output, and uses 20 per cent of the body's energy consumption. The brain is normally dependent for its high energy expenditure upon aerobic metabolism. The brain as a result is highly sensitive to failure of its oxygen supply with loss of consciousness occurring within six to seven seconds,with its EEG going flat in

23 seconds. If it affected the oxygen and glucose supply to the brain, the metabolic demands of exercise could therefore quickly disrupt its functioning.

Protecting the brain from even minor disruption is important since exercise depends upon motor control, and particularly, because humans are bipeds, the motor control needed for keeping balance. Indeed, for this reason, brain energy consumption is increased during intense physical exercise due to the demands in the motor cognition needed to control the body.

Cerebral Oxygen

Cerebral autoregulation usually ensures the brain has priority to cardiac output, though this is impaired slightly by exhaustive exercise. During submaximal exercise, cardiac output increases and cerebral blood flow increases beyond the brain's oxygen needs. However, this is not the case for continuous maximal exertion: "Maximal exercise is, despite the increase in capillary oxygenation [in the brain], associated with a reduced mitochondrial O_2 content during whole body exercise" The autoregulation of the brain's blood supply is impaired particularly in warm environments

Glucose

In adults, exercise depletes the plasma glucose available to the brain: short intense exercise (35 min ergometer cycling) can reduce brain glucose uptake by 32 per cent. At rest, energy for the adult brain is normally provided by glucose but the brain has a compensatory capacity to replace some of this with lactate. Research suggests that this can be raised, when a person rests in a brain scanner, to about 17 per cent, with a higher percentage of 25 per cent occurring during hypoglycemia. During intense exercise, lactate has been estimated to provide a third of the brain's energy needs. There is evidence that the brain might, however, in spite of these alternative sources of energy, still suffer an energy crisis since IL-6 (a sign of metabolic stress) is released during exercise from the brain.

Hyperthermia

Humans use sweat thermoregulation for body heat removal, particularly to remove the heat produced during exercise. Moderate dehydration as a consequence of exercise and heat is reported to impair cognition. These impairments can start after body mass lost that is greater than 1 per cent. Cognitive impairment, particularly due to heat and exercise is likely to be due to loss of integrity to the blood brain barrier. Hyperthermia also can lower cerebral blood flow, and raise brain temperature.

FATIGUE

Intense Activity

Researchers once attributed fatigue to a build-up of lactic acid in muscles. However, this is no longer believed. Rather, lactate may stop muscle fatigue by

keeping muscles fully responding to nerve signals. The available oxygen and energy supply, and disturbances of muscle ion homeostasis are the main factor determining exercise performance, at least during brief very intense exercise. Each muscle contraction involves an action potential that activates voltage sensors, and so releases Ca^{2+} ions from the muscle fibre's sarcoplasmic reticulum. The action potentials that cause this require also ion changes: Na influxes during the depolarization phase and K effluxes for the repolarization phase. C_l^- ions also diffuse into the sarcoplasm to aid the repolarization phase. During intense muscle contraction, the ion pumps that maintain homeostasis of these ions are inactivated and this (with other ion related disruption) causes ionic disturbances. This causes cellular membrane depolarization, inexcitability, and so muscle weakness. Ca^{2+} leakage from type 1 ryanodine receptor) channels has also been identified with fatigue.

Endurance Failure

After intense prolonged exercise, there can be a collapse in body homeostasis. Some famous examples include:

- Dorando Pietri in the 1908 Summer Olympic men's marathon ran the wrong way and collapsed several times.
- Jim Peters in the marathon of the 1954 Commonwealth Games staggered and collapsed several times, and though he had a five-kilometre (three-mile) lead, failed to finish. Though it was formerly believed that this was due to severe dehydration, more recent research suggests it was the combined effects upon the brain of hyperthermia, hypertonic hypernatraemia associated with dehydration, and possibly hypoglycaemia.
- Gabriela Andersen-Schiess in the woman's marathon at the Los Angeles 1984 Summer Olympics in the race's final 400 meters, stopping occasionally and shown signs of heat exhaustion. Though she fell across the finish line, she was released from medical care only two hours later.

Central Governor

Tim Noakes, based on an earlier idea by the 1922 Nobel Prize in Physiology or Medicine winner Archibald Hill has proposed the existence of a central governor. In this, the brain continuously adjusts the power output by muscles during exercise in regard to a safe level of exertion.

These neural calculations factor in prior length of strenuous exercise, the planned duration of further exertion, and the present metabolic state of the body. This adjusts the number of activated skeletal muscle motor units, and is subjectively experienced as fatigue and exhaustion.

The idea of a central governor rejects the earlier idea that fatigue is only caused by mechanical failure of the exercising muscles ("peripheral fatigue"). Instead, the brain models the metabolic limits of the body to ensure that whole body homeostasis is protected, in particular that the heart is guarded from

hypoxia, and an emergency reserve is always maintained. The idea of the central governor has been questioned since 'physiological catastrophes' can and do occur suggesting athletes (such as Dorando Pietri,Jim Peters and Gabriela Andersen-Schiess) can over-ride the ''central governor'.

Other Factors

The exercise fatigue has also been suggested to be effected by:

- Brain hyperthermia
- Glycogen depletion in brain cells
- Reactive oxygen species impairing skeletal muscle function
- Reduced level of glutamate secondary to uptake of ammonia in the brain
- Fatigue in diaphragm and abdominal respiratory muscles limiting breathing
- Impaired oxygen supply to muscles
- Ammonia effects upon the brain
- Serotonin pathways in the brain

CARDIAC BIOMARKERS

Prolonged exercise such as marathons can increase cardiac biomarkers such as troponin, B-type natriuretic peptide (BNP), and ischemia-modified (aka MI) albumin. This can be misinterpreted by medical personnel as signs of myocardial infarction, or cardiac dysfunction. In these clinical conditions, such cardiac biomarkers are produced by irreversible injury of muscles. In contrast, the processes that create them after strenuous exertion in endurance sports are reversible, with their levels returning to normal within 24-hours (further research, however, is still needed).

HUMAN ADAPTATIONS

Humans are specifically adapted to engage in prolonged strenuous muscular activity (such as efficient long distance bipedal running). This capacity for endurance running evolved to allow the running down of game animals by persistent slow but constant chase over many hours.

Central to the success of this is the ability of the human body, unlike that of the animals they hunt, to effectively remove muscle heat waste. In most animals, this is stored by allowing a temporary increase in body temperature. This allows them to escape from animals that quickly speed after them for a short duration (the way nearly all predators catch their prey). Humans, unlike other animals that catch prey, remove heat with a specialized thermoregulation based on sweat evaporation.

One gram of sweat can remove 2,598 J of heat energy. Another mechanism is increased skin blood flow during exercise that allows for greater convective heat loss that is aided by our upright posture. This skin based cooling has resulted in humans acquiring an increased number of sweat glands, combined with a lack of body fur that would otherwise stop air circulation and efficient

evaporation. Because humans can remove exercise heat, they can avoid the fatigue from heat exhaustion that affects animals chased in a persistent manner, and so eventually catch them.

SELECTIVE BREEDING EXPERIMENTS WITH RODENTS

Rodents have been specifically bred for exercise behaviour or performance in several different studies. For example, laboratory rats have been bred for high or low performance on a motorized treadmill with electrical stimulation as motivation. The high-performance line of rats also exhibits increased voluntary wheel-running behaviour as compared with the low-capacity line. In an experimental evolution approach, four replicate lines of laboratory mice have been bred for high levels of voluntary exercise on wheels, while four additional control lines are maintained by breeding without regard to the amount of wheel running. These selected lines of mice also show increased endurance capacity in tests of forced endurance capacity on a motorized treadmill. However, in neither selection experiment have the precise causes of fatigue during either forced or voluntary exercise been determined.

EXERCISE-INDUCED MUSCLE PAIN

Physical exercise may cause pain both as an immediate effect that may result from stimulation of free nerve endings by low pH, as well as a delayed onset muscle soreness. The delayed soreness is fundamentally the result of ruptures within the muscle, although apparently not involving the rupture of whole muscle fibers.

Curriculum

The curriculum for exercise physiology includes biology, chemistry, and applied sciences. The purpose of the classes selected for this major is to have a proficient understanding of human anatomy, human physiology, and exercise physiology. Includes instruction in muscular and skeletal anatomy; molecular and cellular basis of muscle contraction; fuel utilization; neurophysiology of motor mechanics; systemic physiological responses (respiration, blood flow, endocrine secretions, and others); fatigue and exhaustion; muscle and body training; physiology of specific exercises and activities; physiology of injury; and the effects of disabilities and disease. Not only is a full class schedule needed to complete a degree in Exercise Physiology, but a minimum amount of practicum experience is required and internships are recommended.

BRIDGING THE THEORY - PRACTICE GAP IN ENERGY SYSTEMS TRAINING

Coaches without real knowledge of energy systems often intuitively develop programmes that train the dominant energy system for their sport. For instance, sprint coaches intuitively train their athletes with sprint distances even though

they are unfamiliar with the benefits of such training on the nervous system and the anaerobic energy systems. However, energy systems training should also take into consideration the recruitment of muscle fibre types. Improvement in energy system efficiency depends on the neuromuscular system's ability to withstand the development of tension and fatigue resulting from chronic training. For instance, continual training of the anaerobic lactic system makes the fast-twitch muscle fibers able to generate force in the presence of lactic acid accumulation. This result is accomplished through an increase in motor unit recruitment and the reuse of lactic acid by the slow-twitch muscle fibers. Anaerobic metabolism can be maximized by designing a programme that combines maximum strength and power endurance training with 150- to 400-meter sprinting.

The energy system tapped to produce energy during an athletic activity depends directly on the intensity and duration of the activity. The anaerobic alactic system primarily produces energy for all sports of short duration (up to 8 to 10 seconds), in which speed and power are the dominant abilities. Alactic system-dominant sports include short sprinting, throwing and jumping events in track and field, ski jumping, diving, vaulting in gymnastics, and Olympic weightlifting.

The movements in these sports are explosive and of short duration and use high loads; in other words, they require maximum strength and power. Therefore, the anaerobic alactic energy system is used in conjunction with the recruitment of a high number of fast-twitch muscle fibers (for maximum strength) and an increase in the discharge rate of those fibers (for maximum power).

The anaerobic lactic system, on the other hand, is the main energy provider forhigh-intensity sporting activities of prolonged duration (15 to 60 seconds). A partial list of anaerobic lactic system-dominant sports includes the 200- and 400-meter running events in track and field, 50-meter swimming, track cycling, and 500-meter speedskating. Performance in these sports requires maximum power of both the anaerobic alactic system and the anaerobic lactic system. The maximum capacity of the anaerobic metabolism is required for sports of slightly longer duration, such as mid-distance events in track and field, 100- and 200-meter swimming, 500-meter canoeing and kayaking, 1,000-meter speedskating, most events in gymnastics, alpine skiing, rhythmic gymnastics, and pursuit in track cycling.

The purpose of strength training for these sports is to develop either power endurance or muscle endurance of short duration. The athlete must be able not only to increase the discharge rate of the fast-twitch muscle fibers but also to maintain the level of discharge for a longer time (from 10 to 120 seconds). Recall that gains in power endurance and muscular endurance of short duration are possible only as a result of increasing maximum strength. Therefore, athletes in these sports should develop a strong foundation of maximum strength.

As previously mentioned, the aerobic energy system is used to produce the energy for sports ranging from one minute to more than three hours. Many

coaches have difficulty understanding how to train for events with such a wide range of duration. As a rule of thumb, the closer the event's duration is to one minute, the lower the aerobic contribution to overall performance will be. The opposite is also true: The longer the duration is, the more dominant the aerobic system will be.

The same reasoning applies if we want to differentiate between power and capacity of the aerobic energy system. The power output reached at maximum aerobic power can usually be sustained for 6 minutes (Billat et al.2013), whereas maximum aerobic power can be maintained up to 15 minutes if the power output is adjusted (Billat et al.1999).

Therefore, any event lasting 1 to 15 minutes requires a high level of aerobic power; in addition, for events longer than 15 minutes, the closer to the 15-minute limit the event is, the higher the required aerobic power level is, as compared with the higher aerobic capacity requirements for longer events. Many sports belong in the aerobic-dominant category: long- (and to some degree mid-) distance events in track and field; swimming; speedskating, 1,000-meter kayaking and canoeing; wrestling; figure skating; synchronized swimming; rowing; cross-country skiing; cycling (road races); and triathlon. Athletes in all of these sports benefit physiologically from training muscular endurance of medium or long duration.

Although most sports fall somewhere along a clear continuum of varying energy system contributions, special consideration must be applied to team sports, boxing, the martial arts, and racket sports - that is, to sports characterized by intermittent activity. In these sports, all three energy systems are used according to the intensity, rhythm, and duration of the competition. Most of these sports use the anaerobic energy pathway during the active part of competition and rely on strong aerobic power for quick recovery and regeneration between actions (Bogdanis et al.1996) (creatine phosphate resynthesis through the aerobic phosphorylation).

As a result, this sport category requires a high proportion of training dedicated to the improvement of maximum strength, power, and power endurance.

The relationships between the energy systems and the type of strength training suggested for the sports falling into each category.

This table clearly shows the need for maximum strength training throughout the energy system continuum. Regardless of whether the sport is primarily anaerobic, aerobic, or characterized by equal contributions from both systems, the development of maximum strength provides the foundation on which other dominant abilities are maximized.

More specifically, increased muscle fibre density (the laying down of protein filaments in muscle) and improved motor unit recruitment patterns result in more muscle being available for use in sports that require a high power output (anaerobic-dominant sports) and in endurance-based sports, as the slow-twitch muscle fibers increase in size and provide greater surface area for capillarization and mitochondrial density.

Table. Relationship Between Energy System and Strength Training Methods.

Energy system	**Anaerobic (oxygen independent)**					**Aerobic (oxygen dependent)**	
	Alactic	**lactic acid**					
Modality	**Power**	**Capacity**	**Power**	**capacity**	**Power**		**Capacity**
Duration	1-6 seconds	7-8 seconds	8-20 seconds	20-60 seconds	1-2 minutes	2-8 minutes	8->120 minutes
Type of strenght training needed	MxS, P		MxS, P, PE	MxS, P, PE, MES	MxS, P, PE, MEM	MxS, PE, MEM	MxS (< 80% of 1RM), PE, MEL

Again, every sport has its own physiological profile and its own distinctive combination of required biomotor abilities. Consequently, effective training specialists understand intimately what separates one sport from another and successfully apply these physiological principles in the day-to-day training process. To help you apply sport-specific characteristics in training, the following passages discuss how energy systems relate to metabolic training and how the six intensity zones can be used in most sport training along with strength training.

To better understand the relationship between the duration of effort and the contribution of energy systems to energy production. As you can infer from table below, the transition from anaerobic to aerobic dominance in energy contribution happens once the effort lasts more than one minute.

Table. Energy System Contribution in Track-and-Field Performance.

Event	**Duration**	**ATP-CP**	**GLYCOGEN Lactic**	**Aerobic**	**Triglyceride (fatty acid)**
100 m	10 sec.	53%	44%	3%	-
200 m	20 sec.	26%	45%	29%	-
400 m	45 sec.	12%	50%	38%	-
800 m	1 min. 45 sec.	6%	33%	61%	-
1,500 m	3 min. 40 sec.	-	20%	80%	-
5,000 m	13 min.	-	12.5%	87.5%	-
10,000 m	27 min.	-	3%	97%	-
Marathon	2 hr. 10 min.	-	-	80%	20%

Table below demonstrates that a number of sports demand the energy produced by all three energy systems. When a sport combines energy systems, the training and physiology associated with that sport are more complex. The spectrum of energy systems training - and their individual zones' physiological and training characteristics - are reflected in the six intensity zones. The table indicates the type of training for each intensity zone, the suggested duration of reps or drills, the suggested number of reps, the necessary rest interval to achieve the training goal, the lactic acid concentration following a rep, and the percentage

of maximum intensity necessary to stimulate a given energy system. However, practical application of the six intensity zones must be planned according to an athlete's potential, his or her work tolerance, and the specifics of a given training phase. The following brief analysis of the intensity zones addresses certain details of each type of energy systems training. The application of intensity zones to an athlete's training is usually more familiar to coaches of individual sports than to coaches of team sports. The methodology used to apply the intensity zones to the training of any sport determines the training efficiency and performance outcome.

Table. Physiological Characteristics of Energy Systems Training and its Six Intensity Zones.

				Training Modality		
Intensity zone	**Type of training**	**Duration of rep**	**Number of reps**	**Rest interval (work-to-rest ratio)**	**Sets Series of sets**	**% of max intensity**
1	Alactic system	1-8 sec.	6-12	1:50-1:100		95-100
2	Lactic system (power-short)	3-10 sec.	10-20	1:5-1:20		95-100
	Lactic system (power-long)	10-20 sec.	1-3	1:40-1:130	–	95-100
	Lactic system (capacity)	20-60 sec.	2-10	1:4-1:24		80-95

Intensity zone	**Type of training**	**Duration of rep**	**Number of reps**	**Rest interval (work-to-rest ratio**	**lactic acid concentration (mmol)**	**%max heart rate**	**% of VO_2 max**
3	Max oxygen consumption	1-6 min.	8-25	1:1-1:4	6-12	98-100	95-100
4	Anaerobic threshold training	1-10 min.	3-40	1:0.3-1:1	4-6	85-95	80-90
5	Aerobic training	10-120 min. threshold	-(continuous steady state		2-3	75-80	60-70
6	Aerobic compensation	5-30 min.	-(continuous steady state		2-3	55-75	45-60

HUMAN BODY - RESPONSES TO EXERCISE

When you begin to exercise your body must immediately adjust to the change in activity level. Energy production must increase to meet demand with changes to the predominant energy system and fuel source occuring throughout the exercise in order to maintain the required level of performance.

Responses to Anaerobic Exercise:

- In order to immediately meet the sudden higher energy demand, stored ATP is the first energy source. This lasts for approximately 2 seconds.
- When stored ATP is broken down into ADP + P, the rising ADP level stimulates Creatine Kinase to begin the breakdown of Phosphocreatine.
- As discussed on the energy systems page the ATP-PC system can only last 8-10 seconds before PC stores are depleted.
- The lactic acid system (Anaerobic glycolysis) must then take over as the predominant source of energy production. High intensity (but sub-maximal) exercise can last for between 3 and 5 minutes using this system
- If the exercise continues at a high intensity, and so Oxygen is not available at a fast enough rate to allow aerobic metabolism to take over, the production of lactic acid will reach the point where it interferes with muscular function. This is called the Lactate threshold.
- Muscles begin to fatigue when ATP resynthesis can no longer match demand.

Responses to Aerobic Exercise:

- Due to the necessity of Oxygen being present for aerobic metabolism, the first few minutes of low to moderate intensity exercise are powered by anaerobic metabolism.
- Continued low to moderate intensity exercise is then fuelled by carbohydrate and fat stores using aerobic metabolism.
- The intensity and duration of exercise determines which fuel source is used. Fat metabolism is a slow process and so can only be used as fuel for exercise at less than 60% VO2 max.
- Carbohydrate is a much faster fuel source and so can be used for exercise up to 80 per cent (in trained individuals).
- Carbohydrate stores within the muscle and liver can fuel exercise for up to 80 minutes. As carbohydrate stores get lower, the body has to rely more and more on fat stores.
- The intensity of exercise which can be maintained drops as fat cannot supply the required amount of energy.

EXERCISE ENERGY SYSTEMS

When you exercise your body is constantly working to supply your muscles with enough energy to keep going, but the way energy is made available to your muscles changes depending on the specific intensity and duration of your exercise.

ADENOSINE TRIPHOSPHATE (ATP) - THE ENERGY SOURCE FOR MUSCLE CONTRACTION

Before discussing the various systems by which your body can provide energy to your muscles, we first need to define what muscle "energy" actually is. We know that your muscle cells need an energy source to be able to contract during

exercise. At the highest level, the energy source for muscle contractions is the food you eat. A complex chemical process within your cells, called cellular respiration, ultimately converts the energy stored in the foods you eat into a form that is optimized for use at the cellular level of your muscles. Once food energy has been converted by cellular respiration it exists at the cellular level in the form of a molecule called adenosine triphosphate (ATP).

The composition of an ATP molecule can be inferred from its name. It is composed of three (or "tri") phosphate groups attached to an adenine (or "adenosine") nucleotide. The energy that is stored within anATP molecule is released for your muscles to use when the bond between the second and third phosphate groups is broken. Breaking this bond releases the third phosphate group on its own and thus reduces the ATP molecule to adenosine diphosphate (ADP). The ADP molecule can be restored back to its ATP form by replenishing the missing phosphate group (this is called rephosphorylization).

THREE EXERCISE ENERGY SYSTEMS

The cellular respiration process that converts your food energy into ATP is in large part dependent on the availability of oxygen. When you exercise, the supply and demand of oxygen available to your muscle cells is affected by the duration and intensity of your exercise and by your cardiorespiratory fitness level. Luckily, you have three exercise energy systems that can be selectively recruited, depending on how much oxygen is available, as part of the cellular respiration process to generate the ATP energy for your muscles.

THE ALACTIC ANAEROBIC ENERGY SYSTEM

This energy system is the first one recruited for exercise and it is the dominant source of muscle energy for high intensity explosive exercise that lasts for 10 seconds or less. For example, the alactic anaerobic energy system would be the main energy source for a 100 m sprint, or a short set of a weightlifting exercise. It can provide energy immediately, it does not require any oxygen (that's what "anaerobic" means), and it does not produce any lactic acid (that's what "alactic" means). It is also referred to as theATP-PCr energy system or the phosphagen energy system.

The alactic anaerobic energy system provides itsATP energy through a combination of ATP already stored in the muscles (about 1 or 2 seconds worth from prior cellular respiration during rest) and its subsequent rephosphorylization (about 8 or 9 seconds worth) after use by another molecule called phosphocreatine (PCr). Essentially, PCr is a molecule that carries back-up phosphate groups ready to be donated to the already used ADPmolecules to rephosphorylize them back into utilizable ATP. Once the PCr stored in your muscles runs out the alactic anaerobic energy system will not provide further ATP energy until your muscles have rested and been able to regenerate their PCr levels. Creatine supplementation is a method used to extend the duration of effectiveness of the alactic anaerobic energy system for a few seconds by increasing the amount of PCr stored within your muscles.

THE LACTIC ANAEROBIC ENERGY SYSTEM

This system is the dominant source of muscle energy for high intensity exercise activities that last up to approximately 90 seconds. For example, it would be the main energy contributor in an 800 m sprint, or a single shift in ice hockey. Essentially, this system is dominant when your alactic anaerobic energy system is depleted but you continue to exercise at an intensity that is too demanding for your aerobic energy system to handle. Like the alactic anaerobic energy system, this system is also anaerobic and so it does not require any oxygen. However, unlike the alactic anaerobic energy system, this system is lactic and so it does produce lactic acid. It is also referred to as the lactic acid system or the anaerobic glycolytic system.

In contrast to the alactic anaerobic energy system, which uses ATP stored from previous cellular respiration in combination with a PCr phosphate buffer, the lactic anaerobic energy system must directly recruit the active cellular respiration process to provide ATP energy. The cellular respiration process consists of a very complex series of chemical reactions, but the short summary of it is that it ultimately converts food energy (from carbohydrates, fats, and proteins) into ATP energy. When oxygen is not available for cellular respiration, as is the case for the lactic anaerobic energy system, lactic acid is produced as a byproduct.

THE AEROBIC ENERGY SYSTEM

During continuous aerobic exercise your intensity level, relative to the high intensity levels that recruit your alactic anaerobic and lactic anaerobic energy systems, must be reduced so that the energy demand placed on your muscles equals the energy supply (compare this to the alactic anaerobic and lactic anaerobic systems, where demand usually exceeds supply and energy stores are quickly depleted).

The energy supply at this lower intensity level, in contrast to the alactic anaerobic and lactic anaerobic systems, which do not require oxygen, now becomes dependent on how efficiently oxygen can be delivered to, and processed by, your muscles. A continuous supply of oxygen allows you to maintain a reduced intensity level for a long period of time. If you are able to extend an exercise activity beyond approximately two minutes in length it will be due to the fact that you are working at an exercise intensity level that can be accommodated by your aerobic energy system. By five minutes of exercise duration the aerobic energy system will have become your dominant energy source. As an example, the aerobic energy system would be the main energy contributor to a marathon runner. The aerobic energy system does not produce lactic acid, but unlike the other two energy systems, it does require oxygen.

Just like the lactic anaerobic energy system, the aerobic energy system must directly recruit the active cellular respiration process to provide ATP energy. Food energy is converted into ATP by your muscle cells through a very complex series of reactions.

The difference, relative to the lactic anaerobic energy system, however, is that since oxygen is now available to your muscles no lactic acid will be produced as a byproduct. The generation of ATP energy by the aerobic energy system can be continued as long as oxygen is available to your muscles and your food energy supplies don't run out.

RELATIVE CONTRIBUTIONS - AEROBIC VS. ANAEROBIC ENERGY SYSTEMS

The table shown below compares experimentally measured (accumulated oxygen deficit method) energy contributions of the aerobic and anaerobic energy systems for various track running events. A quick review of the table illustrates how the aerobic energy system's contribution increases with increasing event distance, and vice versa for the anaerobic energy system.

Energy Contributions of the Aerobic and Anaerobic Energy Systems to Track Running Events

	Males		Females	
Event	**Aerobic Energy Contribution**	**Anaerobic Energy Contribution**	**Aerobic Energy Contribution**	**Anaerobic Energy Contribution**
100 m	21%	79%	25%	75%
200 m	28%	72%	33%	67%
400 m	41%	59%	45%	55%
800 m	60%	40%	70%	30%
1500 m	77%	23%	86%	14%
3000 m	86%	14%	94%	6%

EXERCISE ENERGY SYSTEMS - CONCLUSION

Now you have a basic understanding of the three exercise energy systems that keep you active. As a final note, it's important to understand that, although one of the systems will be the dominant source of your energy during a particular type of exercise, all of the exercise energy systems are active at all times.

It is simply the relative amount of energy that each system is providing that will change with varying exercise intensity and duration. Therefore, you will never be receiving your energy exclusively from one energy system while you are exercising, but from all three to different degrees.

STUDY OF EXERCISE PSYCHOLOGY

Exercise psychology can be defined as the study of psychological issues and theories related to exercise. Exercise psychology is a sub-discipline within the field of psychology and is typically grouped with sport psychology. For example, Division 47 of the APA is for exercise and sport psychology, not just one or the other, while organizations like AASP encompass both exercise and sport psychology.

The link between exercise and psychology has long been recognized. In 1899, William James discussed the importance of exercise, writing it was needed to "furnish the background of sanity, serenity...and make us good-humored and easy of approach." Other researchers noted the connection between exercise and depression, concluding a moderate amount of exercise was more helpful than no exercise in symptom improvement.

As a sub-discipline, the amount of research in exercise psychology increased in the 1950s and 1960s, leading to several presentations at the second gathering of the International Society of Sport Psychology in 1968. Throughout the 1970s and 1980s, William Morgan wrote several pieces on the relationship between exercise and various topics, such as mood, anxiety, and adherence to exercise programmes. Morgan also went on to found APA Division 47 in 1986.

As an interdisciplinary subject, exercise psychology draws on several different scientific fields, ranging from psychology to physiology to neuroscience. Major topics of study are the relationship between exercise and mental health (*e.g.*, stress, affect, self-esteem), interventions that promote physical activity, exploring exercise patterns in different populations (*e.g.*, the elderly, the obese), theories of behaviour change, and problems associated with exercise (*e.g.*, injury, eating disorders, exercise addiction).

Exercise physiology is the study of the acute responses and chronic adaptations to a wide-range of physical exercise conditions. In addition, many exercise physiologists study the effect of exercise on pathology, and the mechanisms by which exercise can reduce or reverse disease progression. Accreditation programmes exist with professional bodies in most developed countries, ensuring the quality and consistency of education.

An exercise physiologist's area of study may include but is not limited to biochemistry, bioenergetics, cardiopulmonary function, hematology, biomechanics, skeletal muscle physiology, neuroendocrine function, and central and peripheral nervous system function. Furthermore, exercise physiologists range from basic scientists, to clinical researchers, to clinicians, to sports trainers.

ENERGY

Humans have a high capacity to expend energy for many hours doing sustained exercise. For example, one individual cycling at a speed of 26.4 km/h (16.4 mph) across 8,204 km (5,098 mi) on 50 consecutive days may expended a total of 1,145 MJ (273,850 kcal) with an average power output of 182.5 W.

Skeletal muscle burns 90 mg (0.5 mmol) of glucose each minute in continuous activity (such as when repetitively extending the human knee), generating H"24 W of mechanical energy, and since muscle energy conversion is only 22-26% efficient, H"76 W of heat energy. Resting skeletal muscle has a basal metabolic rate (resting energy consumption) of 0.63 W/kg making a 160 fold difference between the energy consumption of inactive and active muscles. For short muscular exertion, energy expenditure can be far greater: an adult human male when jumping up from a squat mechanically generates 314 W/kg, and such

rapid movement can generate twice this power in nonhuman animals such as bonobos, and in some small lizards. This energy expenditure is very large compared to the resting metabolism basal metabolic rate of the adult human body. This varies somewhat with size, gender and age but is typically between 45 W and 85 W. Total energy expenditure (TEE) due to muscular expended energy is much higher and depends upon the average level of physical work and exercise done during a day.Thus exercise, particularly if sustained for very long periods, dominates the energy metabolism of the body.

EXERCISE-INDUCED MUSCLE PAIN AND EFFECT

Physical exercise may cause pain both as an immediate pain effect that may result from stimulation of free nerve endings by low pH, as well as a delayed onset muscle soreness. The delayed soreness is fundamentally the result of ruptures within the muscle, although apparently not involving the rupture of whole muscle fibres.

EDUCATION IN EXERCISE PHYSIOLOGY

Colleges and Universities offer Exercise Physiology as a programme of study on various different levels, including undergraduate, graduate, and doctoral programmes. The basis of Exercise Physiology as a major is to prepare students for a career in field of health sciences. A programme that focuses on the scientific study of the physiological processes involved in physical or motor activity, including sensorimotor interactions, response mechanisms, and the effects of injury, disease, and disability.

Includes instruction in muscular and skeletal anatomy; molecular and cellular basis of muscle contraction; fuel utilization; neurophysiology of motor mechanics; systemic physiological responses (respiration, blood flow, endocrine secretions, and others); fatigue and exhaustion; muscle and body training; physiology of specific exercises and activities; physiology of injury; and the effects of disabilities and disease. Careers available with a degree in Exercise Physiology can include: non-clinical, client-based work; strength and conditioning specialists; cardiopulmonary treatment; and clinical-based research.

In order to gauge the multiple areas of study, students are taught processes in which to follow on a client-based level. Practical and lecture teachings are instructed in the classroom and in a laboratory setting.

These include:

- *Health and Risk Assessment:* In order to safely work with a client on the job, you must first be able to know the benefits and risks associated with physical activity. Examples of this include knowing specific injuries the body can experience during exercise, how to properly screen a client before their training begins, and what factors to look for that may inhibit their performance.

- *Exercise Testing:* Coordinating exercise tests in order to measure body compositions, cardiorespiratory fitness, muscular strength/ endurance, and flexibility. Functional tests are also used in order to gain understanding on a more specific part of the body. Once the information is gathered about a client, exercise physiologists must also be able to interpret the test data and decide what health-related outcomes have been discovered.
- *Exercise Prescription:* Forming training programmes that best meet an individuals health and fitness goals. Must be able to take into account different types of exercises, the reasons/goal for a clients workout, and pre-screened assessments. Knowing how to prescribe exercises for special considerations and populations is also required. These may include age differences, pregnancy, joint diseases, obesity, pulmonary disease, *etc.*

CURRICULUM

The curriculum for Exercise Physiology includes biology, chemistry, and applied sciences. The purpose of the classes selected for this major is to have a proficient understanding of human anatomy, human physiology, and exercise physiology. Includes instruction in muscular and skeletal anatomy; molecular and cellular basis of muscle contraction; fuel utilization; neurophysiology of motor mechanics; systemic physiological responses (respiration, blood flow, endocrine secretions, and others); fatigue and exhaustion; muscle and body training; physiology of specific exercises and activities; physiology of injury; and the effects of disabilities and disease. Not only is a full class schedule needed to complete a degree in Exercise Physiology, but a minimum hours of practicum are require and internships are recommended.

STARTING AN EXERCISE PROGRAMME

EMPHASIS ON HEALTH-RELATED PHYSICAL FITNESS

Remember, your exercise programme should include activities that emphasize flexibility, muscular strength/endurance, cardiorespiratory fitness, and body composition. Flexibility can be emphasized (*e.g.*, stretching) as part of the warm-up and cool-down. Muscular strength/endurance exercise should include all major muscle groups and could be included in the activity (*e.g.*, swimming) or as a separate segment of the exercise plan (*e.g.*, calisthenics or weight training). Cardiorespiratory fitness is emphasized when the activities are continuous and heart rate is maintained in the 60-85 % target heart rate zone (or RPE of 13-17) for the duration of the activity. Body composition is directly related to caloric expenditure (*e.g.*, amount of activity) and is influenced by the total amount of physical activity/exercise performed.

The time guidelines for each of the health-related physical fitness components on a minute's per week basis. Baseline values represent minimums and

recommended values represent those related to good health-related fitness levels. The body composition minutes include flexibility, muscular strength/endurance and cardiorespiratory minutes in addition to minutes from other activities.

Also, cardiorespiratory minutes might include muscular strength/endurance minutes depending on the cardiorespiratory activity performed (*e.g.*, rowing). Flexibility minutes are normally completed as part of the warm-up and cool-down for each exercise session.

MOVE A MEASURED MILE (MMM) PROGRAMME

There are as many reasons to start exercising, as there are people. You may want to lose weight or to regain physical conditioning that has been lost over the years. You may exercise to improve your health or because it's fun. Perhaps you would like to improve your endurance for physical activity. Moving a measured mile is an excellent way to start an exercise programme. You can walk, jog, run, swim, cycle, row, dance, or "wheel" (wheelchairs) you're way to improved fitness!

The Move A Measured Mile (MMM) Programme is a convenient way to organize and keep track of your physical activity/exercise. A MILE UNIT represents the amount of energy required to walk/run a mile. Energy requirements of other activities (*e.g.*, swimming, cycling and tennis) are also expressed in MILE UNITS to provide a "common denominator" in relation to energy expenditure. The presents MILE UNIT equivalents for various activities. An AEROBIC MILE UNIT is defined as a MILE UNIT where heart rate is maintained in the 60-85 % target heart rate zone (or RPE of 13-17) for the duration of the MILE UNIT. It should be clear that total AEROBIC MILE UNITS in a week is related to cardiorespiratory fitness and total MILE UNITS in a week is related to body composition.

Follow these five steps to begin your MMM programme:

1. The first task is to decide what your physical activity wll be and where you will exercise. For walking and running you could use a measured track or fitness trail, or a route around your workplace, through your neighbourhood, or in a park. As with cycling, you can measure your mile by driving your route and checking your car odometer. Swimming pools lend themselves easily to determination of distance (72 lengths (25yd) = 1 mi). Also, obtain any equipment you might need—a watch, comfortable supportive walking/running/exercise shoes, a cycling helmet for safety, *etc.*
2. Next, determine the time of day that is best for you. Morning people like to "work out" before breakfast, others find it convenient during their lunch break, and still others like to use exercise to relax after a stressful day. Pick a time that suits YOU, schedule it, and make it a habit. Tip-exercise with a friend(s) for good conversation and fun.
3. Remember to emphasize flexibility as you warm-up before and cool-down after each physical activity/exercise session. Also, be sure that

your continuous cardiorespiratory exercise lasts at least 10-15 min. For an individual beginning a walking programme this could mean a 1-mile walk; for another who is into jogging, it could mean 2 miles at an 8-minute mile pace. A cyclist might ride 3 miles in 12 minutes; while a swimmer might do 24 lengths or 1/3 mile (25-yd pool) in 14 minutes. An individual into aerobic dance, rowing, or calisthenics might work through a continuous 20 minute programme. The key is that your intensity level should be held between 60-85% of maximum or an RPE of 13-17 for a minimum of 10-15 minutes. Make sure that you exercise the major muscle groups of the arms, legs and trunk as part of your cardiorespiratory exercise or as a separate part of your exercise programme. Finally, to emphasize body composition, plan your exercise and physical activity such that you complete at least 10-MILE UNITS per week.

4. Keep a daily, weekly and eight-week record of your activity. A guide, record all of your physical activity/exercise in MILE UNITS and AEROBIC MILE UNITS (Assignment 1).
5. Set weekly and eight week goals, write them down and GO FOR IT!!! The presents suggested MMM goals. Note, a baseline (Bronze level) AEROBIC MILE UNITS goal would be one that accounts for 30 min of aerobic physical activity per week. For a 65 yr. old this might mean walking 3 times per week for a minimum of 10-15 min (maintaining heart rate and/or RPE in target zone). For a 20-year-old it could mean jogging 1 1/4 miles 3 times per week at an 8-min mile pace. After you determine the number of AEROBIC MILE UNITS you can perform in 30 min, substitute this value to determine your AEROBIC MILE UNITS goal.

The Bronze level should provide sufficient quality and quantity of physical activity for baseline health-related physical fitness; the Silver level represents the recommended level of physical activity for good health-related physical fitness; and the Gold level is for those who wish to go beyond good health-related physical fitness to a higher level of physiological function.

FATIGUE OF ATHELETIC

INTENSE ACTIVITY

Researchers once attributed fatigue to a build-up of lactic acid in muscles. However, this is no longer believed. Indeed, lactate may stop muscle fatigue by keeping muscles fully responding to nerve signals. Instead, providing available oxygen and energy supply and disturbances of muscle ion homeostasis are the main factor determining exercise performance, at least during brief very intense exercise.

Each muscle contraction involves an action potential that activates voltage sensors, and so releases Ca^{2+} ions from the muscle fibre's sarcoplasmic reticulum.

The action potentials causing this require also ion changes: Na influxes during the depolarization phase and K effluxes for the repolarization phase. Cl^- ions also

diffuse into the sarcoplasm to aid the repolarization phase. During intense muscle contraction the ion pumps that maintain homeostasis of these ions are inactivated and this (with other ion related disruption) causes ionic disturbances.

This causes cellular membrane depolarization, inexcitability, and so muscle weakness. Ca^{2+} leakage from type 1 ryanodine receptor) channels has also been identified with fatigue.

ENDURANCE FAILURE

After intense prolonged exercise, there can be a collapse in body homeostasis. Some famous examples include:

- Dorando Pietri in the 1908 Summer Olympic men's marathon ran the wrong way and collapsed several times.
- Jim Peters in the marathon of the 1954 Commonwealth Games staggered and collapsed several times, and though he had a five-kilometre (three-mile) lead, failed to finish. Though it was formerly believed that this was due to severe dehydration, more recent research suggests it was the combined effects upon the brain of hyperthermia, hypertonic hypernatraemia associated with dehydration, and possibly hypoglycaemia.
- Gabriela Andersen-Schiess in the woman's marathon at the Los Angeles 1984 Summer Olympics in the race's final 400 meters, stopping occasionally and shown signs of heat exhaustion. Though she fell across the finish line, she was released from medical care only two hours later.

OTHER FACTORS

The exercise fatigue has also been suggested to be effected by:

- Brain hyperthermia
- Glycogen depletion in brain cells
- Reactive oxygen species impairing skeletal muscle function
- Reduced level of glutamate secondary to uptake of ammonia in the brain
- Fatigue in diaphragm and abdominal respiratory muscles limiting breathing
- Impaired oxygen supply to muscles
- Ammonia effects upon the brain
- Serotonin pathways in the brain

CARDIAC BIOMARKERS

Prolonged exercise such as marathons can increase cardiac biomarkers such as troponin, B-type natriuretic peptide (BNP), and ischemia-modified albumin. This can be misinterpreted by medical personnel as signs of myocardial ischemia, or cardiac dysfunction. In these clinical conditions, such cardiac biomarkers are produced by irreversible injury of muscles. In contrast, the processes that create them after strenuous exertion in endurance sports are reversible, with their levels returning to normal within 24-hours (further research, however, is still needed).

HUMAN EVOLUTION

Humans are specifically adapted to engage in prolonged strenuous muscular activity (such as efficient long distance bipedal running). This capacity for endurance running evolved to allow therunning down of game animals by persistent slow but constant chase over many hours. Central to the success of this is the ability of the human body, unlike that of the animals they hunt, to effectively remove muscle heat waste. In most animals, this is stored by allowing a temporary increase in body temperature. This allows them to escape from animals that quickly speed after them for a short duration (the way nearly all predators catch their prey). Humans unlike other animals that catch prey remove heat with a specialized thermoregulation based on sweat evaporation. One gram of sweat can remove 2,598 J of heat energy. Another mechanism is increased skin blood flow during exercise that allows for greater convective heat loss that is aided by the upright posture. This skin based cooling has involved humans in acquiring an increased number of sweat glands, combined with a lack of body fur that would otherwise stop air circulation and efficient evaporation. Because humans can remove exercise heat, they can avoid the fatigue from heat exhaustion that affects animals chased in persistence hunting, and so eventually catch them when they fatigue from heat exhaustion due to being forced to move constantly.

SELECTIVE BREEDING EXPERIMENTS WITH RODENTS

Rodents have been specifically bred for exercise behaviour or performance in several different studies. For example, laboratory rats have been bred for high or low performance on a motorized treadmill with electrical stimulation as motivation. The high-performance line of rats also exhibits increased voluntary wheel-running behaviour as compared with the low-capacity line. In anexperimental evolution approach, four replicate lines of laboratory mice have been bred for high levels of voluntary exercise on wheels, while four additional control lines are maintained by breeding without regard to the amount of wheel running. These selected lines of mice also show increased endurance capacity in tests of forced endurance capacity on a motorized treadmill. However, in neither selection experiment have the precise causes of fatigue during either forced or voluntary exercise been determined.

AEROBIC AND ANAEROBIC ENERGY SYSTEMS

UNDERSTANDING YOUR ENERGY SYSTEMS FOR ENDURANCE AND SPEED TRAINING

Your body is a machine and like any machine it needs energy to power it. Understanding how its energy systems work and interact with each other will put our workouts into context and direct our training. Training the wrong energy system will be detrimental to your sports performance. The three energy systems.

Aerobic Energy System

Oxygen provides the catalyst for a chemical reaction in our muscles (including the heart) that generates aerobic energy. If it were not for other factors – such as insufficient muscle fuel (notably, carbohydrate or, more specifically, *glycogen*) over-heating and dehydration, we could theoretically continue to exercise aerobically indefinitely.

Aerobic workouts are often also called 'steady state'. This is because, during them, the body's energy demands are balanced by energy supply. This allows us to continuously exercise – hence the steady state. When the steady state is breached, for example, by increasing our effort and using more energy, our body will change the way it produces energy. It will do this with less oxygen and energy will be produced anaerobically.

Whatever our sport, aerobic energy provides a base of fitness, regardless of the specific energy system demands of our actual sport. A good foundation will enable a sprinter (who relies predominantly on the immediate anaerobic system) to recover more quickly between training efforts or a football mid-fielder to sustain the high energy output required over a match (football relies particularly on the short-term anaerobic energy system). It should be noted that certain sports require more aerobic fitness than others, and others combinations of all three.

Fat as a Fuel Source for the Aerobic Energy System

Although carbohydrate is the body's preferred source of fuel during activity, fat also supplies energy. Aerobic training increases the body's ability to mobilise fat as an energy source at sub-maximal intensities (as well as improving carbohydrate *metabolism*). This will significantly improve the 'range' of endurance athletes.

To develop an improved fat burning capability you need to train religiously at about 80 per cent of maximum heart rate (HRmax). This is known as 'fat max'.

The Immediate Anaerobic Energy System

When our bodies generate energy through the immediate anaerobic system, no reliance is placed on oxygen. Consequently, it supplies energy for no more than 6-8 seconds. To get its power it uses 'high energy' stored body chemicals – such as adenosine troposphere (ATP) and creatine phosphate (CP) and a chemical reaction that 'fires' them up.

Explosive Energy

You might like to think of the immediate anaerobic energy system as being like an explosion. An incredible amount of energy is released in a very short time. From this you can appreciate that this is the energy system of choice for equally explosive athletes, such as power and weight lifters and sprinters.

Too much aerobic training can dull this explosiveness. It can reduce the power capability of our power and speed generating fast twitch muscle fibres.

The Short-term Anaerobic Energy System

Like its immediate energy system brother, the short-term anaerobic energy system also produces high-powered energy. However, it is a little more enduring and can provide energy for up to 90 seconds.

This energy system is exemplified by the efforts of a 400m runner. Their high-intensity effort passes well beyond the energy supply capabilities of the immediate system and consequently huge amounts of energy are released by further intra-muscular chemical reactions. Many of us will be familiar with the burning sensations we feel in our muscles after a near flat-out effort (this is the result of the short-term energy system going into overdrive and the over spilling of one of the energy producing chemicals,*lactate* and its conversion to lactic acid). Invariably, during such an effort, our hearts will reach maximum output. These are the physiological consequences of our body (and in particular its muscles) crying out for more and more oxygen but not getting it.

Insufficient Oxygen Supply

As short-term anaerobic energy system production passes the 20-second mark, more and more demand is placed on oxygen as a fuel source, after 30 seconds, 20 per cent of the energy produced is done so aerobically and after 60 seconds, 30 per cent. As the one-and-a half minute mark is reached, no amount of oxygen gulping will save the anaerobic 'engine' and we will grind to a potentially painful halt.

Boost your Anaerobic Energy Supplies

Training the anaerobic energy system (by interval training, for example) will increase your body's ability to replenish the high energy phosphates used to generate energy. This will, in turn, extend their ability to produce more high powered efforts, as long as adequate rest is allowed.

Table below:

Event	**Aerobic energy system contribution**	**Anaerobic energy system contribution**
200m	5%	95%
800m	34%	66%
1,500m	50%	50%
10,000m	80%	20%
Marathon	98%	2%
Football-		
Goalkeeper		100%
Forward		100%
Mid-fielder	20%	80%

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Strength Development and Exercise

In selecting the right kind and amount of physical activity for any particular unfit boy or girl, the physical educator should consider the place of strength in the total physical fitness pattern. As viewed in this book, strength is a basic element; emphasis upon its development is vital for those who are sub-standard. However, for total-body fitness, exercise should not be limited to strengthening activities, but should be balanced properly by endurance (circulatory-respiratory) activities. Moreover, provisions should be made within the framework of the strength-endurance activity programme for other important developments, including skill, agility, flexibility, co-ordination, grace, poise, and so forth.

ISOMETRIC VS. ISOTONIC EXERCISE

In this presentation, *muscular strength* is defined as the maximum contraction that can be voluntarily applied in a single contraction. Two types of muscular endurance are recognised: *isometric,* whereby a maximum static muscular contraction is held; and *isotonic,* whereby the muscle continues to raise and lower a submaximal load.

A great many studies have been conducted to determine the relative effectiveness of isometric and isotonic exercises and of various systems of progressive resistance exercise in the development of muscular strength and muscular endurance. These studies have been summarized by Clarke; the conclusions drawn from his synthesis follow.

1. Both isometric and isotonic forms of exercise improve muscular strength. However, the evidence shows little if any difference in the

effectiveness of the two forms in achieving strength increase; the same result was obtained for different systems of progressive resistance exercise. Considerable variation in individual strength improvement exists for both forms of exercise.

2. No study has verified the strength gain of 5 per cent per week for ten weeks (50 per cent for the entire period) from a single six-second daily contraction against resistance consisting of two-thirds of the muscle's strength, as reported by Hettinger and Mueller. Apparently, a more realistic, although perhaps still generous, figure is nearer 2 per cent each week.
3. The effects of isotonic exercise favour the improvement of muscular endurance and the retention of muscular strength following the cessation of exercise for a period of time. Isometric contractions restrict blood circulation to a greater extent than do isotonic contraction. For isometric work, Clarke found that the amount of oxygen, oxygen debt, and total oxygen requirement increase linearly in proportion to the size of the load; this constriction of circulation with attendant effects on the oxygen supply to the muscles logically restricts the development of muscular endurance when training with isometric exercise.
4. Hypotheses have been supported that the amount of tension developed in a muscle is a major factor in determining strength improvement and that the work done per unit of time is the factor essential in the extension of muscular strength and muscular endurance performances.
5. Nearly all studies on the conditioning effects of isometric and isotonic regimens of exercise utilized very limited training sessions. Possibly these brief exercise sessions are insufficient for adequate strength development or for any one method of exercising to achieve superiority over another. It may be contended that a person's rate of strength improvement depends largely upon the degree he overloads and that, in most of these studies, the overload principle has not been adequately applied.

Hellebrandt and Houtz have shed some light on the mechanism of muscle training in an experimental demonstration of the overload principle. In their application, the overload principle implies that the limits of performance must be persistently extended to improve muscle strength; and the rate of improvement depends on the willingness of the subject to overload. Comparisons were made with the manner in which athletes extend themselves in training for and participating in their events. The following conclusions were drawn from their experimentation:

(a) The slope gradient of the training curve varies with the magnitude of the stress imposed, the frequency of the practice sessions, and the duration of the overload effort.
(b) Mere repetition of contractions which places little stress on the neuromuscular system has little effect on the functional capacity of the skeletal muscles.

(c) The amount of work done per unit of time is the critical variable upon which extension of the limits of performance depends.
(d) The speed with which functional capacity increases suggests that the central nervous system changes contribute an important component to training.
(e) The ability to develop maximal tension appears to be dependent on the proprioceptive facilitation with which overloading is associated. Hellebrandt and Houtz further demonstrated that currently popular systems of progressive resistance exercise, such as the DeLorme and the Oxford techniques, are conducted at a low level of overload.

Strengthening Activities

As will be surmised from the above, in choosing physical activities to develop strength, those which offer the greatest resistance to muscles should be selected. In this section, various ways by which resistance may be applied to muscles presented.

Resistance supplied by parts of the body: In this category, the legs, arms, and trunk may supply the resistance elements, as is the case in "conditioning" drills, football "grass drills," "guerrilla exercises," Danish drills, and the like. Although calisthenics are in disrepute with many physical educators today (largely because of the atrocious manner in which they have been conducted), nevertheless they are valuable in developmental programmes, especially when individually arranged. The dosage of exercise can be controlled, especially for convalescents and extreme sub-strength students; the exercise series can be systematically planned to cover all muscle groups of the body with emphasis being placed on areas of greatest need; and progression can be regulated from very mild forms to vigorous and exhaustive efforts. Also, exercises of this type may be performed daily at home as special apparatus and exercise rooms are not required. Excellent systems of mat exercises can be devised which will provide for the development of body control, flexibility, and good posture, as well as increased strength. With good motivation of the unfit individual and with the application of appropriate methods, an enthusiastic response can be obtained and excellent results can be achieved.

Resistance supplied by inanimate objects: Utilizing objects of various types and weights, the amount of exercise can be precisely prescribed through specification of the amount of weight lifted, the number of repetitions, and the cadence of movements. Furthermore, exercises can be designed to include all the large-muscle groups of the body, and exercise concentration can be placed on various muscles as desired. Barbell exercises, use of weighted dumbbells, log drills with iron wands, relays and races carrying weights, and the like, are examples of this type of exercise. These activities properly applied are probably the most effective methods of rapidly improving muscular strength and muscular endurance.

Resistance applied by entire body weight: The entire body weight can be used as the resistance medium. Arm strength is developed through chinning

the bar, dipping from the parallel bars, use of travelling rings and overhead ladder, some forms of dance, and exercises on the horse, horizontal bar, and parallel bars. Development of leg muscles through vaulting from beatboard or springboard and bouncing on the trampoline, and constant use of abdominal and trunk muscles in lifting the legs and controlling the body are also effective in physical development. Agility, co-ordination, neuromuscular control, flexibility, and poise are other benefits derived from modern dance, apparatus exercises, and tumbling exercises on the mats. The unfit individual, however, especially if he is subpar in strength, will not be able to perform even the simplest exercises on the apparatus. Thus, this form of strength development activity has limited usefulness until strength sufficient to support the body with some facility has been developed by other means.

Resistance applied by another individual: For sub-strength individuals well advanced in development, exercises in which resistance is applied by another person may be used. Thus, wrestling, combatives, tug-of-war, and various pushes and pulls have excellent body-building values. Caution needs to be exercised, however, in utilizing such activities for unfit individuals, until they have been conditioned sufficiently to benefit from them.

PHYSIOLOGICAL EFFECTS OF EXERCISE

Brains without muscles would not get animals very far or the human body out of an armchair. The capacity to move is a dominant factor in biology. In order to understand and to evaluate the effects of movement and exercise, *per se,* upon the human organism, a knowledge of the related physiological processes is needed. The proper selection of the types of exercise to achieve physical fitness results should be based upon the insight which this knowledge should provide. Consequently, a brief discussion of the physiology of exercise is presented. The physiology of muscular strength and endurance will be considered in this section; and the physiology of circulatory-respiratory endurance, in the section immediately following.

MUSCLE FIBERS

The process of developing muscular strength through exercise is physiological; muscle fibers cannot reproduce, although they can increase in size. This growth is due to a number of factors, which include toughening and thickening of the sarcolemma (wall) of the muscle fibre, increasing the amount of connective tissue wiithin the muscle, enlarging individual muscle fibers, and increasing circulatory and respiratory activities during repeated contractions. Individual muscle fibers do hypertrophy as a result of certain types of exercise. Furthermore, latent and normally unused fibers and fibers that are small from lack of use are developed in response to demands made upon them.

Increase in a muscle's size is related to the amount of work it performs. Seibert exercised rats on a treadmill at various speeds and found that those

running at higher speeds developed larger muscles. The muscles reached an optimum size for a given speed and remained at this level no matter how long the speed was continued; the size enlarged further when the speed was definitely increased.

The gain in the endurance of a muscle as a result of exercise, however, is out of all proportion to its gain in size. Therefore, the quality of contractions must be improved through such factors as the following: fuel is made more available and in greater amount; oxygen is more abundant, owing to improved circulation of the blood through the muscle; and better co-ordination of the individual muscle fibers and more complete use of all fibers are realised. Systematic exercise facilitates the transmission of nerve impulses across motor end-plates, which, in turn, leads to a more complete use of all muscle fibers. Also, improved co-ordination of agonists and antagonists and of the timing of impulses which reach the individual muscles are significant contributors to the amount of strength and power that is possible.

The condition of muscles is reflected somewhat by their tone, a muscle condition manifested by a quality of firmness, which may be noted by palpation when the muscle is at rest. Muscle tone results partly from sustained contractions when the muscles are at rest. Such action is reflex in nature with the sensory stimulation provided by the proprioceptors located in the muscles and by the tendinous attachments to bones. From a review of electromyographies studies, Ralston and Libet stressed that no action potential is obtained when a muscle is completely relaxed. As a consequence, factors other than contractile fibers must account for muscle tone, in part at least. After reviewing research on this subject, Pantin proposed that muscle tone might conceivably be due to connective tissue as well. At any rate, the stretch reflex is a fundamental factor in muscle tone and is usually well developed in the antigravity (extensor) muscles; and it is mainly responsible for maintenance of body posture.

Connective Tissue

Ingelmark reported the following changes in fibrous, cartilaginous, and osseous tissues. Functional strain on connective tissue increases the thickness of ligaments, tendons, and other connective tissue in muscles; the hypertrophy of a tendon under training conditions is as great as that of its muscle.

The hyaline cartilage, which covers the articulating surfaces of bones in joints, shows similar changes in training. Conversely, the thickness of joint cartilage reduces very rapidly when joints are immobilized. These rapid changes appear to be due to changes in the fluid content of cartilage. The functional adaptation of cartilage brought on by exercise is confined to those parts of the surface which are normally load bearing; other parts are much less capable of such adaptation, probably because their nutrition is poorer. Normal cartilage surfaces are always rough and scratched and the synovial fluid contains particles abraded from the cartilage. The amount of abraded particles

in exercised joints varies with the kind and degree of exercise. Bones show marked changes in the amounts of calcium phosphate and calcium carbonate as related to the degree of training.

Steinhaus suggests several applications of Ingelmark's findings to conditioning situations. The rapid functional adaptation of the cartilage to exercise has the same value as the long term training effects and may be a hitherto unrecognised reason for "warming up" before strenuous athletic participation. The presence of abraded cartilaginous substance in the synovial fluid may support the inference that long-continued pounding in joints, as experienced in boxers' elbows and the knees of football players, could cause permanent damage to cartilage.

Capillaries

Either new blood capillaries or the opening of unused ones result from the continued use of muscles. Upon comparing one side of the body with corresponding inactive muscle on the other side, Krogh found that the number of capillaries in the active muscle ranged from 40 to 100 times the number in the inactive muscle. An increase of 45 per cent in the number of capillaries in guinea pig muscles during exercise was obtained as compared with no capillary increase in those muscles not exercised. This increase in capillarization provides a more generous circulation of blood to the muscles, resulting in a better supply of fuel and oxygen and the more effective removal of waste substances. Maison and Broeker demonstrated that the endurance of muscles with adequate blood supply increased more rapidly and reached a higher level than those without an adequate supply.

Muscle Hemoglobin

There are two types of skeletal muscles, known in general by their colour, red and pale. The colour of muscle is dependent upon the amount of hemoglobin present. The red muscles control more muscle hemoglobin, which has the property of combining with oxygen more rapidly than does blood hemoglobin. Thus, these are the muscles located where long continued contractions are required. The pale muscles, which are rapid-acting, contain high concentrates of cytochome oxidise, which are primarily concerned with the activation of molecular oxygen and its utilization in oxidative processes. It is believed that flabby muscles become pale because of the rapid loss of myohemoglobin. Whipple found two to three times as much hemoglobin in the muscles of active dogs than in inactive ones. A consequence of exercise, therefore, is to maintain and improve the amount of this compound in the muscles.

Chemical Actions

It has generally been thought that lactic acid production from glycogen was a fundamental chemical process in providing energy for muscular contraction. Lactic acid accumulates in the absence of oxygen. Thus, at the beginning of

exercise, some lactic acid may be deposited in the muscles due to the circulatory-respiratory lag, but is removed when the oxygen supply becomes adequate to meet the energy requirements of the activity. During fatigue states, lactic acid is again produced and becomes a limiting factor in the ability of the organism to sustain exercise. Severe fatigue results when the amount of lactic acid reaches about 0.3 per cent. After exercise, the accumulation of oxygen debt permits continued removal of lactate and the refilling of oxygen stores. Lactic acid is rapidly diffusible and is uniformly distributed throughout the body, so that concentration of lactic acid in the blood is proportional to the amount of the amount of lactic acid in the body at a given time.

Based on Szent-Gyorgyi's theory of muscle contraction, Henry has described the process of muscle shortening, as follows. When the muscles are in their resting state, the actomyosin-ATP complex is in delicate balance; this is a high-energy state that contains its own potential energy for reaction. Action globules are held together in the form of fibrous F-actin by the presence of ATP molecules. In the resting state, the balance between myosin-ATP and F-actin is very delicate. By means of a slight change in ionic concentration caused by the nerve impulse, probably involving the release of potassium, the balance is upset and the filaments come together. With this union, an electric charge, dehydration, and folding up of the fibers occur, which consists of the contraction. As a result of the contraction, F-actin breaks up the globular G-actin, which separates from myosin. The myosin enzymatically splits ATP, releasing its Nph which furnishes the energy required to dissociate the actomyosin-ATP complex. Once dissociated, the G-actin molecules spontaneously unite to again form the fibrous F-actin. Myocine attaches to a new molecule of ATP, hydrates, and stretches out again to line up close to, but separate from, the F-actin fibers in the actomyosin-ATP complex.

In summarizing this research, Henry indicated that oxygen does not participate directly in energy release; the only function of oxygen, whether at rest, during exercise, or during recovery from exercise is to remove and convert into water the hydrogen atom that the enzymes have abstracted from foodstuffs. The energy for muscular work comes from the enzymatic removal of oxygen from the food. All levels of muscular work necessarily produce oxygen debt, since the continuation of energy production and physical activity would be impossible if oxygen did not dispose of the hydorgen molecules. Pyruvic acid assists oxygen in removing hydrogen from the energy-releasing enzymes, being converted into lactic acid as it does so.

Chemically, both the phosphocreatine content and the amount of glycogen in the muscles definitely increases as a result of training; the quantity of non-nitrogenous substances is also increased. The colour of the trained muscle, as indicated before, is darker than that of the untrained muscle, indicating a more favourable state for the transport and utilization of oxygen. Inasmuch as phosphocreatine may be directly resynthesized without lactic acid accumulation, it is probable that the highly perfected oxygen transport of the trained individual

provides the conditions necessary for more of this direct resynthesis, thus reducing the need for the indirect process involving the formation of lactic acid. The finding of an increased glycogen content in an intermediate state of training and its subsequent disappearance in highly trained dogs lends supports to this hypothesis.

Muscle Fatigue

When fatigued, the ability of the muscle to contract is greatly reduced. The site of this fatigue has been variously proposed as being in the synopses of the central nervous system, in the motor end-plate, and in the muscle itself. Evidence cited to refute the muscle as the site purports to show that fatigued muscles will continue to contract when stimulated by electrical charges. Merton, however, demonstrated that a muscle does not contract by electrical stimulation after it has become actually fatigued by voluntary effort. Experimenting with the thumb adductor of the hand, voluntary strength was compared with maximal tetani and the two were found to be equal. When strength failed, electrical stimulation of the motor nerve did not restore it, thus suggesting that fatigue is peripheral. To further substantiate this position, action potentials evoked by nerve stimulation were not significantly reduced even in extreme fatigue; and recovery from fatigue did not take place if circulation to the muscle was arrested.

Loss of strength application is a common phenomenon of muscle fatigue, but recovery rate is not so well understood. Clarke and associates isotonicly exercised the elbow flexor muscles to a point where voluntary movement was not manifested, utilizing the Kelso-Helle-brandt ergograph with a load equal to three-eighths the strength of each subject's exercised muscles. The loss in strength 30 seconds after exercise was approximately one-third; a rapid gain in strength occurred, to about one-half the loss, during the next twelve minutes. Strength recovery was still not complete for most subjects two hours after the cessation of exercise. In a study by D. H. Clarke, strength decrements of equal amounts were obtained immediately following prescribed isotonic and isometric exercises.

Training increases the endurance, or retards the fatigue of muscles. Training also improves their strength recovery rate after exhaustive efforts. In the ergograph study mentioned above, the recovery of trained muscles was much faster than that of untrained muscles. Furthermore, the strength recovery of trained muscles was quicker when the subjects moved about, thus increasing general body circulation, than when they were required to lie quietly during the recovery period.

Muscular Strength-Endurance Relationships

The absolute strength of a set of muscles does not necessarily indicate the degree of their endurance, or resistance to fatigue. The following eight relationships between these two factors are proposed by Clarke: largely supported from his own research: (*i*) The amount of resistance required to induce muscular

exhaustion in a relatively short time varies among individuals, depending on the strength of the muscles primarily involved. (*ii*) The work output of muscles in exhaustion performances is greater when they are in position to apply greatest tension at the point of greatest stress. (*iii*) The speed of muscular contraction affects muscular endurance performance; there appears to be a specific combination of load and cadence which produces maximal work output of each muscle group. (*iv*) Individuals with greatest muscular strength have greatest absolute endurance; however, stronger muscles tend to maintain a smaller proportion of maximum strength than do weaker muscles, (*v*) An immediate effect of fatiguing muscles is to reduce their ability to apply tension; the amount of this decrement is an indicator of the degree of muscular fatigue. (*vi*) Strength recovery rates resulting from muscular fatigue are increased by muscular condition and by general body movement following exercise. (*vii*) Muscular fatigue patterns from total-body activity can be revealed by the strength decrements of individual muscle groups. (*viii*) The strength decrement of all involved muscle groups may be used to determine total-body muscular fatigue resulting from strenuous activity, and may serve as a criterion for evaluating the muscular fatigue effects of such activity on the body as a whole.

Muscle Skill

Volitional contractions are involved in the development of motor skills. In the initial phases, before real skill is attained, greater attention is devoted to the component movements in a skilled act. The motor apparatus controls these, although visual and proprioceptive mechanisms aid in the necessary adjustments of strength and the extent of movements. With practice, the proper sequence of the various components of skilled movements are learned and complete attention is no longer as necessary. Finally, the act may be performed entirely by proprioceptive guidance. The elements that contribute to neuromuscular skill are principally strength, power, speed, agility, accuracy, form, rhythm, and balance.

Where heavy muscular work is involved, the condition of the muscles as reflected in their fatigue is obviously a factor in neuromuscular skill. Whether failure of the muscles involved has much to do with fatigue observed in light but highly skilled tasks is not clear. However, Merton reported that handwriting may be continued without difficulty for one minute 30 seconds with circulation to the writing arm occlubed; in the following 30 seconds, it was extremely hard to write at all. In another experiment, the subject wrote for two minutes with free circulation, after which it was arrested; whether he continued writing at once or took a two-minute rest first, he was able to continue for only 30 seconds without severe difficulty. Very similar results were obtained with an expert violinist and with a pianist.

Royce verified these findings in part when studying fatigue curves for the forearm muscles during sustained isometric contraction. He found no difference between the curves obtained with or without artificial occlusion of the circulation down to a point where the exerted force became less than approximately 60 per

cent of the maximum strength. Below this critical level, the amount of exerted force continued to diminish under the occulded condition, but leveled off when there was no occlusion. Clarke examined the rate and pattern of muscular fatigue and recovery from both isometric and isotonic exercise. The isotonic exercise consisted of maximum grip and release once every two seconds for six minutes; the isometric exercise consisted of maintaining a single maximum effort for two minutes. The rate of recovery was much faster following static fatigue, although the two recovery curves were nearly identical 250 seconds after the cessation of exercise and thereafter. The investigator suggested that the difference in recovery curves may be due to: (a) the work being carried on over a longer period of time by the isotonic group, thus slowing its recovery rate, and (*b*) the sudden release of circulation which had been occluded by the static fatiguing exercise of the isometric group, thus hastening its recovery.

EXERCISE: (AESTHIC VALUE OF EXERCISE)

Exercises are very significant for Keeping the body healthy and fit. Exercises tone up our muscle. One should not misunderstand exercises with only light physical exercises rather it needs to be associated with the sports. Exercises should be effectively strengthening, reviving and developing.

Exercises are a perfect amalgamation or a blend of art and aesthecity. There should be a specific objective behind exercises *i.e.*, they should be purposeful. For instance, Gymnastic, Water polo, *etc.* Only to move or to bend body unwillingly could not be called as an exercise.

EFFECT OF EXERCISE ON VARIOUS PARTS

1. *Blood Circulation:* Exercise fasters the rate of heart-beat, leading to hastening of blood circulation and increases its pressure.
2. *Breathing:* During exercise respiratory system exhales carbondioxcide (CO_2) and inhales oxygen rapidly. This work is carried out naturally by blood tubes. This system plays a very important role in providing energy to the ligaments and tendons.
3. *Digestion System:* The food is easily digested by doing exercise. Exercise increases the movement of digesting power.
4. *Skin:* Blood circulation increases in skin and all the poisonous elements or substances are encreted.
5. *Kidneys:* Excretion becomes more easier through exercises. Uric acid is released easily out of the body.
6. *Nervous System:* Sensitive and activity nerves work more quickly. Although being minute they are capable enough. It provides physical and mental peace.
7. *Muscular System:* This exercise is done through tendons and ligaments the action in ligaments is carried out with the help of energy. We need more energy during exercise. Ligaments work quickly to create and at the same time to reduce the acidity of this energy. Physical strength or strongness is increased and it further leads to the healthy development of body.

(RULES OF EXERCISE)

Exercise effects all the parts of the body equally.

1. Exercise should done in the morning where-as sports activity should be done in the evening.
2. Meals should not be in taken just before starting exercise.
3. Exercise must be done in open rather than in a closed room.
4. Those who work regularly must do light exercises.
5. It is necessary to remove the fatigue caused due to exercises.
6. Exercises should be done regularly, hygienically and aesthetically.
7. Exercises should be learnt, only by a good teacher in order to avo]id any negative effects.
8. Yoga should be done only under the authentic guidance.
9. A member of disease can be cured through exercises, therefore genuine guidance is a must.
10. To play any of the games regularly make our life charming and symmetrical and various diseases existing in our bodies are diminished.

ACTIVITIES OCCURRING WITHIN THE BODY

1. *Movement:* The each and every activity or the action of man like walking, sitting, standing, bending, coming and exciting these all are the physical activities. These activities are known as movement.
2. *Growth and Development:* Every living thing grows in size on its own character is of continuous growth and development is not found in any other matter.
3. *Assimilation:* All living things intake food and digest it. This characteristic of intaking the food followed by the digestion is called as assimilation. Other machines lack this quality.
4. *Excrelion:* Each and every living being intakes food and out of the waste produced by it is excreted in the form of farces. Such type of activity is not seen in other matters.
5. *Tolerance and Sensitivity:* Every living matter/being possess the endurance and experience to exhilaration or depression and coldness or hotness respectively, that is not found in any other ordinary machine.
6. *Reproduction:* All living beings produce of their own kinds, that is oftenly rather generally not noticed in other machines.
   - If the body is compared to a machine, then we will come to know that as the engine needs steam to work, in the same way and it derives this energy from the fuel, in the same way, human body needs food and water to acquire energy.
   - As the human being excretes after taking in the food similarly the engines lets out ashes and smoke after fueled in by coal and water.
   - Human body cannot remain alive without oxygen.
   - In case if human body does not remains hygienically it becomes a victim of various deadly diseases.

- Human body arranges food for itself on its own.
- Human body is associated with intellectual and development.
- Human body is alive.
- Human body is capable of thinking and defending itself on its own.
- Human body is capable or competent to face external attacks (invasions).
- Human tries himself/herself to keep the body healthy and fit.
- Human possess the characteristic of reproduction.
- Self-movement is created in human body.

Above mentioned all the characteristics are due to chemical elements.

FACTORS THAT INFLUENCE HYGIENE

Science of Hygiene makes us aware of those rules which are helpful to us in living hygienically diurnally or day-to-day routine.

We should keep in consideration following points which for personal hygiene and health:

1. *Good Manners:* Nature various from person to person. It is very difficult to change the basic nature of a person. The hygiene or health of a person completely depends on his nature. Therefore, all the habits and manner are to incalculated wisely and thoughtfully. Therefore, we should inculcate almost all the manners intellectually. Mannes play a very significant role in our daily life. It is all according to our manners, we make up in the meaning, go to toilet, wash our face and hands, do breakfast, go through our studies and go to bed at time. This is the reason for which, if possible, we must possess good manners and try our level best to leave bad manners. Good manners inspire a person to follow or guides him to step towards the proper or appropriate path and bad manners makes the life of a person makes the life of a person poishable and create an obstacle in his mental, social and spiritual development. For instance, the ill effects of bad society and company are smoking, using abusive language, robbing, speaking lies and living physically unhygienically.

Due to cigaretes and guides of tobacco: Causes harm in lungs and the blood present in body does not remains pure.

Unchastity or prostituation also results in or causes various diseases and one's self and the surroundings deteriorate.

Mental: Body and mind go hand in hand. If we can remain physically healthy only if we are mentally sound.

Liquor and Gambling: These are the biggest enemies for both body and mind. Conception of liquor causes harm to liver and roots up various diseases in the person's body. Food is the prime ingredient of our body. It should be vegetarian and calorie free. Non-vegetarian food is essential only is cold regions. The digestive system of body carries out a lets of functions and its functioning becomes over-burdened if due to intake of spicy and more calories. Having

meals at fixed in towards of times and going toilet regularly are good manners. Cleanliness of exceretory system along with the food is also a very essential process.

Food: The man is entirely dependent on food so, he should take balanced and nutritious diet at fixed and regular intervals of time. Nutritious and simple food gets digested easily. A man should have meals 3 or 4 times during a time period of 24 hours and there should be a gap of at least 3-4 hours between two diets.

HUMAN BODY AND ENERGY CREATING ACTIONS/MOVEMENTS

Human body is composed of a group of various cell. Every cell consists of a living fluid namely protoplasm. Scientists of chemical Sciences have proved that this protoplasm is made up of distinct types of chemical sub-stances. These chemical substances are as mentioned—oxygen, nitrogen, hydrogen, chlorine sulphur, Magne-sium, Sodium, Potassium, Carbon, Fluorine, from, *etc.*

Oxygen is found in abundance in body, carbon being at secondary level and hydrogen at tertiary level. The quantity of Nitrogen is less then that of Hydrogen. Rest all substances are present in scarcity. Among all the solid substances. Carbon is found in abundance-Oxygen is essential to ignite coals in store and in absence of oxygen coal exciting wishes. Coal is also a form of Carbon.

When the coal ignites it mixes with the oxygen present in the air. This process is known as Oxidation. This is how the cells of our body acquire oxygen alongwith the carbon through the lungs that further produces heat and energy in the body. This leads to various significant activities in our body.

Some people believe that health is a condition of body in which they work more in a short interval of time or their life-span is increased, and they serve cell. According to Doctors when all the organs of the body of a person are working appropriately then he is consi-dered to be as healthy. When the organs do not work appropriately then it is a condition of unhealthiness. According to world Health Organization, "Health is a State of Complete Physical mental and Social well being and not merely the absence of disease or infirmity."

We consider that person to be healthy who is able to manage all the organs of his body internally and is able to establish a charming co-ordination with the external atmosphere. A healthy human remains delighted physically as well as mentally. His physical systems remain strong. No signs of either individual dissolution or emotional tension seems to appear such a kind of person.

Personal Hygiene: The word "Hygiene" has been derived from the Greek word (Hygieno). It means "Healthful" or full of health but Hygiene is also called as "Hygia" in the Greek language, which means the "Goddess of health" but in this modern age it means the "Process of living" or "Art of living," It is rightly said that a healthy heart lies with in a healthy body. Not only nutritious diet is sufficient to keep the body completely healthy also one should take care of his health because physical hygiene is considered as equally important therefore

one should take proper care of his/her physical hygiene. One can remain completely healthy only when he keeps his dwellings physique and clothes, properly hygienic. Besides all these, fresh air, balanced diet, exercises, rest and sound sleep are yet/very much essential factors.

POINTS FOR MEAL HABITS

1. Eat only when you feel appetite.
2. Have meals at regular intervals of time.
3. While having meals, the surroundings and hands must be clean.
4. We should chew the food properly and after having need we should do gargling.

Toilet: Excretion is the most essential process. It is more necessary to excrete than to have meals. If excretes remains in body it starts acting as poison for the body. After having the meals, digestion takes place. When the food gets digested, then and one of its part becomes the element of the body and the second part is changed into excrete. We should be habitual of going for toilet regular.

The best time for excretion is early in the morning. If the excrete remains in the body, it starts putrefying in the large intestine which leads to the spreading of various verionous (poisonous) elements in our body. It is only because of these poisonous elements that a person becomes a victim of diseases like piles and indigestion.

Sleep: The only and only means of providing complete rest to body and mind is through having proper and complete sleep. It is no less important than food and water. Generally, every man spends 1/2 of the portion of his life in sleeping. A person feels fatigue of after working for whole day and to get rid of fatiques, he need a sound sleep. The process of respiration and the heart beat of a sleeping person slows down while sleeping. It is not an easy task to fix the hours of, rest and sleep for a person. It depends upon the requirement and the necessity of a person.

Below is given the duration of intervals of sleep in accordance to the ratios of age:

Age Group		Duration
Infant	–	18-20 hours
3-7 years	–	13 hours
8-13 years	–	11 hours
14-19 years	–	9 hours
More than 20 yrs.	–	8 hours
More than 65 yrs.	–	11 hours

POINTS FOR SLEEPING HABITS

1. Keep your face uncovered
2. Go to sleep after washing your hands and mouth on a clean bed putting on clean clothes.

3. Before you go to sleep, work laboriously so that may immediately fall asleep.
4. Have your meals 2-3 hours before you go to sleep.
5. Do meditation and pay obeisance to the almighty god in order to have proper blood circulation in the brain.

PLANNING EXERCISE

In planning exercise regimens for unfit individuals, the specific physical status of each student should be known. No formulae exist to guide physical educators in determining the specific types and amounts of exercise which should be prescribed at each stage of the unfit individual's progress towards the realisation of adequate standards of fitness. The following principles may be used as guides in the preparation of exercise regimens.

Overloading should be applied to induce a higher level of performance: In overloading, the individual's exercise is increased in intensity or extended for a longer time than normally. Thus, overload is a relative term; a slight overload exceeds normal activity to a small degree, while a heavy overload equals the maximal performance of which the individual is capable at the moment.

In order to develop either strength or endurance effectively, therefore, the individual must be pushed beyond his customary performance. Athletic coaches use his principle routinely. In track, work-outs are planned to extend the runner more and more as his exercise tolerance increases until his maximum is reached during the competitive season; in football and basketball, scrimmages and other procedures are utilized to accomplish the same end. For the unfit individual, too, overloading means increased intensity and dosage within his tolerance level.

The exercise plan should provide for progression: Progression is intimately involved with the first two principles. The exercise plan starts with an understanding of the individual's exercise tolerance, then, within this tolerance level, an exercise regimen is prepared to provide for overloading the muscles to develop strength or for increasing the demands on the circulatory-respiratory systems to improve cardiovascular endurance. If the exercise regimen stopped at this point, some improvement in fitness elements could reasonably be expected, but it would soon cease as the body adjusted to the new requirements in output. Both normal exercise and exercise tolerance levels have risen. Progression must now be effected by increasing exercise in some logical way, thus keeping its demands ahead of the improvement made.

Progression may be accomplished by increasing either the intensity or the duration of exercise. In strength development, the common method of intensifying exercise is by adding to the resistance against which muscles work, as by increasing the amount of weight in weight training. Greater intensity, however, can be achieved by increasing the cadence (speed) of the lift and leaving the load unchanged. Progression in duration for this form of development is accomplished by requiring more repetitions of the same load. In circulatory-

respiratory endurance, intensity is increased by stepping up the speed at which a cardiovascular activity, such as running is performed; duration is enhanced by prolonging the time the activity is continued at the previous pace. Untrained persons should not be overloaded by increasing both intensity and duration at the same time. It is probably best first to increase duration a bit; later, to increase intensity; then, repeat the pattern as often as desired in keeping with the individual's progress.

Exercise should be adapted to the individual's exercise tolerance: Exercise tolerance refers to the ability of the individual to execute a given exercise, series of exercises, or activities involving exercise, in accordance with a specified dosage without undue discomfort or fatigue. An exercise performed as specified which is easy for the individual falls short of his exercise tolerance; on the other hand, an exercise which is either impossible for the individual to perform or leaves him in a distressful state exceeds a reasonable interpretation of exercise tolerance.

For the most part, exercise tolerance must be judged by the physical educator through observation of the student, although some rough estimates are possible from his physical or motor fitness scores; the lower the scope, of course, the less his exercise tolerance. Furthermore, the scores on the different items composing the test battery may give information related to the student's exercise tolerance. For example, if the student cannot chin himself, the inclusion of chins in his exercise plan would be useless. Such indicators as the degree of discomfort during exercise and the amount of breathlessness following exercise are helpful in judging the tolerance level. Also, the presence of exhaustion, slow recuperation, and excessively sore muscles would indicate that the exercise assigned was too severe. With unfit groups, exercise tolerance will be low at the start, but should gradually rise as the fitness programme continues and is effective.

THE TYPE OF BODY EXERCISED SHOULD BE CONSIDERED

Generally speaking, the dominant endomorph will score low on tests of physical and motor fitness; the dominant mesomorph will excel in tests or strength and power; the dominant ectomorph, if he has at least a moderate amount of mesomorphy, will do well on tests involving running and agility. Although not adequately studied, it may be conjectured that many boys and girls in classes for the physically unfit are either above average in endomorphy and or below in mesomorphy.

In planning exercises programmes, therefore, account should be taken of the fact that the dominant endomorphic boy is seriously handicapped in ability to perform physical activities and the dominant mesomorph is favoured in this respect. In support of this view, Clarke, Irving, and Heath found that no boys aged nine through 15 years who were dominant endomorphs could chin themselves. Of 18 boys in this somatotype category, only two could perform a

one-half chin. At 14 years of age, dominant mesomorphs averaged eight chins, while dominant ectomorphs and mid-types had mean performances of five and four chins respectively. For all boys in their sample, the mean Physical Fitness Indices for the different somatotype categories were as follows: mesomorphs, 124; ectomorphs, 121; mid-types, 116; endo-mesomorphs, 104; and endomorphs, 88. It should be added that the boys in the entire sample reported here were a superior group physically as compared with national standards.

Individuals must desire to improve: The desire of the unfit student, his basic attitude towards his own physical condition, is an essential factor in the attempt to improve his fitness status. Every effort must be made to secure the student's full cooperation, as the effectiveness of his exercise prescription will only be in proportion to the degree of his voluntary participation. Additional development of this topic will not be included here.

Consideration should be given to the individual's relative maturity: The relative maturity of the unfit student may be a factor in his ability to do well on tests of some physical fitness elements. Clarke and Harrison found this to be true for strength tests but not for motor fitness items. These investigators contrasted various physical and motor performances of boys classified as advanced, normal, and retarded on the basis of skeletal age for each of three age groups, nine, 12, and 15 years. In general at each age, the advanced maturity group had significantly higher means than the normal maturity group and this latter group in turn had significantly higher means than the retarded maturity group on such gross strength tests as the Strength Index and the average of 12 cable-tension tests. However, for pull-ups and push-ups, significant differences between the means were not obtained; at two ages, this was also the case for the standing broad jump.

The determination of relative maturity, *i.e.*, whether the boy or girl is advanced, normal, or retarded for his or her age, has its difficulties. The use of skeletal age, which is based on an assessment of an X-ray of the hand and wrist is now generally confined to the research laboratory. During adolescence, some estimation of maturity can be made by judging pubescent development. For girls, the date of menarche is also a helpful index. Pubescent development, however, is a crude indicator of maturity and has limited use, as shown by Clarke and Degutis in a study of 10, 13, and 16 year old boys. These investigators found that, at these three ages, physical maturation was differentiated by this means most effectively at 13 years, although it was not so sensitive to maturational change as skeletal age. At 16 years of age, maturational differentiation by pubescent assessment was much more limited. At 10 years of age, little or no value was attributed to this method.

Advance the unfit individual's psychological limits of effort: For unfit students, psychological tolerance for strenuous exercise is usually reached long before their physiological limits are attained. The psychological limit is frequently conditioned by habit, boredom, slight aches, breathlessness, and by such mental factors as anxiety and fear of physical harm. All too frequently, such mildly

distressful feelings halt exercise before there has been any real overloading; consequently, no appreciable increase in strength or endurance results. Here, some judgements must be exercised, since certain of the factors related to psychological limits also serve as safeguards, preventing overstrain.

Except for participants in highly competitive athletic events, very few boys and girls have ever been fully extended physiologically. Actually, most live through the years of their youth—and, hence, through life—at a low level of energy expenditure. The stepping up of physical effort in intensity and duration is most desirable. For the unfit student, this process may be a gradual progression, in which he constantly attempts to improve his own former performances. Psychological tolerance for exercise, especially for the unfit, can best be developed in this way.

Thus, there may be considerable difference between a person's physiologic capacity and the output he is able to express through muscular effort at any given time; psychological limits are generally imposed in strength and endurance activities involving "all-out" performances. The "cracking" of this psychologic barrier was demonstrated by Ikai and Steinhaus by use of hypnosis, a loud noise made by a starter's pistol, and a shout produced by the subject himself. Pastor demonstrated the value of simply setting goals, as opposed to urging subjects to exercise to exhaustion on the ergograph, in increasing the amount of work done by college men. After considerable experimentation, Lawther observed that a subject's maximum effort is affected by his degree of motivation, his background of punishing experience, and his willingness to endure the pain of all-out effort.

8. *Physical development should be tested and recorded at set times:* A number of the exercise activities frequently included in unfit programmes, such as chinning, sit-ups, dips, weight lifting, and the like, are automatically self-testing. This self-testing may be formalised by use of individual progress charts, upon which the student records his performances on a particular day each week. Individual items on the physical or motor fitness test used to identify unfit students may be included on the progress chart as well with a repetition of the entire test every five or six weeks. It may also be desirable to record body weight from week to week; some unfit students should increase, some decrease in weight. These charts can be excellent motivational devices. More important, however, they provide constant check on student progress.

In the light of these eight principles, the question may now be asked: How should an exercise programme for any particular unfit student be prepared? This is an individual process to be studied by trial for each student. The first step is to determine his exercise tolerance by trying him out on different activities, including both strengthening and endurance elements. Thus, the unfit individual who cannot chin or dip should not be expected to do apparatus work, but should start on the mats with simple conditioning drills and modified chinning and dipping. If he cannot do sit-ups or leg raisings, modified forms of these exercises must also be used at the start. If "once around the track"

leaves him exhausted, the distance must be shortened or the pace lessened. Eventually, the amount of work the individual can do without unreasonable discomfort will be determined. The other principles given can then be applied. The starting point, however, must be a proper evaluation of his exercise tolerance.

6

Benefits of Physical Training

Playing is the fundamental right of a child, either in school or outside. The children, after school, make their own teams with the locally available friends, choose a game of their liking, devise rules and play the game to their heart's content. They tactfully deal with the idea of referee and penalty for infringement of rules.

The main idea behind such games is that the children enjoy playing, they make friends, they play as teams and, such play is to provide them with lot of challenging opportunities to provide their talents and fun. The most important factor here is that we could not overlook an outsider, even as the teacher or a coach or a leader does not control the children. When this is possible without a leader, a teacher or a coach outside the school, why is it that such things are not happening in the school where physical education is compulsory for all and a physicaleducation teacher is available?

Really, we as physical education teachers hinder their interests and curb their originality. This is the sole reason for such a sad state of affair in schools. In most of the schools in India, the physical education teachers are manning the classes from six. Such a teacher is to manage a minimum of 100 children at a time within a limited space of the playground surrounded by houses, bushes and filthy waste dumps. What happens to the children of classes three, four and five? They are given to class teachers with the timetable marked by physical training. What do they do? They simply use such periods for correction work and keep the children idle under trees. Some teachers choose class leaders and ask them to give some exercise regimen under a tree outside a classroom while the teacher minds his/her business of correction.

Beyond the sixth standard, the physical education teacher is unable to man the whole lot of 100 and more children. The teacher decides what the children should play and gives them some instructions toplay. Many children slowly get dejected without getting even a single chance to play and walk out of the field to the shady place to spend their time idly. This is a common sight in almost all the schools. Why? No one is accountable in the side of physical education. No testing, no evaluation and no follow-up. Many physical education teachers are unsuccessful in their attempts to do some thing novel. No one is interested in this field. The people who talk a lot on education, fail to understand the delicate line of difference between academics and physical education. They turn down the fact that children could learn whatever they learn in academics through physical education, rejecting the idea that the children would derive the basic values through physical education.

The interest of the children is neglected. The teachers dominate the classes and the children's originality is curbed. How to change this type of setting? We must make the teachers and the heads of the schools understand that sports gives people the chance to get together and have fun, experience success and achievement, keep fit and healthy and learn physical and technical skills. It helps children to develop timing, balance and coordination, improve their mental skills, co-operate and the ability to communicate with others. It enhances motivation, organisation, leadership and interpersonal skills. In a developing country like India, teachers in schools when they teach sports, face many constraints like lack of equipments and specially trained physical education teachers. Students and other teachers should understand the fact that sport and physical education can improve people's lives in many ways. Equal importance should be given to sports and academic subjects. The physical education teachers must be trained to handle classes of children with varied aged groups.

They must be trained to plan their sessions for different classes with progression giving ample opportunity for challenging tasks. The traditional way of evaluating a physical education teacher, based on the number of children who participated at district, zone and state levels from his/her school, should be detached from the existing norms. Usage of standard equipments for all classes should be stopped and provision of equipments suitable to the age level should be implemented. We are in need for a new area of athlete development personnel equipped to work specifically with 8-15 year olds drawing together activities aimed at generating team spirit, fun and enjoyment. Such people should be identified as pacesetters according to the importance of their role in the athlete development programme process, clearly differentiating their role as teachers and coaches.

They should be open for accepting the fact that there is a lot of difference in dealing with a large group of young children and coaching a squad where small numbers are guided in pursuit of a specific skill.

They should understand and accept that for many reasons a talented child at the age of 11 might not be a champion of the future and that they are not in the

business of pressuring young children and should encourage all round development. The aim of the pacesetter should be to develop young people socially and physically through the introduction of athletics in a fun environment and not to produce young individual champions. To get such a trained pacesetter, the existing training methodology in the training colleges must undergo a drastic change. The products of such colleges must suit to the present day needs of the children.

Growth and development of the children play an important role in their physical, intellectual and emotional achievements and accordingly, their implications for sports also differ. It is to be remembered that age is not the only factor while determining which level the child should fit into. Children move through developmental stages of different rates.

They need to move through the skills progressions in a planned, sequential manner according to their individual development. The principles of motor learning with reference to the age of the children also should be considered very seriously. At the age of six to 13, the children are supple, and therefore speed and skill could be developed.

The years from seven to 11 are known as the skill hungry years. It is important that skills are taught well right from the outset, as it is virtually impossible to correct some technical faults later. Practice will make perfect but the skills may be perfectly wrong. Early motor learning should be broad, varied and general in nature. This provides sound base for later, more refined, specialised and complex learning.

The more numerous and varied the dynamic stereotypes acquired through motor learning, the greater the capacity to learn new skills and modify existing patterns. A rich repertoire of fundamental movement skills, also mean the athlete is less prone to injury. Teaching the game like football, basketball and hockey, are to be modified into invasions games. The teacher can invent small games that involve the skills of invading other teams area, and this could bring out the team strategy and cooperation.

Instead of the teacher telling the children what is to be done, the children should be allowed to think and find out for themselves what they should do. It has a greater value in the later years. The children could be made into smaller groups and asked to invent their own games. They should tell the teacher the area required for playing, number of players, rules, how points are scored and such other facts. The teacher as a facilitator should provide them with what they want. They will do excellently well better than us. In such invasion games, children learn how to outwit their opponents and score when playing. They develop skills in finding and using space to keep the ball. In all game activities, children think about how to use skills, strategies and tactics to outwit the opposition.

Children will develop and adapt games themselves, making up their own rules and choosing what equipment to use. They will play a wider range of games, with even sides that go end-to-end on larger play fields, improving their

accuracy and consistency, and learning new invasion game techniques — how to plan tactics as a team, and how to apply them as a team member. They will learn how to evaluate their own and others' performances, and how to identify a focus for improvement. They will also learn to apply their understanding and skills from net games like volleyball, throw ball, badminton and the like, striking and fielding games cricket and softball, and athletics to new invasion games problems. They will also find how playing games can contribute to good health.

While children do this much for themselves, the physical education teacher must be a very good planner of sessions. Good sessions in physical education do not just happen but those sessions require good planning and organisation. Before planning the activities, it is important to think about the children they are teaching and then plan the sessions according to the needs of the children and levels of experience. Planning helps the teacher and the taught to achieve objectives and ambitions. These objectives may be ones of enjoyment, participation or improving skill. While setting objectives, utmost care is to be infused lest it can hinder progress.

Hence, the objectives must be Specific, Measurable, Agreed, Realistic, Time-framed, Exciting and Recorded (Smarter). The safety aspect should be taken care of before and after the session by the way of warm-up and cool-down routines in order to reduce the risk of injury. Children colliding with each other are one of the most common hazards in sport, particularly with large numbers and activities that involve running and chasing. At the end of the session, the teacher should always try to recap on what the groups have achieved. This enhances progress and learning. The children should be insisted upon clearing all the equipments used during the session and neatly arrange them in their places. This would improve the responsibility of the children in taking care of their equipments and play materials.

Children should also be encouraged always to drink plenty of water after the session. After the session, a teacher should evaluate his/her own lesson. This is important because it forms the basis for future planning. It paves way for evaluating our programme as a teacher, as well as giving us a feedback on the progress of our own groups. To help the group's progress in their skills, there needs to be continuity and progress from session to session. When a course or session is ahead, there should be individual session objectives, mid-term objectives and long-term objectives. Those who fail to plan should be prepared to fail.

The equipments the teacher uses in the session add to the variety and challenges to the children. When planning sessions, if the items needed are not at hand, many items could be improvised. For throwing and catching games that do not involve bouncing of the balls, items like paper balls, rag balls, bean bags and cloth balls could be made and used.

The task of making such balls could be given to the children, which they would do excellently and readily well, since they plan and make for their own playtime. For area markers, empty plastic water bottles could be filed with sand

and painted in brilliant colours would suffice. Equipment is vital because the sessions run smoothly and children will have sufficient opportunity to improve their skills.

We should remember that we do not always need to have standard equipment, for many games we can use any type of ball. The more equipment we have, the more chances our children have to practice their skills, because it enables them to work in smaller groups, every one getting opportunity to play and have more fun. As subject and class teachers are appointed with reference to the number of children they have to handle, physical education teachers also must be appointed in relation to the number of children they have to manage. For a minimum of 50 students, there should be at least three physical education teachers so that each group could plan independently their sessions in accordance with the available equipments. This will improve more student participation and the children will enjoy the session and have greater fun while playing.

CONTINUOUS TRAINING

Continuous training is when low- to mid-intensity exercises are performed for more than 15 minutes without resting intervals. Generally, this type of training is used to prepare the body for longer endurance activities, such as a marathon or triathlon, and allows the body to work from its aerobic energy stores to build muscles.

In contrast, interval training allows the body to rest between periods of activity. Some studies have shown that interval training allows the body to sustain activity up to four times longer than continuous training does. Chief benefits of continuous training include burning fat, building muscles, and increasing maximum aerobic potential. As with all forms of exercise, the primary benefit of continuous training is general health and fitness. There is some debate as to which type of training method is better for endurance event training. Continuous training, however, does provide measurable results for improving endurance even if it is at a slightly lower performance level. It can improve the cardiovascular system, as well.

Most athletes typically should not jump into continuous training since the body needs to be prepared for this kind of activity.

Someone who is considering continuous training for aerobic and weight loss benefits usually needs to take the current fitness level of the body into consideration. It generally is recommended that an athlete begin continuously training for 12 to 15 minutes and should add two minutes for every week that the exercise routine is maintained. Increasing the duration of the exercise beyond two minutes can increase the risk of injury. This level of continuous exercise should plateau between 20 and 25 minutes. Once this level of training has been maintained for six or more months, the athlete usually can then consider increasing training. Greater levels of continuous training are generally reserved for long distance runners, cyclists, and swimmers. The athlete typically should focus on the time he or she is spending doing the activity and not the speed of

the exercise. By keeping speeds low, the athlete decreases the chance of injury while building the specific endurance related to his or her sport. When continuously training at this intensity, the athlete must still give the body sufficient time to recover, as well.

INTERVAL TRAINING

Interval training is basically exercise which consists of activity at high intensityfor a period of time, followed by low intensity exercise for a period of time. These 'sets' are repeated.

Sprint Intervals

The high intensity portion are called Sprint Intervals. Sprint intervals are measured either by time or distance. They can be as short as 15 seconds in activities like HIIT or as long as 20 minutes for aerobic interval training. An example of a Sprint Intervals would be running at full pace along a stretch of field for 30 seconds, another would be an indoor cyclist spending 15 minutes simulating a climb on the bike.

Rest Intervals

The periods of recovery are called Rest Intervals. During an rest interval athletes do not stop the activity but generally exercise at a low intensity which allows the body to recover from the sprint interval. The length of these rest intervals are determined primarily by your fitness levels and the type of the sprint interval. The intervals are important; the basis of the interval training is to ensure that your sprints are done at an optimal intensity, without sufficient rest your interval training will resort back to an aerobic type of activity.

TACTICAL TRAINING

Tactical training is defined as any sort of training that is designed around a real-world task. That's our loose and very simplified description of it. Tactical training is the sort of training required by people working in real-life situations where there is a risk of serious injury or death.

This focus of training is vastly different, both physically and psychologically, than training for health or athletic performance. When you train for a sport or for health reasons you can predict the expected demands and plan for them. With real-world work such as law enforcement, military or fire service, there are many more variables and surprising accompanied by increased risk factors. So often we see police and military training programmes that focus on run of the mill fitness and controlled combat training. The technical aspect of the officer's skills is generally fairly fine-tuned, however when it comes to the crunch and they need to call on their conditioning in the field they are rarely prepared.

Everything we do at Personal Evolution is centred around tactical fitness and psychology. By focussing on the tactical you are better able to deal with situations that invoke unexpected stimuli and emotional responses. This applies

primarily to the tasks mentioned such as law enforcement and military, however training this way for all purposes tends to develop a powerful threshold for surprise and adverse situations.

HOPLOLOGY

Hoplology is loosely defined as the "study of the development of human combative behaviour and performance". In other words, it's the study of why we fight, how we fight and the relationships between cultures in regard to combat and conflict.

Increasingly hoplology input has led to a vastly different tactical approach to training individuals and teams involved in regular combat or the likelihood of experiencing such a thing. This has influenced both the physical fitness components and the mental/psychological ones.

Specificity Through Not Specifying

Fitness training experts and sports scientists are often of the belief that training has to be extremely specific. This is true if the individual has highly specific needs with very little chance of variation. For everyone else, especially those getting fit for dangerous situations, a tactical training approach is required. This sort of specificity, as it applies to tactical training, is detrimental to performance. If a soldier or police officer is super-fit in one area of performance such as middle distance running in a controlled environment such as a running track, they hold very limited skills that apply to the real-world, life-threatening situations they are likely to encounter in the field.

The first aspect of tactical training is broad and inclusive. This means that all aspects and extremes of physical and psychological conditioning must be trained and developed to the maximum potential possible while coexisting. This, at first glance, may seem a little haphazard and rather easy to programme. This is a misconception, the training is still highly structured. The structure of this mode of training is designed so that there are no weak links, no peaking and troughing and continuous readiness through all parameters.

Contextual Training Needs

The problem I see with most training approaches, except athletic, is the lack of contextual preparation. In the real world there are many variables and things need to be prepared for from just about every angle imaginable. Go to any martial arts class and you will generally see a bunch of people in a cosy environment practicing technical aspects of fighting.

This gives the practitioner a false sense of security and fools them into believing they are prepared to actually use this stuff should the need arise. The same is true for any sort of training. When something is applied in a high-stress environment the dynamics are different, issues come up such as adrenaline, constant surprise, lack of rules, no opportunity for warm-up, *etc.* This needs to be prepared for and incorporated into the conditioning programme.

A soldier is rarely afforded the luxury of predictable terrain, rules and predictable outcomes. The soldier must be prepared for high-stress situations, exhaustion and being taken by surprise while still maintaining mental faculties and the ability to respond rapidly with appropriate tactics.

With this in mind the conditioning programmes, both mental and physical, need to be structured so as to be undertaken in the most real way possible. So how do we do this?…

First of all training plans must not be revealed to the trainees prior to a given training session. This provides an element of surprise and does not allow the participant to prepare for the session adequately, just as would occur in a real-life situation. This is not always possible for a person preparing themselves with tactical training. So training sessions must be prepared in a highly varied manner. For the individual creating their own training sessions, I would suggest overestimating their own abilities and then rising to the challenge and meeting it.

Secondly there is always an element of technical skill involved in order to carry out a task properly. A technical skill learned in a controlled environment is only applicable to similar controlled environments. In order to learn a technical skill that is needed in real-world situations the trainee needs to be conditioned in the anticipated states that are likely to occur. With this in mind there needs to be a level of stress and exhaustion added to the technical application of skills. To give you an example, when I trained in Hapkido our black belt gradings were always something to be feared. We would be required to perform physical tasks that would result in complete exhaustion and then we were attacked in numerous ways and required to apply whatever we had at our disposal in an effective and efficient manner. Next, the environment and actual methodology used in the training needs to more closely resemble that which is expected in the real-world environment. In other words, the ability to perform a lot of push-ups is not always helpful, this only serves as a base to build from. Performing a lot of push-ups only results in an increased ability to perform a lot of push-ups. The training needs to be more real world focused. What's more specific then? Maybe you need to crawl long distances on your stomach with significant added weight on your body.

Then you should practice that. You might need to climb high walls with added weight and do so quickly and efficiently. Pull-ups would help build some base strength, however they would not be a final conditioning exercise. It would be more specific to do muscle-ups on a wall or simply climb high walls repeatedly. Only by direct simulation of the actual expected stimulus can you be sure you possess the ability to perform the required tasks efficiently.

Lastly, and similar to the second point, required fitness aspects must be conditioned throughout a range of exhaustion levels. If you are required to possess the ability to lift large stones or jump over obstacles, you must be able to do it whilst fresh and still be able to do it after some time of physical exertion. For this reason you need to identify the stimuli needed and train under these

circumstances. For example, if you need power and agility then you need to train for specific power and agility at various points in your conditioning session and condition these aspects even while extremely exhausted and after much endurance effort.

Psychological Threshold Involvement in Tactical Training

Tactical training requires a level of psychological involvement that is simply not applied in ordinary training approaches. I have trained many people in gyms and my experience is that most people, when faced with a significant physical challenge tend to give up, make excuses or simply break down. The same is true when they are faced with exercises or tasks they find difficult such as anything requiring stability. This is why many people prefer to use machines when comes to fitness training, because they're easier to control and require less psychological input. When someone is pushed beyond their usual level of comfort, they tend to find it difficult to go any further. Extreme physical conditioning, when endured, leaves a psychological imprint that stays with a person for some time. I have met people with relatively low fitness levels that perform better on fitness tests than others of higher physical condition. The reason is that the person with the lower fitness level has a higher psychological threshold, either innate or learned at an earlier stage of life or through some other modality.

Knowledge from pushing beyond comfort zones becomes instinctive rather than intellectual. This is useful knowledge and can only be gained from extreme effort. Automatic/instinctive action is always more efficient than well-thought out plans and intellectual thoughts. There is already plenty going through a person's mind at any given moment. As human beings we only have a certain amount of available energy and attention for focus. Once this is taken up that's it, we can't just make more. It's like RAM on your computer.

In confrontational and high-stress situations any action that occurs on autopilot and occurs much more rapidly as a result spares the available attention for important mental processing and decision-making. An effective tactical training approach is to train yourself to a point where common actions are executed automatically via trained instinct.

The type of training I engage in and use with my clients is tactical training and involves extreme effort whilst being required to perform technical actions or simply use of the psychological will to continue beyond one's own supposed limitations.

Extreme Physical Conditioning Applied to Tactical Training

As Gym Jones puts it, "The goal of physical conditioning is to become as indestructible as possible". The harder a man is to kill, the more effective and efficient he will be for longer. This may sound rather extreme, however tactically a person needs to be conditioned to the point of maximum resilience. This means being more difficult to stop and possessing the ability to withstand and excel under extreme variations of conditions.

In order to possess this ability you need to train for it. The kind of fitness you see in gyms and conducted by personal trainers will not do. I see fire fighters going for long jogs and doing bodybuilding type programmes in gyms. This is simply not specific and will not prepare them for the extreme conditions they are likely to endure whilst doing their job.

Depending on the tactical training needs, I prefer to take a realistic approach. Quite often this causes fear and hesitation, however it is necessary. A fire fighter may need to carry heavy gear up and down flights of stairs, they need to climb ladders, carry the dead weight of human beings, *etc.* This means they are required to possess adequate levels of strength possibly after hours of enduring gruelling physical labour.

There are no rests between sets when they are in the field. The same applies to other professionals responding to emergency situations. Police may be required to chase down a suspect then fight after a lengthy pursuit. A soldier may be required to march or even run up a rough hillside carrying all their gear for several hours then apply technical skills and fine motor control. This sort of physical conditioning is far different to a controlled gym programme and requires tactical training approaches that cater to the "real" demands anticipated. There are several approaches that cater to these needs.

Peripheral Adaptive Endurance Training

Peripheral Adaptive Endurance (PAE) was developed initially as a tactical training modality, however it also applies to athletic conditioning and general fitness training. We have discussed PAE previously on this site, so we won't go too far into explaining the science behind it. What we will do is provide a basic run-down of this tactical training modality and then look at how it applies.

PAE can be explained as a broad conditioning approach applying varied modalities of fitness throughout a continuous, enduring duration. This means that PAE sessions are generally continuous and require the effective application of modalities such as strength, speed, power, coordination and balance under circumstances where the body may not be at optimal levels of performance.

PAE often requires continuous application of various exercises until almost complete exhaustion whilst maintaining things like strength. In a gym situation it is easy to be strong when you get a rest between maximal efforts. However, in the field and in emergency situations it's not so easy. You need to possess the ability to be efficient even with high intensity demands when the body is already taxed, depleted and exhausted. It's like competing in a triathlon then being asked to perform flawless Olympic weight lifting at the finish line. Regular training would simply not prepare a person for this sort of demand.

Peripheral Adaptive Endurance is not just extreme effort over long periods of time though. There is a certain structure to the sessions. PAE uses varied movement patterns over the course of a session, moving from one to the next as opposed to continuous effort such as in a marathon. It is continuous effort, however the nature of that effort varies.

The easiest example is using alternating patterns of upper body and lower body effort. This also caters to another aspect, output. By varying the movement pattern you are sparing one group of muscles while others are working maximally. This allows for a continuity that would be impossible otherwise. The intensity level is always as high as humanly possible. This results in extreme output that never ceases until the end of the session. PAE is a simulation of expected demands. It is not 100 per cent specific, however this is a general, broad and inclusive fitness modality used as a base to launch other, more specific tactical training.

Without being used to the extreme output, there is little hope of efficient application of more highly specific training demands. By conditioning the body in this way you are able to cope with high levels of exhaustion and still apply technical skill and strength/power aspects. In the field levels of intensity and effort cannot drop off as the body and mind gets tired.

Another major aspect of Peripheral Adaptive Endurance is the psychological imprint it creates. Generally a person has a threshold that is psychological in nature. This threshold pertains to the will to continue into extreme conditions. The natural reaction is for your mind to tell your body to stop as a protective mechanism. PAE is high intensity over a prolonged period. Gradually the brain begins to increase the psychological threshold for effort so that a person can mentally go beyond that of an average person.

METHODS OF TEACHING PHYSICAL ACTIVITIES

Participation in regular physical activity at a level sufficient to promote health-related physical fitness is an essential behaviour for professionals in all fields of physical activity at all levels (this includes coaches, K-12 teachers, physical education and kinesiology faculty in higher education, fitness professionals, athletes, all advocates of physically active lifestyles). From the beginning of the twentieth century to present times, authorities in our field have stressed the importance of modelling an active lifestyle and physical fitness for professionals in all fields related to physical activity.. A recent survey of physical activity-related professionals and pre-professionals shows that there is continued strong support for this view (Cardinal & Cardinal, 2001). Respondents agreed (4.56 on a 5-point Likert scale) that "role modelling is a powerful teaching tool for HPERD professionals." Several key aspects related to modelling in general, and modelling physical activity and fitness in particular, are presented here.

- The behaviours of models can influence the learning of others.
- Participation in regular physical activity is an essential behaviour of physical educators and professionals in physical activity as role models as well as for personal health-related wellness.
- Achievement and maintenance of health-related physical fitness (based on accepted criterion-referenced standards) is an appropriate expectation for all professionals in the field of physical activity.

Together these points provide support for the position statement. The behaviours of models can influence the learning of others. There is considerable research in diverse domains to support the tenets of social cognitive theory, pointing to the effectiveness of modelling as an important factor in altering human behaviours (Bandura, 1997). Modelling has been shown to be an effective method in working with negative eating behaviours, substance abuse (*e.g.*, alcohol, smoking), and influencing seat belt use (Baranowsky, Perry, & Parcel, 1997). In the psychomotor domain, extensive research has found that modelling can play a major role in the acquisition of motor skills (Ferrari, 1996; Maddalozzo, Stuart, Rose, & Cardinal, 1999; McCullagh, 1993). The use of models can promote competence and feelings of self-confidence and self-efficacy.

Research on modelling related to a physically active lifestyle indicates that children of physically active parents (parent models) are more likely to be active than children of sedentary parents.

Furthermore, the evidence suggests that children who are active with their parents are likely to be more active than children who do not exercise with their parents (Sallis, 1988a; Sallis, 1988b). Physical education teachers may be less powerful role models than parents, however, teachers are among the more important models for children and youth (Cardinal, 2001). In a study of sixth through eighth grade school children, Gilmer, Speck, Bradley, Harrell, and Belyea (1996) found teachers and coaches to be the most frequently cited non-family member adult role models. Modelling a physically active lifestyle by physical education teachers could have effects on youth similar to those of parents (Melville & Maddalozzo, 1988).

Implication: Models can influence attitudes and behaviours in many ways, including health practices, motor skill acquisition, and the adoption of physical activity patterns. Physical educators, coaches, and all professionals in fitness and physical activity have strong modelling status for many children and youth. Participation in regular physical activity is an essential behaviour of physical educators and other physical activity-related professionals as role models as well as for personal health-related wellness. Since a primary goal of the profession is to promote an active healthy lifestyle (AAHPERD, AAHPERD vision statement, 1998) for everyone, those involved in professions related to physical activity and fitness should teach and model the most current "established" behaviours and processes for improving health and physical fitness. Presently, those behaviours include participating in a variety of physical activities as noted in the Physical Activity Pyramid (Corbin & Lindsey, 1997; Heyward, 1998).

The foundation of this model calls for an accumulation of at least 30 minutes of moderate "lifestyle physical activities" on all or most days of the week. To further guide the selection of physical activities, the model recommends moderate to vigorous aerobic activities 3 to 6 times per week, muscle fitness exercises 2 to 3 times per week, and flexibility or range of motion exercises 3 to 7 times per week.

Physical activity professionals should demonstrate a personal understanding and appreciation of the basic physiological training principles such as warm-up, cool-down, gradual overload, progression, and the application of the principles of frequency, intensity, and time as they relate to improving and maintaining fitness (Howley & Franks, 1997; AAHPERD, 1999). Modelling these principles in their own fitness endeavors will have a positive influence on those who expect fitness and exercise leaders to be leaders in their profession and to set a positive example for young people and the community.

Studies by Cardinal and Sachs (1995, 1996) have found that most people are more likely to adopt moderate intensity "lifestyle physical activities" as opposed to traditional, more structured forms of exercise. This finding suggests that encouragement and modelling of "lifestyle physical activities" by fitness and exercise professionals and physical educators may be especially important to young people and a community that is already inclined to adopt moderate physical activity to improve the quality of life. In addition to the importance of a physical activity professional's potential influence on others as a model, engaging in a physically active lifestyle is very important for personal reasons. There are studies that show that participation in organized fitness programmes (*e.g.*, corporate fitness programmes) results in greater productivity, reduced absenteeism, lower health care costs, and greater job satisfaction among employees (Opatz, 1994).

It is reasonable to assume that physical educators and other physical activity professionals who exhibit active lifestyles, similar to those of corporate employees involved in physical activity programmes, can expect to experience similar benefits. This was confirmed in one study conducted among 117 schoolteachers (Blair et al., 1984). Those involved in the school district's experimental wellness programme demonstrated significantly greater improvements compared to those not involved in the wellness programme on a number of physiological variables, as well as general well-being, level of job satisfaction, and self-concept. Moreover, both self-and principal-ratings of the teachers' stress management and performance were higher among those in the wellness programme compared to those not in the programme.

Implications: When children and youth see physical activity professionals participating in accordance with established activity guidelines, applying sound physiological training principles, and actively modelling a physically active lifestyle, it reinforces student learning and will likely lead some to adopt similar activity patterns. The active lifestyle of professionals promotes credibility among parents and colleagues and exemplifies evidence of the value of a physically active lifestyle.

Furthermore, the physical activity professionals who exercise regularly provide examples of the positive physiological, health-related effects of an active lifestyle. Achievement and maintenance of health-related physical fitness (based on accepted criterion referenced standards) is an appropriate expectation for all professionals in the field of physical activity.

Throughout the years, leaders in our discipline have claimed that physical educators need to maintain acceptable physical fitness levels to be totally effective teachers (Cadinal, 2001; Corbin, 1984; McCloy, 1940; Melville, 1999; Sargeant, 1900; Staffo & Stier, 2000; Wilmore, 1982). Physical educators also need to maintain and exhibit acceptable physical fitness levels to be totally effective fitness role models. Professionals and pre-service professionals are adamant that fitness is important and that the components of health-related fitness, cardio-vascular endurance, muscular endurance, muscular strength, flexibility, and body composition (Howley & Franks, 1997) should be a measure of that fitness level.

Cardinal & Cardinal (2001) found that physical education professionals strongly believe, "it is important for health, physical education, recreation, and dance professionals to maintain a healthy body fat percentage." Those same people strongly concurred (4.4 on a 5-point scale) with the statement "involvement in regular physical activity at a level sufficient to promote health-related physical fitness is a desirable and recommended behaviour for physical education teachers." Such models are worthy of commendation if they are careful to keep long-term health considerations ahead of shorter-term performance ones.

Administrators have also expressed that they value teacher fitness. School administrators have identified lack of teacher fitness as a barrier to implementing quality elementary physical education programmes (Sallis, McKenzie, Kolody, & Curtis, 1996). Surveys of individual's responsible for hiring physical educators have shown that applicants perceived to be unfit have a much-reduced chance of employment (Melville & Cardinal, 1997). Although these studies present a topic that requires further study, it should be noted that there has been little research undertaken to determine whether or not a teacher's fitness level actually affects student learning and behaviour or teacher effectiveness.

Implications: Although the physical activity professional's physical fitness level is only one of many characteristics which contribute to the learning process, modelling an appropriate fitness level and an active lifestyle needs to be considered a significant factor in encouraging young people, colleagues, and communities to do the same. The level of physical fitness we model may have a powerful influence on youth and our success in the advocacy for our profession to the public.

PHYSICAL ACTIVITY AND PSYCHOLOGICAL WELL BEING

Over the last decade there have been several extensive reviews of the exercise psychology literature, which together oVer positive if guarded support for the role that exercise can play in the promotion of positive mental health. This optimism is founded on growing numbers of controlled studies which have identified the positive events of exercise, most often among clinical populations. At the same time, caution is expressed both in relation to the direction of causality and in the use of reductionist arguments to interpret findings. In the words of

Rejeski "it is misguided to theorize that explanations for psychosocial outcomes will ultimately be reduced to some physiological system (*e.g.*, cardiac-related cortical activity) or neurochemical activity" (p 1053). Instead, what Rejeski and others maintain is that perceived psychosocial benefits may occur in the absence of clearly identifiable changes in physiological parameters, just as it is possible to establish physiological changes in the absence of any perceived psychological benefits.

In a wide ranging literature review, McAuley has considered the relation between exercise and both positive and negative psychological health. McAuley identifies the positive correlation between exercise and self esteem, self eYcacy, psychological well being, and cognitive functioning, and the negative correlation between exercise and anxiety, stress, and depression. While such information can be used to support the general benefits of exercise, it falls short of suggesting practical guidelines on how exercise may be used to alleviate particular symptoms, and, just as significantly, which forms of exercise are likely to be most beneficial in which circumstances. In addition, establishing the direction of causality has proved diYcult—that is, did psychological well being precede, follow, or operate independently from a particular exercise regimen? With this in mind, it is unsurprising that reviewers remain critical of the methodological limitations of much of the exercise psychology literature.

In a more innovatory critique of the literature, Rejeski attempted to frame the psychosocial outcomes of exercise in terms of a dose-response relation, a relation that had previously enjoyed popularity not in the exercise psychology but in the exercise physiology literature. According to Shepherd, one of the primary issues for exercise physiologists (alongside other health care professionals) centres on establishing the specific association between physical activity undertaken (a product of intensity, frequency, and duration) and biological responses (assessed by improvement in aerobic fitness or health). Despite unresolved concerns over the application of the research paradigm, many public policy initiatives continue to be based on recommendations derived from related research.

According to Rejeski, while the dose-response relation may have heuristic value in relation to the physiology of exercise, in terms of psychological events it fails to account for the cognitive and emotional experiences of the exerciser. Hence the complexity of the relation, in terms of both dose (activity type, frequency, intensity, and duration) and possible responses, makes it diYcult to envisage research ever having the potential to move from description to prescription in relation to mental health.

Recent literature continues to urge caution when extrapolating from the physiological to the psychological, particularly as so few studies are exploring the dose-response relation between exercise and psychosocial outcomes. Rejeski reviews only four such studies, with the most significant conclusion derived from this work being that there appears to be a ceiling level in terms of psychosocial events. More specifically, these studies have suggested that low

to moderate levels of aerobic exercise are better than traditional demanding (anaerobic) exercise programmes in terms of enhancing mood and improving psychological functioning.

There is greater difficulty in establishing precise guidelines with regard to the intensity and duration of exercise, partly because of methodological inconsistencies across studies reviewed, but also reflecting on differences between the psychological functions being evaluated. At the level of general mental health, the literature therefore remains inconclusive as to the relation between exercise regimens and overall psychological well being, and, with this in mind, it is towards the specific effects of exercise on particular psychological functions and conditions that attention has turned.

In 1992, the International Society of Sport Psychology endorsed the position statements earlier issued by the American National Institute of Mental Health which described the link between regular exercise and psychological well being. Briefly, these consensus documents posited that particular psychological dysfunctions, most notably depression, anxiety, and stress, can benefit from involvement in physical activity. The evidence for a significant and positive relation between physical activity and psychological variables is taken as compelling for mentally healthy individuals but is seen as even stronger for the psychiatric population. This may not be unexpected—for example, given that the normal population "score at the low end of depression scores and therefore, have relatively little room for improvement", p 161. Much of the existing literature on exercise and mental health has focused on changes in anxiety, depression, mood, self esteem, and stress reactivity. Alongside these, for the purpose of this review it was decided also to examine two less frequently cited areas of research, those dealing with exercise effects on premenstrual syndrome (PMS) and also the relation between exercise and body image.

DEPRESSION

Martinsen reviewed the literature dealing with the effects of exercise on patients diagnosed as suffering from clinical depression. Initially, he found that such patients tended to be physically sedentary and were characterised by a reduced physical work capacity compared with the general population. In itself this finding immediately provides an argument for the integration of physical fitness training into comprehensive treatment programmes for depression, while at the same time signalling the difficulties that may be involved in implementing an exercise regimen with a population who are not predisposed towards exercise.

Although a number of studies stress the importance of using aerobic exercise in the treatment of clinical depression, Martinsen found that the antidepressant effects linked with non-aerobic exercise were equally effective. He also found that those who continued to exercise regularly after termination of a one year training programme were found to have lower depression scores than those who were sedentary. In addition, the patients themselves were found to be very much appreciative of the use of exercise as a form of treatment and, as Martinsen states,

the patients ranked exercise as, "the most important element in comprehensive treatment programmes for depression" (p 388). In 1990, North *et al* conducted a meta-analysis based on 80 studies conducted between 1969 and 1989, and included 290 effect sizes in their analysis. The results provided positive support for a relation between physical exercise and depression. In particular, it was concluded that acute and chronic exercise effectively reduced clinical depression. All groups of participants, regardless of gender, age, or health status, experienced the anti-depressant effects of exercise, with the greatest benefits noted among those experiencing medical or psychological care. The mode and duration of exercise were also examined and it was found that both aerobic and non-aerobic exercise operated as effective antidepressants. However, the authors concede that additional research should focus on the proposed psycho-therapeutic benefits of non-aerobic exercise, given that numerous studies do not concur with this finding—for example, Folkins and Sime and Sachs. Finally, the authors also examined issues relating to length of exercise programme, number of sessions, as well as intensity and frequency of exercise.

True experimental training studies remain rare, although more recent contributions are attempting firstly to manipulate levels of aerobic fitness experimentally and secondly to correlate these fitness levels with stress responsively. In addition, a number of studies have found that aerobic exercise does appear to influence stress responses. In each of these studies, comparisons have been drawn between aerobic exercise and anaerobic strength training, with participants typically exercising at least three times a week at moderate intensity for 12 weeks. While the effect appears robust, other studies that have employed a similar exercise paradigm and have used similar measures have failed to replicate these results. As a consequence, discussion often revolves around methodological concerns, and definitive conclusions remain elusive.

In conclusion, while it may be that aerobically fit individuals do show a reduced psychosocial stress response, the role that exercise can play is probably best described as preventive rather than corrective, and the stress response itself remains only partially understood. Clearly, this work lies at the interface between physiology and psychology and hence raises a great many unanswered questions about the stress response itself and its relation to physiological and psychological symptoms. With these caveats in mind, it would appear that a regimen of aerobic exercise (continuous exercise of sufficient intensity to elevate heart rate significantly above resting pulse rate for over 21 minutes duration) may significantly enhance stress responsively, and in particular stress that is related to lifestyle or work.

MOOD STATE

Numerous studies have investigated the mood enhancing properties of exercise and have shown that exercise can indeed have a positive influence on mood state. At the same time, the early optimism generated by studies of clinical samples has been tempered by the discovery that the effects of exercise on

mood state may not be as pervasive as earlier thought. For example, Dishman and Frazier and Nagy have identified individuals who were not initially depressed or anxious, who failed to match a post-exercise mood enhancement as had been noted with clinical samples. On the other hand, it has also been shown that individuals may self report an improvement in mood state without a corresponding improvement being detected by the psychometric test of mood. These and other methodological concerns have been addressed. In particular, the fact that most studies examining exercise effects on mood have utilised the Profile of Mood States (POMS) has been criticised because the test was initially validated for use in clinical populations and includes only one positive mood dimension. In the light of these and other criticisms, future reliance on the POMS as the primary measure of mood state in exercise research must be questioned.

A meta-analysis by McDonald and Hodgdon appeared to confirm a clear relation between exercise and positive moods, with significant effect sizes being shown for all six sub-scales of the POMS.

However, more recent research suggests that this relation may be quite complex and demands further clarification. For example, Lennox *et aP0* compared aerobic, anaerobic, and waiting list control groups and found no significant improvements in long term mood states among non-clinical samples.

By comparison, other studies found improvements in mood states of female exercisers. Both of these latter studies examined chronic exercise over a similar duration to that used by Lennox *et al,* although the intensity of exercise was less pronounced. These studies highlight the possibility that gains in physical fitness may operate independently of mood, and hence it may be possible to show physical fitness gains in the absence of mood effects and vice versa. In comparison, acute aerobic exercise has been shown to be associated with significant positive mood changes. Two recent studies examining the benefits of acute exercise have also found mood benefits associated with exercise. Steinberg *et aP4* compared different intensity (low impact/high impact) aerobic exercise of 25 minutes duration with a video watching control group and found increases in positive moods and decreases in negative moods after exercise. Another study adopting a slightly different approach set out to determine if a lengthy bout of acute aerobic exercise would attenuate the adverse mood effects induced by prescribed P blockers to normal healthy individuals. Results showed that one hour of moderate (50% of maximum) treadmill walking was able to produce mood states comparable with those recorded for participants in placebo trials. The authors concluded that exercise prescription should be considered a highly desirable adjuvant therapy in cases where drug therapy is necessary.

Overall these results do indicate that various forms of exercise, both aerobic and anaerobic, can be associated with an elevation of mood state, particularly for clinical samples, although given the diversity of results it is likely that more than one underlying mechanism may be implicated. The nature of these mechanisms, whether psychosocial, psychological, psycho-pharmacological,

or psychophysiological, has yet to be understood. In conclusion, although the evidence continues to point to the benefits of exercise for those who experience PMS, while less strenuous forms of non-competitive exercise appear most effective, the type of exercise, its duration, and length and in turn the reasons for improvement in symptoms still await clarification.

BODY IMAGE

In prescribing activity for both physical and psychological benefit, due caution must be taken to ensure that risk factors are not introduced that may attenuate the process of exercise induced psychological health. The gendered nature of physical activity cannot be disregarded in this debate, for while men may enjoy a symbiotic relationship with sport, too often in the past women's sport has been associated with sex role conflict and associated disorders. Fortunately, this picture may be changing rapidly but at the same time the relation between exercise and problems with body image should not be ignored, for either gender. Despite significant gains in public acceptance and participation, women are still more likely to engage in non-competitive activities such as aerobics and keep fit, which in turn may serve to reinforce the cult of thinness and femininity. Franzoi has described a tendency among women to focus on their body as an aesthetic statement whereas traditionally men have been more likely to attend to the dynamic aspects of their bodies, such as coordination, strength, and speed. This emphasis on the female form in exercise settings may foster feelings of social-physique-anxiety (SPA), constrain enjoyment of the activity itself, and may even be exacerbated by the nature of the clothing required.

McAuley *et al* reported that SPA correlates with self presentational motives for exercise such as weight control and attractiveness, and is higher among women. Women consistently score higher than men on measures of self confidence with regard to their bodies and physical competence. Biddle *et al*, among others, have emphasised the need for exercise promoters to address this issue of poor self confidence among women, and to think carefully about sporting venues and other contextual factors (for example, changing facilities) in order to make women feel more comfortable with their body image during exercise.

Body image itself refers to a multidimensional construct consisting of a set of cognitions and feelings about one's physique. Research shows that body image tends to be less positive among women, and is more closely linked to women's overall self esteem than men's. For example, in a national survey of 803 US women, over half reported globally negative evaluations of their body parts and a preoccupation with losing weight. The implications of such findings are considerable given that disturbances in body image have been so strongly implicated in the development of eating disorders and clinical depression. Without doubt, physicians who advocate the adoption of exercise regimens must remain alert to these body related concerns when prescribing forms of physical activity.

When training and diet regimens are overly stringent, women in particular are susceptible to three distinct although interrelated disorders collectively referred to as the female athlete triad (FAT). Referring to disordered eating, amenorrhoea, and osteoporosis, FAT is the physical manifestation of a pathological adherence to exercise, often coupled with inappropriate diet. In its position paper, the ACSM maintains that the syndrome can cause morbidity and mortality, and notes in particular that women involved in sports that emphasise low body weight for performance or appearance—for example, gymnastics and dance—are most at risk. Nattiv has characterised the typical sufferer as someone driven to excel, who equates leanness with improved performance, and who feels pressured to maintain a low body weight. Nattiv has further outlined criteria for screening those at risk, based on interviewing and physical examination.

What is more, not only may exercise be associated with body dissatisfaction, once undertaken, it may actually be implicated in the perpetuation of eating disorders and weight control. Davis *et al* have described the role that exercise may play in sustaining the cyclical repetitious nature of eating disorders, and have also outlined the manner in which exercise and self starvation may interact as mutual catalysts.

Disordered eating practices and a drive for thinness or leanness are often accompanied by psychopathological consequences observable in depressive symptoms such as low energy and poor self esteem. With these thoughts in mind, caution is required when recommending exercise practices which may provide a link in the chain of disordered eating or which may present itself as a dysfunctional response to body dissatisfaction.

EXERCISE ADDICTION AND WITHDRAWAL

Within the psychophysiology literature, an emerging research focus is on the notion of exercise addiction, the contention being that the mood enhancing and analgesic properties associated with exercise are influenced by chemicals in the brain which are akin to opiates. Until recently, support for the existence of exercise addiction was meagre and often anecdotal. More recent research has suggested strong links between exercise addiction and eating disorders. For example, Davis *et al* found a significant relation between exercise dependence, weight preoccupation, and obsessive-compulsive personality traits in eating disordered women.

All these arguments aside, general practitioners remain the ideal mechanism by which to promote exercise regimens. At the same time, recent surveys suggest that, despite a generally favourable reception from general practitioners themselves, their role is not without problems, particularly in relation to the referral system, their lack of knowledge of exercise recommendations, and difficulty in evaluating community health promotion schemes. Simultaneously, "exercise by prescription" schemes are gaining in popularity; a recent newspaper article reports on one fundholding general practitioner in Warrington, Cheshire who has invested practice funds in opening up a medical centre gym for his patients.

This level of enthusiasm for exercise promotion makes it all the more important that researchers, physicians, and exercise practitioners continue to work together to develop sound guidelines. This will be of practical benefit to the patient, and will also advance our understanding of the interplay between exercise and well being, allowing us to develop a firm foundation from which to make recommendations in the years to come. General recommendations are now commonly accepted as to the somatic benefits that accrue from exercise; the relation between exercise, fitness, and general cognitive functioning is now also receiving closer scrutiny. Alongside this research activity, now is the time to develop more specific guidelines relating to psychological benefits of exercise, taking due cognisance of psychosocial variables—for example, gender, age, previous mental health, environment—and recognising that the picture that will be revealed will not be as unidimensional as previous work may have implied.

7

Physical Education, Health and Wellness

PROMOTION OF SPORTS AND PHYSICAL EDUCATION

Administration alone cannot promote and develop sports and physical education on the scale required. Active participation and support from non-governmental institutions, whether public or private, in the matter of finance, infrastructure and organisation should be encouraged.

EXPLORE AND DEVELOPMENT

Explore and development in the field of sports and physical education should be actively encouraged both in the private and public sectors. In this context, special attention needs to be paid to the development of sports science in the country.

EMPLOYMENT OF MASS MEDIA

The mass media should be effectively employed in spreading and sustaining sports consciousness in the country.

SPORTS PROGRAMME AND SPORTS POLICY

The implementation of this Sports Policy need substantial additional financial outlays by the Central and State Governments. Investment in the promotion of

sports and physical education, being investment in health, fitness, productivity and social well-being of the people, which is really for upgration of our human resources for development. Such investment in sports and physical education should, therefore, be adequately increased. The Government of India should review alongwith the State Governments, every five years, the progress made in the implementation of this National Policy and suggest further course of action as may be necessary as a result of such review. The Programmes implemented by the Govt. of India are as follows:

GRANTS FORMATION OF SPORTS INFRASTRUCTURE

Under the Scheme of Grants for Creation of Sports Infrastructure, Grant is given to State Governments, UT Administrations, Local Statutory Bodies such as Municipalities, Municipal Corporations/Notified Area Committees/Cantonment Boards and Registered Voluntary Organizations active in the field of sports. Grant can be availed by them for Development of play fields, construction of Indoor/ Outdoor Stadia/facilities, Swimming Pool, Water & Winter Sports Infrastructure, Shooting Ranges and Additional facilities in existing sports projects. In addition, State/UT Governments are also assisted for construction of District/State Level Sports Complexes. Financial assistance is rendered subject to the cost being shared between the Union Government and the sponsoring agencies/State Government concerned in the ratio of 75:25 in respect of Special Category States, Hilly/Tribal Areas and 50:50 in case of other Areas. The Central assistance is limit to the ceilings in the scheme for various facilities. Kendriya Vidyala Sangathan/Navodaya Vidyala Samiti/State/UT Administration are also be eligible to avail assistance up to Rs.5.00 lakhs for construction/improvement of certain facilities in the schools. The budget allocation for this scheme is Rs.656 lakh. Though the expenditure incurred so far is Rs.142 lakhs (as 31st January, 2000) it is expected that allocation will be utilized by the end of financial year.

PURCHASE OF SPORTS

Equipments and Development of Playground: This is Sub-Scheme of the Main Scheme of Grant for Creation of Sports Infrastructure. Secondary/State Secondary Schools located in Rural Areas and fulfilled the conditions regarding availability of play field requisite size, having a regularly appointed physical education Teacher, *etc.*, are given grant up maximum of Rs.1.50 lakhs for development of field and/or purchase of consumable/non-construct sports equipment. There is no matching contribute required against this grant either from the State Governments or the School. Only one school per block and not exceeding two schools per during a plan period will be provided assistance of the scheme. Schools in the hilly areas have also been made eligible for grant towards fencing of playground.

During 1999-2000, budget provision for this scheme is Rs.200.00 lakhs.

Synthetic Playing Surfaces: Under this scheme, State/UTs, State Sports Councils/Authorities, Sports Authority of India, National Sports Associates/

Federations, Services/Railway Sports Control Boards, Local bodies and Universities/Colleges/Schools are provided Central assistance. The assistance is also made available to the Public/Private Sector enterprises who are running sports academics for sports hostels for promoting sports excellence. Under the scheme, assistance upto Rs.1.00 crore or 50% of the estimated cost, which ever is less is provided for laying or replacement of the hockey surface and athletic track only.

During 1999-2000, budget provision for the scheme is Rs.600 lakh.

Promotion of Sports in Universities and Colleges: Under the Scheme of Grants for Promotion of Sports in Universities and Colleges, assistance is provided to the Universities/Colleges for development of playgrounds, construction of Indoor Stadium/facilities in the ratio of 75:25 in the case of Special Category States and in the ratio of 50:50 to all other States. Subject to certain ceilings. Assistance is also given for purchase of sports equipment upto maximum ceiling of Rs.3.00 lakhs without any matching share from the Institutions. The Association of Indian University (AIU) is also provided assistance for holding Coaching/Training Camps of Sports persons, inter-university tournaments and participation in foreign tournaments Maulana Abul Kalam Azad Trophy, a Rolling Trophy, is also awarded every year to the overall winner of inter university tournaments. This year, the trophy was awarded to the Guru Nana Dev University. Amritsar for winning 1st Position in the university tournaments of 1997-98. Cash incentive of Rs.1 lakh, Rs.50,000/- and Rs.25,000/- are also given to the Universities winning the first three positions for purchase of sports equipments.

Assistance of National Sports Federations (NSFs): Financial assistance is given to National Sports Federations for sending their teams abroad for training and participation in International Tournaments, for holding International Tournaments in India, for conducting National Championships, for procuring equipment. The assistance is also extended through Sports Authority of India for organizing coaching camps for preparing National teams and for engaging the services of foreign coaches. Limited secretarial assistance is also provided by way of reimbursement of salary of Joint/Assistant secretaries of the Federations. The requests for assistance are processed according to the Guidelines laid down by the Department. The Indian Olympic Association is also assisted under the scheme. During 1999-2000, 78 proposals of NSFs for foreign exposure and holding International Tournament at Government Cost and 39 proposals at No Cost to Government were cleared.

Currently we are having 12 foreign coaches/experts in the disciplines of Shooting, Boxing, Weight Lifting, Athletics, Sports Medicine and Masseurs. These foreign coaches/expert aforesaid air fare salary, TA/DA, medical expenses local transport, *etc.*, are borne during their stay in India.

Sports Capacity Search Scholarship Scheme: The Sports Talent Search Scholarship Scheme was launched in 1970-71 with a view to assisting talented young boys and girls, for their outstanding performance in sports. This scheme

aims at recognizing achievements of young sports persons showing outstanding performance at National and State levels. It aims at assisting the sports persons so that they can afford nutritious diet, sports equipment, *etc.*, and pursue sports as a career. In view of the prevailing social conditions restricting participation of women in sports, the scheme also extends special assistance to women for pursuing sports and physical education.

The scholarship is for the following three categories:

(i) State level Scholarship under which scholarship @ Rs.450/- per month *i.e.*, Rs.5,400/- per annum will be provided to sports persons excelling at State level.

(ii) National level Scholarship, under which scholarship @ Rs.600/- per month *i.e.*, Rs.7200/- per annum will be, provided to sport persons, excelling at National level.

(iii) University/Colleges level Scholarship under which scholarship @ Rs.750/- per month *i.e.*, Rs.9000/- per annum will be provided to sport persons excelling in university and colleges.

Special scholarship for women has three component namely:

(i) Scholarship for senior women champions, under which scholarship @ Rs.1,000/- per month *i.e.*, Rs.12,000/- per annum will be provided senior women sports persons.

(ii) Scholarship for women doing Diploma in sport coaching at SAI Center, under which scholarship @ Rs.6000/- per course will awarded.

(iii) Scholarship for women doing M.Phil/Ph.D Physical Education under which scholarship Rs.6000/- per annum will be awarded for a maximum period of 3 years.

These scholarships are awarded on the basis of performance of the sports persons in the previous financial year. In the year 1999-2000, the Scholarship Committee for award of scholarships under various categories selected 5696 persons.

Sports discipline research fellowship scheme: Under the Scheme, scholarships are offered to doctors and scientists and project grants are given to selected Institutions to motivate and encourage them for research in different components of sports sciences *i.e.*, nutrition, physiology, psychology, and sports injuries. During 1999-2000, 94 applications were received for 7 sports science disciplines. Research fellowships were finally offered to two, but only one candidate (Ms. Preeti Chopra) could avail of it. Three research fellows have been given extension for another year. They are Ms. Seema Bhatnagar (Sports Psychology), Ms. Paramjit Kaur (Sports Psychology) and Mr. Deepak Kaushal (GTMT). The research fellows are given a monthly stipend of Rs.3,000/- and an annual contingency of Rs.14,000/-.

Arjuna Awards: The Arjuna Award, instituted in 1961 as the highest national recognition of distinguished sports persons, is given for outstanding performance by sports persons during the year for which it is given and in the preceding three years. The scope of the award has been enlarged to include such sports

persons also as have made lifetime contribution to their discipline. The Awardee is given a bronze statue of Arjuna, a scroll and a cash prize of Rs.1,50,000/-. The Awardee is also provided a ceremonial dress.

Arjuna award for the year 1998 were presented by the Hon'ble President of India to 30 outstanding sports persons at Rashtrapati Bhawan on 1st September, 1999. The total number of sports persons who have so far been given Arjuna Awards is 522.

Rajiv Gandhi Khel Ratna Award: The scheme was launched from the year 1991-92 with the objective of honouring sports persons to enhance their general status and to give them greater dignity and place of honour in society. Under this scheme, an amount of Rs.1.00 lakhs is given as award for the most spectacular and outstanding performance in the field of sports by an individual sports person or a team. The scheme has recently been revised and the award amount of Rs.1.00 lakhs has been enhanced to Rs.3.00 lakhs. Mrs. Jyotirmoyee Sikdar was conferred the Rajiv Gandhi Khel Ratna Award for the year 1998-99 for her outstanding performance in the field of Athletics.

PHYSICAL EDUCATION PROGRAMME PHILOSOPHY

Physical education is a unique and important component of the total school programme. Physical education provides the physical component of a total education facilitating health maintenance and physical vitality. It is only physical education that contributes to physical development while integrating the emotional, social, and intellectual components that develop the whole child. The programme prepares the adolescent to meet the physical demands of daily life, to use activity for preventive health benefits for a lifetime, and to enjoy physical activity during leisure time. The school community focuses on balanced learning opportunities addressing the following three major goals as set forth in Turning Points: Preparing American Youth for the 21st Century, a report of the Carnegie Council on Adolescent Development.

- Academic achievement
- Developmental responsiveness
- Social equitability.

The unique objective of physical education is to guide all students into being physically active for a lifetime. A developmentally and instructionally appropriate physical education programme promotes a physically active lifestyle. It accommodates a variety of individual differences such as cultural identity; previous movement experiences; fitness and skill levels; and intellectual, physical, and social-emotional maturity. Appropriate instruction in physical education incorporates best practices derived from both research and experience for teaching early adolescents in ways that encourage success for all students. Providing a safe and inclusive learning environment allows all students to experience positive, challenging, and enjoyable physical activity while learning about the benefits and importance of physical activity. Specific outcomes for

each grade level are denoted within the curriculum. The outcomes indicate what skills students should learn and the knowledge and behaviours they should possess when completing the programme. This is accomplished through a sequence of carefully selected activities, curricular and intramural, which build on each previous level of the physical education curriculum as a means of developing proficiency in a few motor skills and competence in many. Physical education content should be clear, comprehensive, and unified. The delivery of this content should provide for a positive learning environment that consists of the cognitive, psychomotor, and affective domains.

The cognitive domain of physical education stresses the objectives of critical thinking, decision-making and problem solving. Included within this domain are developing vocabulary, gaining knowledge about how the body moves, learning about safety and understanding the rules and strategies of games, dance, gymnastics and aquatics.

Within the psychomotor domain, the student should become a versatile and efficient mover in the programme areas of games, dance, gymnastics and aquatics.

In the affective domain, the student as a participator and observer develops an awareness of the joy of movement. Learning to make healthy choices, taking responsibility for oneself, showing self-control, following rules, participating safely, working well with others, demonstrating respect and display of good sportsmanship are key to developing abilities within the social and emotional areas.

WELLNESS PROGRAMME, K-8 PHILOSOPHY

Wellness is an active process of becoming aware of and making choices towards achieving a more successful existence. Personal wellness occurs when one commits to a continuous, lifelong process of developing a lifestyle based on healthy attitudes and actions. Wellness extends the definition of health to encompass a process of awareness, education and growth. By presenting a planned, sequential programme that embraces the six dimensions of wellness, students develop knowledge, attitudes, skills and behaviours necessary to achieve optimal wellness and become committed to lifelong learning. This approach builds resiliency, which in turn leads to healthy families and communities.

The programme goals are to:

- Promote excellence in the teaching and learning of wellness.
- Implement the core concepts of wellness outlined in the Massachusetts Comprehensive Health Curriculum Framework.
- Provide opportunities for students to set goals, assess risks and demonstrate behaviours that protect and enhance their wellness.
- Establish partnerships with community partnerships to enhance the classroom experience.

The Brockton Public Schools Wellness Programme, K-8, adopts the standards of the Massachusetts Comprehensive Health Education Curriculum Framework.

The fourteen content areas include:

1. Growth and Development
2. Physical Activity and Fitness
3. Nutrition
4. Reproduction/Sexuality
5. Mental Health
6. Family Life
7. Interpersonal Relationships
8. Disease Prevention and Control
9. Safety and Injury Prevention
10. Tobacco, Alcohol and Other Substances Abuse Prevention
11. Violence Prevention
12. Consumer Health and Resource Management
13. Ecological Health
14. Community and Public Health.

The Brockton Public Schools Wellness Programme, K-8 adopts the vision of the Massachusetts Health Education Curriculum Framework in presenting a comprehensive wellness programme that teaches fundamental health concepts, promotes habits and conduct that enhance health and wellness, and guides efforts to build healthy youth. The Wellness Programme also embraces the Framework's Guiding Principles in offering a sequential and coordinated teaching programme.

WELLNESS EDUCATION PROGRAMME, 9-12 PHILOSOPHY

The Physical Education and Health Departments have traditionally been separate entities at Brockton High School. An initiative is underway that will integrate the current Physical Education and Health Education programmes into a single Wellness Education programme.

The restructured Wellness Education programme has been designed to support the academic mission of the school, as well as the lifelong health and well-being of our students. Our nation's youth are currently experiencing a health crisis of epidemic proportions. Individuals who are overweight or obese have an increased risk of developing such chronic diseases as Type II diabetes, cardiovascular disease, as well as several forms of cancer. The objective of the Wellness Education programme is to support learning through enhanced student awareness and appreciation for lifestyles that are based on healthy attitudes and actions.

Offering one Wellness Education Programme allows for the synthesis of Physical Education and Health Education concepts within a single, stimulating curriculum. Academic concepts such as "strengthening the heart muscle" or "weight management" can come to life in the fitness room and gym, on the track, as well as in the classroom. By offering a variety of innovative courses, students will learn the criteria for a healthy lifestyle along with wellness practices that can be incorporated into their daily lives. Expanding the scope of the existing curricula will bring the present programme into the twenty-first century.

The Wellness Education Steering Committee is in the process of making changes that will provide our students with an academic programme to challenge students cognitively and physically. In keeping with the established Massachusetts Comprehensive Health Curriculum Frameworks, which include Health and Physical Education, students will participate in a course of study that concentrates on the Six Dimensions of Wellness: physical, social, emotional, spiritual, intellectual and occupational/leisure.

The inclusion of Physical Education components is integral to an overall Wellness programme of study. A comprehensive Wellness programme includes developmentally appropriate skills, logical and sequential progression learning through a variety of movement activities, as well as a relevant academic component. Intramural offerings are intended to enhance the classroom experience and the students' appreciation for lifelong activity.

The first phase of the Wellness Education initiative involves redesigning the freshmen "Fitness and Wellness" programme to help students demonstrate personal and social responsibility through physical activity. The emphasis will be placed on fitness assessment, character education, cooperative games and trust-building activities that are developmentally appropriate as an introductory course for new high school students.

Comprehensive School Health Education is similar to effective programmes in the traditional academic disciplines. It includes a planned, sequential programme that integrates health information and concepts into a variety of interactive wellness initiatives for all students. The Brockton Public Schools Wellness Education Programme has been designed to support students' development of the knowledge, attitudes, skills and behaviours that are necessary for lifelong learning and wellness. The intent of this approach is to build resiliency, which in turn will lead to healthy families and communities.

The programme goals are to:

- Promote excellence in the teaching and learning of wellness education.
- Implement the core concepts of the Massachusetts Comprehensive Health Curriculum Framework focusing on the health and physical education standards
- Provide opportunities for students to set goals, assess risks and demonstrate behaviours that protect and enhance their well-being.
- Establish collaborative partnerships with school and community organizations in an effort to deliver a high quality wellness curriculum.

QUALITY TEACHING FRAMEWORK IN PHYSICAL EDUCATION

The introduction of the 'NSW Quality Teaching Framework' (2003a) has had a very significant impact upon teaching and learning in NSW (New South Wales) public schools. In NSW the Department of Education and Training (2003c) argues that recent developments in educational research have shed light on what constitutes quality teaching and have consequently established a new

model for pedagogy in NSW schools based upon the idea of providing quality teaching (NSW Department of Education and Training, 2003b). The NSW model of pedagogy focuses on the teaching practices that research indicates can make the most difference when it comes to improving student learning outcomes. The emphasis on providing intellectual quality, a quality learning environment and making the significance of learning explicit to students provides valuable framework within which teachers can strive to deliver quality teaching. It does, however, provide a challenge for the teaching of physical education in a subject area that has a long history of neglecting the intellectual dimensions of games, sport and other movement (Light, 2002). While many PDHPE teachers may struggle to deliver quality physical education teaching within this framework we suggest, as others have (Pearson, Webb & McKeen, 20005), that Game Sense pedagogy provides an ideal means through which PDHPE teachers in NSW can address the Quality Teaching Framework in the teaching of games and sport.

In this paper we address the rationale and main ideas of the quality teaching framework and provide an overview of the Game Sense approach to games teaching. We then specifically address the three central concerns of the Quality Teaching Framework, intellectual quality, providing a quality learning environment and making the significance of learning explicit to students showing how game Sense addresses each of these.

PERSONAL, SOCIAL AND HEALTH EDUCATION

Personal, social, health and economic (PSHE) education has in various forms been part of the national curriculum for schools in England since 2000. Some aspects, but not all, have been compulsory. PSHE is defined by the schools inspectorate Ofsted as a planned programme to help children and young people develop fully as individuals and as members of families and social and economic communities. Its goal is to equip young people with the knowledge, understanding, attitudes and practical skills to live healthily, safely, productively and responsibly.

In Wales, the comparable element of the state school curriculum topic is Personal and Social Education (PSE). In Ireland, it is Social, Personal and Health education (SPHE). It is also known as PSHEE (Personal, Social, Health and Economic Education), PSED (Personal, Social and Emotional Development) and PSHCE (Personal, Social, Health and Citizenship Education).

RECENT DEVELOPMENTS

Recent research at the University of Southampton and the University of Bristol has resulted in a thrust towards changing this. The UK government published in May 2005 the "SEAL" pack (Social and Emotional Aspects of Learning) for primary schools to teach emotional literacy and personal growth overtly through PSHE and the curriculum. This is to be supported also in secondary schools in England and Wales with a similar pack, still in development, called

"SEBS" or Social, Emotional and Behavioural Skills. It is also sometimes referred to as variants of PSHEE (Personal Social Health Economic Education). More recently, the largest ever study of PSHE education in primary and secondary schools in England was completed by the Centre for Education and Inclusion Research (CEIR) at Sheffield Hallam University (Formby *et al.*, 2011). This research was based on a nationally representative survey and in-depth case studies to map and assess the delivery and effectiveness of current provision in English primary and secondary schools.

In July 2011, the Department for Education launched an internal review of personal, social, health and economic education to look at the content and quality of teaching of PSHE in schools. Closing date for the responses to the review was Wednesday 30 November 2011.

HEALTH CRISIS BY REAFFIRMING THE ROLE OF PHYSICAL EDUCATION

In the United States today, children's poor physical health has become a national concern. Much of the recent literature pertaining to the status of children's health today is written in shocking language, as in: "Obesity in kids is now epidemic in the United States." However, such alarming wording seems to be justified. According to Carol Torgan, Ph.D., "The number of children who are overweight [in the U.S.] has doubled in the last two to three decades; currently one child in five is overweight. The increase is in both children and adolescents, and in all age, race and gender groups." Such data is certainly indicative of a widespread decline in children's health in the United States, especially in the areas of nutrition and physical activity. It is important to note that the rise in overweight and obesity is occurring in all sectors of society. This problem is not limited to particular groups, and therefore one can hypothesize that the causes are prevalent throughout American society, rather than specific geographic regions, cultural groups or other social divisions.

HOW DO WEIGHT PROBLEMS ARISE IN CHILDREN?

The causes of overweight are essentially twofold: poor dietary habits and insufficient physical exercise. "Research shows that good nutrition lowers people's risk for many chronic diseases, including heart disease, stroke, some types of cancer, diabetes, and osteoporosis." However, "[o]nly 21% of young people eat the recommended five or more servings of fruits and vegetables each day." Our bodies are composed of what we eat; when we eat poorly, our bodies suffer. However, nutrition is only part of the problem.

Children also need to live physically active lives to burn off excess calories and keep their bodies physically fit. Many children are not leading such lives. For example, "More than a third of young people in grades 9-12 do not regularly engage in vigorous physical activity." The Surgeon General recommends "at least 60 minutes of moderate physical activity most days of the week," and while there is no national data to assess how well this standard is being met, in

1997, only "65% of adolescents reported participating in vigorous activity for 20 minutes or more 3 [days a week.]" Although it is difficult to interpret this data in relation to the Surgeon General's guidelines, one can safely acknowledge that a full 35% of American adolescents are not even getting 20 minutes of vigorous exercise 3 days a week. Such a number represents a huge number of children. Additionally, "[r]esearch has demonstrated that virtually all individuals can benefit from regular physical activity." That is, very few children are at risk of serious physical harm by exercising regularly. Rather, the greater harm comes from ignoring government guidelines and succumbing to sedentary lifestyles.

HOW DOES PHYSICAL EDUCATION FIT INTO THIS SITUATION?

As stated earlier, regular physical activity has profound effects on personal health and fitness. It reduces the risk of developing many life-threatening conditions and generally improves life expectancy. Among children, physical education classes are a great way to meet these exercise needs. The Surgeon General recommends that schools

"[p]rovide all children, from kindergarten through grade 12, with quality daily physical education that helps develop the knowledge, attitudes, skills, behaviours, and confidence needed to be physically active for life." Such a commitment to physical education would ensure that all children in our schools get the physical activity they need as part of a healthy lifestyle. Furthermore, it would instill a long-term commitment to physical activity in those children, such that those children would maintain their healthy lifestyles well into adulthood. Additionally, "[w]eight-bearing physical activity is essential for normal skeletal development during childhood and adolescence and for achieving and maintaining peak bone mass in young adults." All children need regular exercise for proper body development as well as weight control and disease prevention; it is part of our natural growth to need physical activity, and without it our bodies are at risk for severe physical problems.

Physical education has other great benefits as well. For example, "[s]tudies have found participation in physical activity increases adolescents' self-esteem and reduces anxiety and stress. Through its effects on mental health, physical activity may help increase students' capacity for learning." Additionally, "[r]egular physical activity reduces morbidity and mortality from mental health disorders… In adults with affective disorders, [it] has a beneficial effect on symptoms of depression and anxiety." Thus, exercise not only improves one's physical health, but one's mental health as well. As overweight often leads to low self-esteem and depression, it is important to note that exercising regularly can cure both the condition (overweight) and one of its symptoms (depression).

Unfortunately, as school budgets tighten and schools struggle to meet the demands of standards-based reforms, many physical education programmes have been drastically weakened. For example, under budgetary pressure, some Hamilton County (TN) schools "have cut P.E. instruction from 45 minutes a week to 30 minutes." In Wisconsin, "[a]s school budgets suffer under revenue

controls and increasing pressure from the [No Child Left Behind Act,] physical education classes, athletic programmes, and extracurricular sports are becoming targets for school boards." Programmes aimed at promoting healthy living are often the first to be cut or reduced by school boards worried about adequately covering the so-called "core subjects" (*i.e.*, Mathematics, Science, Reading). However, considering how eating and exercise behaviours learned in childhood persist into adulthood, it would seem that appropriate health education should be promoted as a primary area of learning for the long-term health of our students.

Ironically, as educators cut health and fitness programmes to slash budgets, it has been documented that poor health resulting from obesity and overweight has considerable financial costs. According to a study by the National Institutes of Health, "[I]n 2000, the total cost of overweight and obesity was estimated to be $117 billion… The [Federal] Medicare and Medicaid programmes currently spend $84 billion annually on five major chronic conditions that could be significantly improved by increased physical activity…" With school districts across the country struggling to find funds and cut programmes to balance budgets, it seems especially wasteful that the United States is forced to spend so much on health care costs for preventable diseases. If school districts across the country committed to effective physical education programmes and made real progress in fighting obesity in children, it can be anticipated that these costs would decrease dramatically. Not only would those programmes essentially "pay for themselves," but America's children would be healthier, both physically and psychologically, and more likely to carry that improved health into adulthood.

THE OBESITY CRISIS IN THE UNITED STATES AND THE ROLE OF PHYSICAL ACTIVITY

Obesity and overweight are rising in the United States at extremely high rates. From a 2004 report by the Centres for Disease Control, clearly demonstrates how the percentages of adults who are obese in the US have risen over from 1991 to 2002. For example, in 1991, no state reported an adult obesity rate of more than 19%, and 9 (Colorado, Georgia, Massachusetts, Montana, New Jersey, New Mexico, Rhode Island, Utah, and Washington) reported rates of less than 10%.

In 2002, on the other hand, no state reported a rate of less than 15%, and 3 (Alabama, Mississippi, and West Virginia) had adult obesity rates of more than 25%. According to the Office of the Surgeon General, "an estimated 61 percent of U.S., adults were overweight or obese" in 1999, and the increases in recent years "cut across all ages, racial and ethnic groups, and both genders." These increases have extended to children as well. The CDC reports "[o]f children and adolescents aged 6-19 years, 15% - about 9 million young people – are considered overweight." That percentage of overweight children has more than doubled over the past 20 years. Today, more and more Americans from all demographic groups are living with unhealthy amounts of excess weight.

There is a large body of research detailing the many health risks associated with obesity and overweight. According to the Surgeon General:

Morbidity from obesity may be as great as from poverty, smoking, or problem drinking. Overweight and obesity are associated with an increased risk for coronary heart disease; type 2 diabetes; endometrial, colon, postmenopausal breast, and other cancers; and certain musculoskeletal disorders, such as knee osteoarthritis. These diseases have a significant impact on one's life expectancy: "Individuals who are obese… have a 50 to 100 percent increased risk of premature death from all causes compared to individuals [with a healthy weight.] An estimated 300,00 deaths a year may be attributable to obesity." Additionally, obese children are at increased risk of sleep apnea, which has been linked to problems with learning and memory. Excessive weight contributes to many deadly diseases and conditions, and statistics show that more Americans are placing themselves at risk every year. The potentially fatal effects of these conditions make unhealthy weight a national crisis that is too widespread and too dangerous for educators and communities to ignore.

Unhealthy weight can also have dramatic effects on individuals' self-esteem and socialization. "Overweight and obese individuals… may suffer from social stigmatization, discrimination, and poor body image." Overweight children, through this social discrimination from their peers, "can develop low self-esteem and depression." Unhealthy lifestyles affect the whole child. Through social isolation, low self-esteem and poor self-image, overweight can easily lead to poor psychological health as much as it can lead to poor physical health. Also, poor physical and psychological health can work together against the individual. That is, depression caused by social isolation can weaken a child's motivation to improve his or her physical fitness, worsening the child's physical condition and creating a downward spiraling effect.

Additionally, childhood weight control problems (and their accompanying health risks), more often than not, persist into adulthood. In general, "teens' positive and negative behaviours in adolescence tend to carry over into adulthood;" this includes not only behaviours such as smoking and alcohol consumption, but also eating habits and physical activity.

"Overweight adolescents have a 70 percent chance of becoming overweight or obese adults." Thus, it is critically important to combat overweight at a young age. Children with weight problems are likely to carry those problems into adulthood unless they are addressed and eliminated in childhood. Childhood issues of overweight and obesity that can (and often do) easily develop long-term dangers that have been proven to have drastic impacts on physical and mental health.

SCHOOLS NEED TO PROVIDE TIME AND SPACE FOR PHYSICAL ACTIVITY!

Physical education should provide an opportunity for students to receive the regular physical activity their bodies need. The Surgeon General recommends

"at least 60 minutes of moderate physical activity most days of the week," while the CDC writes, "Youth should strive for at least one hour of exercise a day." Either way, based on the story of schools in Hamilton County, TN, many students are not receiving this level of activity. Again, it is up to public education to ensure that children our living healthy lives, and therefore schools need to use physical education as a vehicle for fostering and promoting physical activity. Such classes should occur on a daily basis to make sure every student is getting sufficient exercise.

Also, these classes need to be mandatory. The CDC reports, "Daily participation in high school physical education classes dropped from 42% in 1991 to 32% in 2001." Granted, a significant part of this drop can probably be attributed to school budget cuts that limited the amount of daily physical education offered (as in the Tennessee example). However, one can surmise that the rise in obesity levels may have had an impact as well. For many overweight students, physical education classes can be very stressful. They are environments in which the students' low fitness levels can become strikingly noticeable. Although it is important to create atmospheres that do not socially alienate these students (more on this later), it is also important to make sure that those students are forced to exercise on a daily basis. Many of these children, because of social fears, will choose not to participate if given a choice. However, those students' psychological and physical health will certainly improve a great deal over the long-term if they receive the daily exercise they (and all students) need.

Physical education classes should also be non-threatening to support all students, regardless of physical fitness or ability. Physical education programmes should emphasize both physical fitness as well as encouraging higher self-esteem, greater confidence and greater knowledge about the value of exercise in daily living. With these goals in mind, competitive environments will only alienate some students. Additionally, competition can focus students' attention on their peers, rather than themselves and their own personal growth.

Wellness programmes can be easily applicable in physical education classrooms. "Simply put, the concept of wellness espouses self-responsibility for a healthy lifestyle…

[It is] the constant and deliberate effort to stay healthy and achieve the highest potential for total well-being." Wellness stresses not only physical fitness but also mental health. It is important, in the context of overweight and obesity, to remember that these two factors can work together with negative consequences for the individual. That is, weight problems can lead to depression, which in turn can make the individual feel a sense of powerlessness, and so the problem escalates. Wellness programmes focus on individual progress, helping students to see how they have improved themselves and how they can continue to do so, with the stress of competition from peers. In one wellness programme in a Philadelphia-area elementary school, "Games are related to life. Skills are taught and children play hard without keeping score… [The teacher] emphasizes that

individuals set their own priorities." Wellness is focused on educating children about how their actions and behaviours influence their bodies' growth, and empowering them to improve themselves over the long-term in a non-competitive environment.

Physical education needs to recognize the myriad ways in which physical fitness is attained. "…[F]itness has become synonymous with aerobic or cardiorespiratory fitness… however… this approach ignores several other components of fitness that are relevant to health, particularly in pediatric populations. These include muscle strength, muscle endurance, flexibility, and body adiposity." Physical education programmes need to be varied, both in the different activities they provide and in the muscle groups and biological systems they target. Growing children, especially, need exercises that challenge all of their body systems in order to develop naturally and successfully. Additionally, it warrants mention that children of all ages will soon grow disconnected from programmes that lack variety. Without variety and spontaneity in daily physical education activities, many children will grow bored and disconnected from the messages teachers are trying to send. Gaining and maintaining interest in physical health are important steps in improving student health, and any programmes that fail to interest students will likewise fail to have a significant long-term impact.

REFORM INITIATIVE PHYSICAL EDUCATION REFORM

Knowing the full extent of the nation's current health crisis and all of its ramifications, what can be done? Is physical education really a viable solution? Many (including this author) believe so. Some examples: "Physical exercise is an excellent means of controlling weight;" "…randomized controlled trials have shown that weight loss (as modest as 5 to 15 percent of excess total body weight) reduces the risk factors for at least some diseases, particularly cardiovascular disease;" "Regular physical activity along with a nutritious diet is key to maintaining a healthy weight… Because physical inactivity is a risk factor for many diseases and conditions, making physical activity an integral part of daily life is crucial." As stated earlier, proper nutrition and regular exercise have been proven to be the primary elements of healthy living. Through health and physical education classes, schools can educate students on how to live a healthy lifestyle and give them the time and opportunity to engage in necessary physical exercise.

SCHOOLS NEED TO EDUCATE!

According to some definitions, especially those used by many in positions of power in education today, the purpose of education is to prepare students for adult life. Such preparation should include health and fitness education. To begin with, we must make sure that our educators are well versed in what constitutes healthy living so that they can explain and model those behaviours to their students. Along that vein, the Surgeon General recommends that schools

"[b]uild awareness among teachers, food service staff, coaches, nurses, and other school staff about the contribution of proper nutrition and physical activity to the maintenance of lifelong healthy weight." Everyone in the schools, not just those directly involved with health and physical education programmes, should be educated about these issues such that they can model healthy choices for their students and advise those students, if necessary, on these matters. Obesity and overweight are problems that affect students all through the day, not just in certain classes. It is important to reinforce healthy behaviours whenever possible and reassure students that those behaviours can and do have positive impacts on one's physical health, body image and self-esteem.

Furthermore, schools need to provide quality health education to teach students how to live healthy lives and what that entails. Students often do not know what a balanced diet is, what appropriate food portions are, or how much physical activity is truly necessary on a daily basis to maintain a healthy weight. Certainly, parents can and should play an important role in this education. The Centres for Disease Control and Prevention report, "Only about one-fourth of U.S., adults eat the recommended five or more servings of fruits and vegetables each day. In addition, in the last 30 years, calorie intake has increased for both men and women." The report goes on to say, "Poor eating habits are often established during childhood." Children, especially younger children, model their habits and behaviours on their parents' habits and behaviours. It is important to inform parents about healthy nutrition and exercise so that they can then educate their children about these behaviours (and hopefully model them as well).

However, we should not ignore the importance of health education in the schools by simply saying, "It's the parents' responsibility to teach that at home." Health education can, at best, supplement messages from parents about appropriate nutrition and exercise, and at worst pick up the slack for parents who neglect to educate their children on these matters. The Surgeon General calls on schools to "[p]rovide age-appropriate and culturally sensitive instruction in health education that helps students develop the knowledge, attitudes, skills, and behaviours to adopt, maintain, and enjoy healthy eating habits and a physically active lifestyle." That is, schools have an ethical responsibility to ensure that their students are well educated in proper nutrition and exercise, no matter how well parents do at teaching their children the basics of healthy living.

WHAT ELSE CAN BE DONE?

Schools also need to support extracurricular activities that emphasize healthy physical activity. Extracurricular sports especially can have wonderful benefits for children. Because sports have competitive elements to them that could alienate some children, it is important to stress the values that sports espouse much more than the competition itself. That said, sports have proven to be very beneficial in many aspects of children's lives:

Participation in physical activity and sports can promote social well-being, as well as good physical and mental health, among young people. Research has

shown that students who participate in interscholastic sports are less likely to be regular and heavy smokers or use drugs, and are more likely to stay in school and have good conduct and high academic achievement. Sports and physical activity programmes can introduce young people to skills such as teamwork, self-discipline, sportsmanship, leadership, and socialization.

Through sports, children can learn important principles that are applicable in many areas of life as a whole, and they can get exercise in a social atmosphere. Sports give students a reason to stay in school, do well academically, and avoid dangerous and illegal behaviours. In an era that emphasizes individual achievement, it is vitally important that our children learn how to work together to meet mutual goals, and team-based sports are a great avenue to those goals. Sports, in general, can be very effective at reaching students that might otherwise be turned off by school, and can teach them important lessons and life skills that traditional classroom instruction may fail at.

Active participation is a critical element in these activities. The Surgeon General asks schools to "[p]rovide extracurricular physical activity programmes, especially inclusive intramural programmes and physical activity clubs." The most important word here is "inclusive." There should be room in these programmes and on these teams to accommodate any and all students who wish to participate. Additionally, there should be enough teams to give all students ample opportunity to play. There are few situations more discouraging for an aspiring athlete than having to spend large amounts of time on the bench, watching others play, because his or her team is too large to give sufficient playing time to everyone. Although this may be costly, the physical and psychological benefits for the child are great. An unhappy experience at an early age can seriously taint a student's perception of the value of sports and physical activity. If we are to truly reach out to these students and give them opportunities for healthy living, we must ensure that they are amenable to the children.

DISSEMINATION PLAN

To begin with, it is vitally important that the information presented in the Issue Assessment be made available to educators. Many in the academic community fail to realize how dangerous the obesity epidemic really is, and how physical education truly can make a significant positive impact. If school boards and administrators fully understood the financial and social ramifications of this epidemic, I believe that they would view physical education with a great deal more respect than it is currently viewed. Educating the public about the inherent dangers of unhealthy lifestyles is an important step that must not be overlooked, for it is on this education that the proposals included in the reform initiative are based. The most important step in this process of reaffirming the value of physical education in our schools is getting information out to those who need it to enact change.

To that end, dialogue is needed between the various players in this process. We need to bring together teachers (in both general and physical education),

administrators, community members, school board members, and parents to talk about these problems and discuss ideas. The proposals in the attached reform composition are foundational, seeking solutions to the obesity epidemic through proven programmes. It is up to specific schools (and those individuals involved in them) to tailor those proposals to the specific needs of the local schools. By bring various people together to talk about these issues, we can raise awareness about the importance of physical education and generate new ideas about how to solve long-running financial and logistical difficulties. Again, it is important to publicize ideas and integrate them into the public consciousness for dialogue, debate, and action.

THE NSW QUALITY TEACHING FRAMEWORK

In May 2003 the NSW Department of Education and Training released 'Quality teaching in NSW public schools'. This was developed as a long-term strategic plan to support and focus on teaching and learning in NSW public schools. The model was designed for implementation across all key learning area (KLAs) from Kindergarten to Year 12. Quality teaching and learning is the result of a long history of research that has tried to identify teaching practices that improve student learning. Until recently there was little consensus about quality pedagogy because of the difficulty in isolating the independent effects of a specific teaching technique on student learning.

Building on research such as that of studies by Newman and Associates (1996) in the USA and the 'productive pedagogies' work in Queensland (Queensland School Reform Longitudinal Study, 2001) the NSW model identifies three key dimensions of quality pedagogy as that which:

(1) Is fundamentally based on promoting high levels of intellectual quality
(2) Is soundly based on promoting a quality learning environment
(3) Develops and makes explicit to students the significance of their work.

The new NSW PDHPE syllabus provides the opportunity to provide high-quality learning experiences that can fit in with the Quality Teaching Framework. To integrate *intellectual quality* into the PDHPE programme, we suggest there is a need to analyse what the central concepts and ideas are that we want the students to learn and the relationship/connections between each of these concepts. The dimension of *quality learning environment* focuses on the need to make students aware of expectations, and ensure that they are challenging, but achievable. Students need the opportunity to exercise some control over what and how they learn. The quality learning environment focuses on learning, with an emphasis on clarity of what is to be learned, high expectations and social support. Students demonstrate this through engagement in learning, self-regulation and self-direction. Because of the nature of PDHPE the dimension of *significance* is of great importance, as students need to see clearly the connections between the learning that takes place in the gym or on the field and their *real world*.

GAME SENSE

The Games Sense approach is a student-centred, inquiry-based approach that allows students to develop their own skills and understanding while being actively involved in the game. Game Sense is a variation of Teaching Games for Understanding (TGfU) developed for coaching through collaboration between Rod Thorpe, the Australian Sports Commission (ASC) and Australian coaches (Light, 2004). It focuses on the game and not on the discrete skills or techniques that traditional approaches see as needing to be mastered before playing the game. All learning occurs within the authentic context of modified games or game-like activities to develop understanding, decision-making and skills that work within the context of a game. Skill development occurs at the same time as understanding with the modified games reducing the technical demands on the students so that they can concentrate on the games as a whole. In this way Game Sense integrates physical, intellectual and social learning. Children can understand similarities between games and explore common principles. Game Sense tends to use small sided, modified games that incorporate essential tactical structures but which are adapted to cater for different age, size, ability, inclination and motivation. As several researchers have argued, Game Sense, TGfU and other variations offer opportunities to intellectualize games teaching in physical education.

As social contructivist learning theory suggests, the social side of games has a major impact on the learning that takes place as full cognitive development arises from social interaction. The social constructivist theory of Vygotsky (1978) highlights the fundamental role that social interaction plays in learning. In Game Sense, the range of skills and understanding that can be developed from verbal and non-verbal interaction between the teacher and students or between peers exceeds that which can be attained alone.

In Game Sense the teacher sets a learning environment with which the students engage and encourages students to explore, experiment, analyse, and solve the range of problems that arise in playing games. Dewey (1916/97) argues that learning occurs through experience in two ways. It occurs through the initial experience and again through the experience of immediate reflection upon that experience. This is precisely how learning occurs in the Game Sense approach to games and sport teaching. The Game Sense teacher and students engage in an active dialogue during the Game Sense lesson and students engage in dialogue between each other during 'team talks' and non-verbal dialogue during games (Light & Fawns, 2003). During game activities students regularly stop and reflect through group discussions that collectively contribute towards the development of understanding that can be articulated and later expressed in intelligent play. Through this process the student's scaffold knowledge and develop skills as the complexity of the games is increased (Light & Georgakis, 2005).

There are times in Game Sense when direct teaching of skills is appropriate but skills can be developed within the framework of the rules and defined spaces and manipulation of time and space in games. As Kirk and MacPhail (2002)

suggest, tactics and strategies need to be learnt in unison with technique development in context. Games Sense teachers aim for a student-centred, teacher driven approach where the teacher acts as the facilitator, is creative and capable of lateral thinking in constructing learning experiences but limits direct instruction. Within this approach good questioning is an important aspect that will help guide the students and have them engage intellectually in the game. Game Sense emphasises the importance of affiliation (social interaction, making friends), achievement (doing something well or noticing improvement), and self-direction (opportunities to make choices) as students desire involvement in sport/games. The focus of Game Sense on the intellectual aspects of games and sport emphasizes higher order thinking in games such as strategic thinking, problem solving and decision-making. Teachers can't achieve intended learning outcomes and provide Quality teaching and learning if they don't understand how learning takes place.

As Forrest, Webb and Pearson (2006) argue, Game Sense is yet to make a significant impact upon teaching in NSW. As several other researchers have noted on a larger scale there tends to be resistance from both experienced and beginning teachers to implement a games sense approach, and this may be due to the fact that it challenges 'traditional' teaching in relation to PE that tends to focus on teaching skills as the basis of good teaching:

While the teacher may be convinced that skill-based Lessons are having a positive affect in that some immediate skill improvement is made, the social and skill-related interactions might over time convince the youngsters of their lack of ability.

ADDRESSING THE QUALITY TEACHING FRAMEWORK WITH GAME SENSE

Intellectual Quality is a core feature of Game Sense and its focus on the intellectual aspects of games distinguishes it from traditional directive, technique-focused approaches. While the new outcomes based curriculum in NSW sets out clear expectations students are expected to gain from PE, there is no identification as to how this can be achieved.

The emphasis that Game Sense places on higher order thinking fits in well with the intellectual Quality of Teaching Framework. Game Sense encourages higher order thinking in two basic ways. First, it occurs through the use of language. This occurs in the discussions between students seeking to solve tactical problems that arise in games and the class reflections upon action that the teacher encourages with generative questioning during and at the conclusion of the lesson. As Light and Fawns (2003) argue, thinking also occurs during games in an embodied way that bypasses language yet communicates meaning between students.

As Light and Fawns suggest, this can be seen a case of the body thinking as students take in cues, perceive what is happening around them and make a range of instant decisions in a way that bypasses the conscious mind. As Dewey

(1936/86) suggests, these can be seen as the body's 'mindful actions' in the form of intelligent movement in games. When the class stops to reflect and discuss, thinking is expressed through speech where the students are encouraged to develop strategies, ideas and concepts. This in turn encourages the students to think about the body's movement and its relationship to the dynamics of space and time.

… TGfU lesson can be seen as a holistic learning process in which the movements of the body are the grammar of the game informed by the articulated reasoning between games. This allows us to see the continuity between the reasoned articulations of play and the students informed movement in games. In this way, speech, thought and action interact to construct individual and collective understandings in a more integrated, cohesive, and human class dialogue. (Light & Fawn 2003, p 167.)

Deep knowledge is provided in Game Sense as students must be familiar with the concepts and key ideas of games and need to be able to apply this knowledge when playing games. They develop, not only a knowledge of games that can be articulated but also knowledge at a deeper, embodied level that is expressed in action within games. Forrest, Webb & Pearson (2006) suggest that deep knowledge develops over four stages of: 1) Elementary understandings of games within a game category, 2) elementary understandings of games across game categories, 3) Advanced understandings of games within game categories, 4) Advanced understandings of games across game categories. The game categories of invasion, striking, net wall and target games emphasize the common tactical dimensions of games within a category. Recognising and understanding the common tactical concerns that games within categories share suggests that the development of deep knowledge is significant in the ways that it can be applied beyond the limits of just the one sport. For example, the long ball used in soccer (football) is a tactic used when the offensive side has a height advantage in it's the height and aggression of its attacking players in competing to head the ball in the air. This is the same in Australian football when forwards compete to 'mark' a long high ball in front of goal. In both cases the time of the ball in the air gives both sides time to contest it. Some similarities are also evident with the use of a high punt in rugby. Understanding of common tactical concerns across games would suggest even deeper and more significant knowledge although these are usually less specific.

Deep understanding is ensured when students are encouraged to think during questioning and demonstrate their understanding in informed action within games. Problematic knowledge is well addressed as knowledge is socially constructed and students are forced to explore multiple and sometimes conflicting interpretations. In Game Sense students explore different strategies, discuss how effective they would be and would, test them in games, evaluate results and build on this to scaffold on developing knowledge. They analyse what had taken place in games and the ways in which they could improve in the game as an individual and as a team. Higher-order requirements are met in

Game Sense as teachers provide opportunities for students to share and demonstrate it. This, in turn encourages students to create new meaning and understanding and to solve problems. Meta-language incorporates showing how language and symbols can be used. In Game Sense, the teacher needs to be explicit about how symbols work and to encourage the student to incorporate them into a game. This may be in the form of tactics or in the discussions when some aspect of the language is discussed. Substantive communication incorporates the question/response that takes place during 'team talks' but goes beyond this where sustained and reciprocal interaction occurs. This can take place in any form and students are encouraged to scaffold the conversation.

Quality learning environment refers to pedagogy that creates environments where students work productively and are clearly focused on learning. As Dewey (1916/97) suggests, children don't learn through direct instruction but through engaging with the environment. He argues then, that the teacher's most important task is to structure and create a suitable learning environment. This is how Game Sense works-by the teacher creating a particular physical and social learning environment.

Explicit quality criteria forces students to analyse the quality of work they are producing, and in Game Sense this would include their participation, interaction within the game/group and the standard of their performance physically, mentally and socially. The criteria they need to meet would be reinforced throughout the game. Engagement is ensuring that students are on task and are deeply involved almost all of the time in the game. This would include physical participation and intellectual and affective engagement.

They would also be seen to take the games seriously and trying their hardest. High expectations encourage students to take risks in the games and be recognized for doing so. The games need to be challenging yet provide opportunities for all students to achieve goals and taste success which would in turn motivate students to strive for greater success. Social support would involve supportive behaviours and comments from peers and teachers. This is met in game sense through praise, teamwork and encouragement of each other and the opportunity to build collaborative understanding and knowledge.

This needs to involve providing support for reluctant students and ensuring that all contributions are valued and acknowledged. When the teacher designs the modified games to be used they typically encourage the inclusion of all players regardless of ability. Rules such limiting dribbling in basketball to three bounds prevents individual players dominating. With this rule in place the player in possession is forced to look for other players to pass to then reposition him/herself to receive again. In addition to such modifications the use of team talks where players discuss tactics involves the less physically able students.

When the teacher builds a culture of trust and support among students this further contributes towards the development of a quality learning environment. Game Sense is ideally suited to the creation of quality learning environments. The capacity of Game Sense/TGfU to do this is very evident in Australian

research (Chen & Light, 2006; Light & Georgakis, 2005; Light, 2002). Students' self-regulation is well met in game sense as it allows students to demonstrate autonomy and initiative in regulating their own behaviours. There is little disruption and the teacher can get involved in the game discussions or encourage students to take ownership. Student direction encourages students in game sense to determine many of the significant aspects of the lesson or game independently or can look to the teacher for approval.

Significance: Games taught using a Game Sense approach give students the opportunity to develop social skills and problem solving abilities that they can use in life situations where they need to be aware of others and anticipate the actions and intentions of others. While students learn to be better game players there is also a wide range of social, affective and intellectual learning and development that arises from the process of learning in Game Sense.

As Light and Fawns (2003) suggest, learning in Game Sense involves a way of being in the world. The world involves relations with people, things and places and "students are not just speakers, writers and thinkers but also doers' as is the case in the Game Sense lesson (Light & Fawns, 2003). The NSW Department of Education and Training (2003b) defines two elements of quality teaching that are highly relevant to Game Sense.

Background Knowledge refers to lessons that regularly and explicitly build from students' existing, real life background knowledge in terms of prior school knowledge, as well as other aspects of their personal lives. The other element of Connectedness involves learning activities that rely on the application of school knowledge in real-life contexts or problems, and provide opportunities for students to share their work with audiences beyond the classroom and school. (p.15). Both of these elements involve connecting to real-life situations. Background Knowledge is backward looking and makes connections with previously existing experience or knowledge. Connectedness is forward looking and makes connections with newly acquired knowledge or experience.

Game Sense draws on students' background knowledge of other games they have played in the past and asks them to draw on this knowledge (and experience) to solve problems and build upon it as games develop in complexity in the Game Sense lesson or unit. This includes rules, skills, tactics and previously observed sport/game interactions, as well as personal significance with the peer group. Cultural knowledge is recognized in Game Sense, as someone's culture is not a determining factor for the success of being involved in a game.

Knowledge integration is ensuring we regularly make connections between topics and subjects and this is done in a number of ways in Game Sense. We question students about different strategies needed in games to improve their success. These include Science and Mathematics, such as speed, direction, velocity, measurement and we draw on other interaction and social skills that are developed in a number of key learning areas. There is also considerable significance for day-to-day life. As Light and Fawns (2003) suggest, games are like life.

The tactics, methods of problem solving and relationships developed in Game Sense lessons apply to social life outside school. For example, when students gather in groups to develop tactical solutions for developing a defense in a 5 Vs 3 small-sided game of touch football they are leaning more than tactical understanding. Hey are also learning how to cooperate, how to draw on others' ideas to arrive at collective solutions and how to best contribute towards a group goal.

This is very important and significant social learning. Not only is there pedagogy for identifying and solving tactical and technical problems but also for solving moral and interpersonal problems. When issues of right and wrong arise in games the same collective problem solving, facilitated by the teacher, can be used to discuss and deal with such problems.

The expectation to be inclusive is particularly well met in Game Sense as students from all groups are included in all aspects of the lesson and their inclusion is both significant and equivalent. The reduction in the demands of technique, modified rules that prevent domination through superior power, speed or skill (such as a 3 bounce dribble limit in basketball) and the emphasis on group collaboration all provide for inclusion and a supportive social environment.

Connectedness is met when students recognize and explore connections between classroom knowledge and situations outside the classroom in ways that create personal meaning and highlight the significance of the knowledge for their lives. Game Sense achieves this as students apply skills and knowledge they have gained in the classroom, such as the rules, teamwork, working in groups, social skills and an increased understanding of how the body moves and how this can be adapted to games. Narrative is used throughout the lesson to enhance the significance of the substance of the lesson. This is done during 'team talks' where ideas are discussed and questions asked and answered and strategies are incorporated into the game.

The NSW quality teaching model of pedagogy provides an important framework to reflect on the strengths and weaknesses of our current teaching and assessment practices in physical education. The new NSW syllabus provides the opportunity to focus our energies on the art of teaching and to begin programming high-quality learning experiences and assessment tasks to reflect the new requirement s of the course. Game Sense meets all the three dimensions of quality teaching practices and should be incorporated into all PDHPE programmes so that all students have the opportunity to experience it and receive many of the benefits it offers.

The NSW QTF offers the opportunity for teachers to highlight the intellectual aspects of games and sport that have been ignored for so long by traditional directive teaching approaches. This, in turn, as Light and Fawns (2003) argue, offers a welcome means of bringing physical education into the mainstream school curriculum.

Because Game Sense draws on student experience and knowledge and the learning is in a larger social and cultural context it is useful and applicable beyond games and schools in everyday life.

Game Sense pedagogy with its student-centred, inquiry-based approach provides not only relevant and significant knowledge per se, but also a way of learning how to learn and a way of negotiating the challenges of social life that confront young people moving into an adult world.

Game Sense generates an increase in expectations as to what it means to be physically educated to include learning how to learn and how to live in society. PE teachers using the Game Sense approach will not only be able to meet the requirements of the NSW Quality Teaching Framework but will also be able to provide high quality learning experiences for students and make a start towards making physical education a truly valuable educational experience in NSW schools.

ILLNESS EXPERIENCE AND HEALTH CARE

The WHO Report addresses the problem of the unequal distribution of health in the world today. Income, access to health-enhancing resources, political and social freedom and other means for achieving health are unequally distributed across the world. Political institutions, social and economic structures, and cultural codes often dispossesses people in certain countries or certain groups of people, who are deprived of chance to fulfil their life potentials. This report is not content to address the causes of disease, but explores "the causes of the causes" of the deprivation of health, and put the health issues squarely in wider context of the globalizing world. It shows that large-scale social forces crystallize into the health deprivation of a locale and they are embodied into the suffering of dispossessed individuals.

This is an inspiring document and suggests some possible ways for historians of medicine to contribute or collaborate with the programme, both explicitly implicitly. The closer examination of the locale of action is an obvious way for a historian to contribute to this programme. This document is truly global in its vision, and few historians are prepared to conduct research in this scale as an individual. Historians are more comfortable at in-depth analysis of relatively small locales.

The report's strong orientation for the future is another feature which is fresh for many historians, who are more accustomed to examining the past. Although change for the healthy world needs new directions and innovative policies, history "teaches" that many successes in improving health relied upon a new use of traditions and old institutions. These two aspects of the local study for global action and the examination of the older layers for change for the future hold promise for the historian to contribute to and benefit from this programme.

The problems analysed and depicted in this report are rooted both in the large-scale historical systems and local contexts. The alleviation of suffering should be conceived in the global context but should be implemented locally in order to benefit those living in the places of deprivation. Means to solve the problems too lie both in the global action and the activation of local resources. As Paul Farmer writes, in order to tackle health problems of a locale, be it a

village in Haiti or prisons in Russia, one should not just think globally and act locally, but one should "think both globally and locally and act in responses to the both levels of analysis" (Farmer, 2003) What follows is a historian's attempt to think locally in search for the potentials for the improvement of health status, using the example of Tokyo in the 1930s.

The material of this paper is concerned less about medical policies of the state and the role of those doctors who closely worked with the state. This paper intends to present a different historiography and different problems. My first concern is introducing "the patient" to the discussion of modern Japanese medicine: or, to use the phrase of the late Roy Porter, I aim at practising "medical history from below" in modern Japanese medical history (Porter and Porter, 1988).

Particularly, I will focus on the subjective experience of illness of the patient and subsequent health-seeking behaviour. Since many cases of experience of illness lead to an action to alleviate the pain or disturbances of one's body, the discussion below will necessarily involve the question of therapeutics, especially the patient's choice of therapeutics, drugs or remedies.

Patients' experience of illness in Japan has been typically explored by historians through qualitative evidence, such as letters, diaries, and autobiographies. (Fukuda 1995) To overcome familiar limitations of such sources as the strong bias towards highly educated "elite" patients and the difficulty to generalize from a small number of case studies, this paper utilizes quantitative data that include a fairly large number of patients from various classes.

The data have been taken from the archive of Takinogawa Health Survey (hereafter THS), which was conducted by Ministry of Health for one year from May 1938. The (then) Metropolitan Ward of Takinogawa lies in the north-eastern outskirt of Tokyo, an area which was rapidly urbanized from the late nineteenth century. Its residential population was a mixture of the wealthy and the poor, and the middle-and working-classes. Scattered mansions of aristocrats gave the area the aura of grandeur, and famous intellectuals and literary celebrities flocked to form a community.

On the other hand, a large number of skilled and unskilled workers lived there and worked in large factories such as the Arsenal for the Imperial Navy and the Printing Office of the Mint Bureau, as well as in small factories of various sorts, among which rubber factories were prominent after the First World War (Araki, 1923). From this mixed population, 370 households, or about one-sixtieth of the entire households of the Ward, were selected as the subjects of the survey.

These households were chosen to include families of various income, class, and background. The selected sample thus included both the destitute and the wealthy. In total, the selected household had 2330 individuals at the beginning of the survey. The subject population of the survey fluctuated due to emigrations and drop-outs (n=283), births (n=36), and deaths (n=24). I excluded emigrants and drop-outs, but kept the newborns and the deceased, which means that the

following analysis is based on the illness experience of 2059 individuals in Tokyo on the eve of World War II. Those subjects were surveyed in both intensive and extensive ways. Each household was asked to keep a diary to record its members' illness experiences, with its nature, duration, types of treatment sought after, and the expense for the treatment and related expenditure. Surveyors made regular monthly visit to the families, examined the diary, asked explanations about ambiguous entries, and made monthly records of the diary entries. Such visits were repeated for a year, after which the monthly records of each individual were transcribed to a tabloid-sized sheet.

The sheet contains not only records of illness episodes, but also various items of information about the individual and about the household to which he or she belonged. The detailed background of this large-scale survey remains to be examined, but it is certain that the major reason lied in state's move to wartime planned production of medicines and re-organization of medical service for the wartime economy. (Komine, 1939) The Ministry of Health tried to assess the consumption of medicines and medical service by the people, whose health was regarded the key in the inevitable total war with US.

From the account above, it must be clear that THS dealt with self-perceived or subjective morbidity, not with objective morbidity such as incidence or prevalence (Riley, 1987, 1997; Johansson, 1991). Whenever the subject felt sick or ill for a continuous period and took some action in response, the illness episode was recorded. Analysis of the incidence of illness in THS has thus only limited value from a purely epidemiological viewpoint, since it did not involve medically reliable assessment of the bodily state by qualified doctors. From social historical point of view, however, THS offers a unique window into the question of how frequently people perceived themselves to be ill and took action against the illness.

Both common sense and several pioneering works by Edward Shorter, James Riley and others suggest that subjective morbidity and objective bodily status do not always agree. Some individuals are hypochondriacs suffering from *maladie imaginaire*, while others hardly notice serious illness which has befallen their body. THS allows us to examine such discrepancies between subjective and objective morbidities with solid statistical basis.

The greatest discrepancy between the two morbidity indices is observed in elderly people. When one uses the duration of illness episodes, or their expenses, as an alternative index of morbidity, the parallel of mortality and morbidity in middle-and old age does not become greater: the average days of sickness per person per year decreased after the peak in the age group of 40-49, again failing to respond to the rise of mortality for those over 50. Expense shows a similar curve, although it exhibits more substantial rise in those over 60. Elderly people in Tokyo in 1938 behaved as if they had been spectacularly insensitive to, or unable to act against, the increasing frailty of their body.

The apparent insensibility to one's disease or inertia in health-seeking behaviour among the elderly did not change until the 1970s, when the Scheme

for the Medical Expense of the Aged made medical service for the aged virtually free and old people's visits to doctor showed a drastic increase. It should be noted, however, the lack of insurance does not explain the senescent inactivity in health-seeking behaviour. Although insurance made some impact on the reported morbidity pattern of Takinogawa residents and the morbidity of insured individuals was generally higher, the medical inactivity of the elderly is still observed for the insured as well as for the uninsured. Although it is certain that the elderly in Tokyo in 1938 did not receive treatment which they certainly needed, the uneven distribution of the treatment to the younger sector of the population meant that the other end of the frail population was getting a fair amount of medical attention.

The children of the age group of 0-4 years old received treatment the most frequently; in terms of per capita expense for treatment, they claimed the largest expense second only to those over 60 years old; in terms of the total expense, 234 individuals (about 10% of the total) between 0-4 years old used up about 16% of the entire expense; the 507 individuals between 0-9 years old claimed about 25% of the total expense. Whether this was "enough" attention was a different matter, but the young children were getting a large proportion of medical attention and resource within their family.

It should also be noted that this proportional generosity to the medical needs of the young members of the family was observed across different social classes. If we divide the families to the "higher income" and "lower income" according to the rent (or its equivalent) of the house they lived in, the high-income and low-income families paid the same proportion (16%) from the total expense to their infants and children. Valuing the health of their children was not restricted to well-off families. This attention to the health of children was a component of medical culture which the post-war rapid improvement of health status of Japan could certainly build upon.

If we turn to the difference in subjective morbidity according to sex, another interesting twist appears. Male and female morbidities were virtually the same until they came of age. After the age 20, they started to differ. Female adults reported illness and took curative measures much more often than their male counterparts, especially in the age groups 30-49, when their mortality was only slightly higher than that of males. They not only reported illness more frequently: they visited doctors more frequently, under medical treatment for a longer period, and spent more money on health. Even when those who gave birth during the survey were excluded, female excesses persisted. The male excess in mortality after the age of 40 did not reverse the situation, although the gap between the morbidities of men and women became smaller.

Although a handful of diseases specific to women played some part in the overall female excess in morbidity, they were not the sole reason why women reported more illness than men. Illness episodes related with pregnancy and childbirth and other gynaecological problems were naturally reported only by women. The large female excess in dental problems was also related with the

biological consequence of pregnancy, due to the deficiency of calcium after childbirth. Frequent childbirth was still the norm at that time, and female reproductive activity depleted nutrients from women and resulted in higher morbidity. On the other hand, the "cracks in the skin" were related with social division of labour. These were itch in the hand, associated with the use of cold water during winter. Women's predominance in this category was little doubt due to their performing household duties: women rinsed rice before boiling, washed dishes, and did laundry works.

These were thus occupational health hazard for adult women, so to speak. Stiff shoulders, or "katakori" in Japanese, were a culturally conditioned illness category whose major symptom was dull pain around one's shoulders. They are believed to be a local disease of Japan (Kuriyama, 1997). Its mechanism remains a mystery to the present, but researchers agree that sedentary work, stress and psycho-somatic causation played a large role. Probably, the physical burden of household chores and psychological stress caused by them underlay the female excess morbidity in this category. The same mixture of the somatic and the psychological or the biological and the cultural was present in women's excess morbidity in other categories.

Women reported that they got cold more often, they had more injuries, more skin problems, more headaches, more respiratory symptoms, more ophthalmologic difficulties, and more gastro-intestinal disorders. Illness episodes in these categories might have some basis of real difference of the bodily status of men and women. It is, however, hard to conceive that female bodies were susceptible to respiratory diseases twice as often as men's, without any correspondingly large differences in the mortality of such diseases.

It is almost certain that adult women's higher subjective morbidity in those diseases resulted not only from their bodily status, due to their reproductive activities and their occupational hazard, but also from their lowered threshold of illness and readiness to treat the condition through various means. There is even possibility that the women's knowledge of female excess mortality heightened their semi-hypochondriac sense of being "at risk", resulting in more active behaviour in their health-seeking. On the other hand, the male culture of bravery and perseverance might have resulted in underreporting of their ill-health.

Adult women's higher subjective morbidity, particularly their larger expenditure on medicine, is at least mildly surprising, for we are accustomed to think of pre-war Japan as a patriarchal society in which women's political and civil rights were severely limited and their voices were suppressed. According to the stereotype, men got the lion's share of food, clothes, and health care at his home, while women persevered on meagre food and endured their illness in the spirit of self-sacrifice. Data from THS controvert a certain part of this image.

The women in Tokyo on the eve of the Pacific War expressed their illness experiences and took action to alleviate the pain or sickness more often and more extensively than men. High health-consciousness of adult women was

another factor which was to act favourably to the rapid rise of health status in post-war Japan. Indeed, the large medical attention the children were receiving might have been closely related with women's keen consciousness of their own health and the dynamics within the family that allowed this consciousness to be translated into actual health-seeking behaviour and expenditure for the purpose. Japanese women were able to put themselves and their children at the centre of the health strategy of the family even before they received political and civil rights.

The ultimate goal of THS was to measure people's use of drugs and other medicinal matters. Among various measures of treatment recorded in the survey, two measures were particularly important, namely consulting a doctor and taking over-the-counter (hereafter OTC) medicines. Of the 4879 illness episodes, about 1600 involved seeing a doctor, and OTC drugs were taken in about 3000 occasions. Other categories listed by the survey, such as folk medicine, religious healing, and alternative medical practice contributed much less, each counting about 500, 170, and 70 episodes respectively. Indeed, since seeing a doctor almost always resulted in getting medicines rather than a prescription (in Japan doctors, not apothecaries, sold medicines), "buying medicines" constituted the major bulk of health-seeking behaviour of the subjects of THS.

OTC was numerically important, while seeing a doctor claimed a large amount of the families' expenditure on health. About two-thirds of illness episodes involved taking patent medicines, while seeing a doctor took place in about one-third of all episodes. The ratio of expenditure, however, was reverse: OTC claimed only 6 % of the total expenditure on health, while seeing a doctor counted for about 55% of the total: if one includes additional expenses which accompanied seeing a doctor (payment for nurses or "gratuity" for doctors), it rises to about 70%. OTC drugs were the first means people resorted when they felt sick. Generally speaking, OTC medicines did not cost a lot.

The median figure for the expenditure on OTC drugs was 0.2 yen. It had become even cheaper in Tokyo after the abolition of the regulation of prices in the early 1930s and the sales of OTC drugs increased rapidly. More importantly, substantial numbers of the OTC drugs (at least 10%) were sold using a unique mechanism of "haichi-yaku" or medicines left with a customer, with those medicines used in the interim being paid for on the peddler's next visit. This mechanism saved the time to visit the druggist and lowered the psychological hurdle of "purchasing" the medicine at the time of illness. Unlike "quack doctors", the peddlers of haichi-yaku were honest and trustworthy salesmen, who reached deep into rural areas of Japan. On the other hand, seeing a doctor was expensive. The median is 2.2 yen, about 10 times as expensive as OTC.

Medical consultation and OTC drug-taking presents particularly interesting questions. The choice between these two measures has been studied in the context of modern health economics as a choice between expensive and "correct" or culturally legitimate treatment favoured by well-off and better-educated individuals on the one hand and cheap but ineffective one resorted by the poorer

and less educated ones on the other hand. In THS, seeing a doctor was, generally speaking, substantially much more expensive than treating one's illness through OTC drugs. As expected, medical consultation was favoured by those with larger income. For individuals belonging in the lowest rent-band A, a qualified doctor was consulted in only one-fifth of entire common cold cases, with the majority of the rest being treated by OTC medication. As we go up the rent-bands, the percentage of medical consultation becomes progressively larger, and at the top rent-band D, one-third of the common cold cases were treated by a doctor. Towards common cold, richer and poorer individuals assumed different attitudes: the former being much more likely to seek a medical consultation, the latter much less likely to do so.

Treating one episode of common cold by OTC medicine cost on average 0.26 yen, while consulting a doctor for the disease cost 7.46 yen, thirty times as much. Moreover, consulting a doctor involved hidden cost of fee for a house call the patient's travel expense, which certainly deterred poorer subjects from seeking treatment by a doctor. Likewise, in treatment choices for acute infectious diseases, the gap between poorer and richer subjects was even wider than in the case of common cold. In the lowest rent-band, only 26% consulted a doctor and 67% employed drugs without seeing a doctor, while in the highest rend-band, 65% consulted a doctor and only 18% resorted to OTC drugs. Dental problems and other categories of diseases show a similar pattern.

In these cases, almost certainly the principle of substituting expensive goods for less expensive ones was operating for the patients with lower income. The situation was, however, much more complex. First, note well that the extent of substitution differed considerably from one disease category to another,. Although treatment choices for dental episodes show the same pattern of progressive increase in the usage of medical practitioners, the rate was very high even among poorer subjects, reaching 56%. Moreover, treatment for external injuries did not show the pattern discussed above: the rate staying roughly fixed around 20% for all four rent-bands. The threshold between injuries that could be coped with OTC drugs and those injuries that needed a consultation with a doctor did not change greatly according to one's economic status. Indeed, in gynaecological problems, beriberi, brain and heart problems, the poor consulted a doctor about as often as the rich. These conditions are serious diseases and some of them resulted in the death of the patients. The data thus suggest that the poor took recourse to costly medical practitioners as often as the rich when they regarded it necessary. This is again mildly surprising: with health insurance far from universal (only 150 from 2342 subjects covered by the National Health Insurance), seeing a doctor must have been a considerable burden on the poor.

ILLNESS AND PERSONALITY

We have entered an age where vast numbers of people are moving away from scientific explanations and putting all their energies into believing

alternative viewpoints, such as Intelligent Design (ID). The ID movement is so strong that it is slowly being introduced into schools around the globe and given equal weight with the teaching of evolution. The manner that ID is being sold as an alternative to evolution seems to be exploiting a fundamental attribute characteristic of humans: belief creation. But just how do we form our beliefs, and how do we know if a belief that we hold is wrong? One way that researchers are currently exploring this area is by looking at people who suffer from various mental illnesses, such as schizophrenia, where delusions experienced by patients are believed to be true. By taking such an approach, medical researchers can determine whether the belief that a person holds meets the criteria of a delusion. Of additional interest is the fact that some of this research takes in other scientific and philosophical disciplines in an effort to answer some very fundamental questions.

Mental illness is defined as a condition that causes serious abnormality in a person's thinking or behaviour. From what is known of the brain, it seems that mental illness is caused either by direct physical damage to the brain itself, or a number of psychological disorders that have developed for one reason or another over time. In the past, these differences have distinguished the fields of study involving the brain and cognition. Traditionally, psychiatry, psychology and other disciplines have played an important role in understanding how the mind functions, while neuroscience has mapped and observed how different areas of the brain interact. In the past, philosophy of mind has not been considered a serious option in regard to the diagnosis and observation of mental illness. But the inclusion of philosophy is becoming more common as psychiatry, psychology and neuroscience advance. The advancement and convergence of the various brain sciences demonstrates how difficult it is to reconcile the physical and psychological processes of the brain, and that the evidence currently available is far from adequate in answering many of the big questions about the brain, such as delusions in the mentally ill.

A rudimentary explanation of delusions is that people strongly believe something to be true in the face of evidence to the contrary, giving rise to false beliefs. These false beliefs can originate in many ways, but more usually they arise because someone may misinterpret another's actions or misread their intentions. But how do we know that these closely held beliefs are actually false? Before discussing that aspect, it might be useful to look at some more obvious examples. Having a "phantom" limb is a condition where a person believes that they can still "feel" a limb long after it has been amputated. The Director of the Centre for Brain and Cognition at the University of California, Professor Vilayanur Ramachandran, even refers to cases where it is not uncommon for amputees to believe that their phantom limb waves, picks things up and feels pain. This suggests that limbs are "wired" to other networks within the brain, so that in the case of an amputee the brain continues to register the limb as still present. Ramachandran explains that these sensations are a result of an exact representational "map" of the body, known as the Penfield

Homunculus, telling the brain how the body is constructed. The phantom limb comes from the Penfield Homunculus not having had time to readjust after a limb has been removed.

Though the above example does not constitute a mental illness as such, it does raise questions of how much autonomy is present in any person's mind over what we can say we think about. It does seem that much of our thinking relies on "hardwired" neural networks that continue to function long after they have outlived their usefulness. This is probably somewhat true of the way that we hold our own beliefs on cultural phenomenon like religion. This becomes easier to notice when the belief system of a person begins to override or take control of a person's mind, which manifests as a mental illness. Schizophrenic people are just one of many examples where visions and the irrational behaviour that they may provoke are something that they find nigh on impossible to control. "Unlike normal people, the schizophrenic can't tell the difference between their own internally-generated images and thoughts versus perceptions that are evoked by real things outside," says Ramachandran. Bill Fulford, Professor of Philosophy and Mental Health in the Department of Philosophy, University of Warwick, says that a: "schizophrenic patient may be well aware that their experience is odd." Unlike the person with the phantom limb, however, it is considerably more difficult, if not impossible, for the schizophrenic to independently verify that they are actually experiencing a delusion, especially if a certain level of paranoia accompanies the delusion.

Neuropsychologist Max Coltheart, from Macquarie University, claims that it's even difficult to say what is meant by delusion. "For instance it seems to me that if you believed 2,000 years ago that the earth was round, that's a delusion. It's a delusion because nobody else believes it and you've got no evidence for it. It happens to be true but you can have delusions that are true, the crucial thing is do you have real evidence for this? Is it what people generally believe? So in our research centre we have to be very interdisciplinary, we need someone who can tell us what the concept of belief really means. That's been completely neglected in psychology but it's been studied in philosophy for two and a half thousand years and so a lot of our work is done in collaboration with philosophers of mind who can say, no that's not really what you mean by the concept of belief. So they can say to us 'well, why does a delusion have to be false?' And then one thinks yes, that's a good question, that's a typical philosopher's question. I'm making a mistake if I require that delusions be false. What the philosopher has shown to me is that what I really think is it has to be impervious to evidence. That's what's crucial; it doesn't matter whether it's false or not."

So, if a belief cannot be falsified, if it is impervious to evidence, it is, more than likely, a delusion. Coltheart says that once this criterion for delusions has been established, they can set about finding out why the person is impervious to evidence that is contrary to their belief. Having this understanding, says Coltheart, allows a more scientific approach, because in many cases the delusional state is a result of damage suffered to the right side of the brain.

There is always a "but" when it comes to how the brain works, however, and this case is no exception. "Across a range of delusions the answer sometimes is right hemisphere brain damage but it isn't always. So our choice is to say, we'll just stick to delusions that are clearly due to brain damage, or we'll be more ambitious and try and apply this two-factor approach, even to cases where we don't think the effect is due to brain damage," says Coltheart. This is why mental illness is so difficult to pin down, as it seems that many of these illnesses manifest from the extremes of an ability that we all have: belief formation. Coltheart adds that they are a long way off from a complete theory, but he does think that people suffering from delusions have an impairment of their system for evaluating beliefs.

Coltheart's theory of not being able to control the evaluation of beliefs may be consistent with one particular social disorder. How we present ourselves to society everyday, and how think we appear to other people seems to be an important factor in human relations, and many studies have shown how the face and body are crucial to how we judge other people. Take the little known, though not rare, disorder of Body Dysmorphic Disorder (BDD), where proper categorization is still contested by doctors. According to one definition, people with BDD are excessively preoccupied with an imagined or slight defect in their appearance. As a result, social interactivity and functioning are significantly impaired, causing distress. Researchers agree that BDD does not meet the criteria of other bodily-related disorders, such as anorexia nervosa, but it can have equally devastating effects, as BDD can lead to self imposed isolation and eventual suicide. Katherine Phillips, in her book Broken Mirror, describes cases of self-surgery that patients turn to in desperation, with predictably horrendous results. In one example, a person who was unhappy with the shape of their nose cut it open and replaced their own cartilage with chicken cartilage. BDD has a long history, and Phillips has found 100-year-old records that accurately describe BDD behaviour patterns.

Ramachandran claims that: "brains are essentially model-making machines. We need to construct useful, virtual reality simulations of the world that we can act on." Both Stephen Pinker and Ramachandran claim that society is what ultimately shapes the way in which we think, and the way that we model the world for our own understanding. They also seem to agree that human behaviours are for an evolutionary purpose; survival as a species, say. The plasticity of the brain makes humans capable of change and adaptability, but it also means that there is a chance that this characteristic might work against us. In this respect, the adaptive potential within the brain goes pear shaped. In the case of BDD a person becomes overly obsessed by the way society expects them to present their external appearance. It is interesting to note that BDD nearly always begins in adolescence. Neuro-scientists agree that the way the brain becomes wired when we "learn" something new is not the same for everyone. That is, if I learn the meaning of the letter "B" and everything associated with the letter "B", my brain doesn't care through what neural networks it passes, so long as the meaning

of "B" is clear to me. Subsequently, it's possible that in the process of learning something as a child we might become more prone to believing one thing more than another person would.

Coltheart describes how a person might believe that aliens have abducted them because as they awoke from sleep they felt paralyzed and they felt as though they were floating up to the ceiling. In his study, participants explained that these "abductions" always took place in the morning when the subject was waking. Coltheart explains that these sensations are called hypnagogic hallucinations and they are experienced by 30 percent of the population. But the question is why the subjects were so willing to believe that they are being abducted over any other available explanation. "In this study, everybody who had the alien abduction delusion… also had new age beliefs throughout their life. So they are willing to accept the possibility of alien abduction; I wouldn't be," said Coltheart.

So, while you can explain to a person who holds such beliefs that there are other explanations, it is unlikely that you will shake their belief that it was in fact aliens that abducted them. Their model of the world somehow includes Earth visiting aliens as a real possibility. This type of thinking can be related to religious beliefs as well, and because religions have such a long tradition and such devout followers, the delusion is reinforced tenfold. In reality, however, the religion is no more testable than other delusions. It might be comforting to know that Ramachandran considers the brain to be very plastic and pliable, so a person changing their beliefs over time is not entirely impossible.

There is still much to learn about the brain, but if the examples above are any clue, then we know that many of the beliefs that we hold have developed over a long period of time. As Ramachandran says, brains are model-making machines that ultimately determine how we view and behave in the environment that we find ourselves in, and our beliefs are a product of this model.

It is important, then, that we feed this model-making machine with the right information, which does not include teaching children belief systems that cannot be verified or tested by any available means. If society's goal is to avoid people forming beliefs that are not grounded in reality, beliefs that are impervious to evidence, then why would we deliberately set out to teach a system that is itself impervious to evidence? Like the person who still feels their limb after it has been removed, once learned and integrated into the neural networks, these false beliefs are hard to shake, and will continue to guide an individual's thinking for a long time.

PHYSIOLOGICAL ASPECTS OF PHYSICAL EDUCATION

The physiological aspects of physical education encompass the study of how the human body responds and adapts to physical activity. This field explores various physiological processes, including cardiovascular, respiratory, muscular, and metabolic responses during exercise. Understanding these aspects is essential for designing effective physical education programs and optimizing athletic performance. Muscular responses entail the contraction and relaxation of muscles to produce movement. Regular physical activity strengthens muscles, improves endurance, and enhances overall muscular function. Metabolic responses involve energy production and utilization during exercise, with different energy systems being utilized depending on the intensity and duration of activity. Moreover, the physiological aspects of physical education consider factors such as age, sex, fitness level, and genetics, which influence individual responses to exercise. By understanding these physiological responses, physical educators can tailor exercise prescriptions and training regimens to meet the unique needs and goals of their students. Furthermore, knowledge of physiological principles guides the development of safe and effective exercise protocols, minimizing the risk of injury and optimizing health benefits. Overall, an appreciation of the physiological aspects of physical education is fundamental for promoting lifelong fitness and well-being. It empowers individuals to engage in physical activity responsibly, leading to improved health outcomes and enhanced quality of life. The book on Physiological Aspects of Physical Education provides a comprehensive exploration of the body's responses to exercise, offering insights into optimizing athletic performance and promoting lifelong fitness.

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