# Sports Sciences SR1002

## Lecture 2

## When anatomy and physiology collide

* Bones of the skull join tightly to form a rigid case, protecting the brain
* Bones of the finders are more loose to allow movement
* Walls of lungs (air sacs) are thin, allowing movement of oxygen into blood
* Urinary bladder has a much thicker lining, yet it is stretchy as the bladder fills with urine.

## Sub disciplines of physiology

* Neurophysiology- Functional properties of nerve cells
* Endocrinology – Hormones in the blood and how they control body functions
* Cardiovascular – Represents functions of the heart and blood vessels
* Immunology – How body defends itself against disease-causing agents
* Respiratory – Represents functions of air passages and lungs
* Renal – Functions of the kidneys
* Etc. etc.

## Levels of organization

* Atoms
* Cells
* Tissues – Epithelial, muscular, nervous, connective
* Organs – E.g. stomach, liver, brain
* Organ Systems – Digestive, circulatory, nervous …

## Organ

* Heart
* Skin
* Lungs
* Stomach
* Kidneys

## Organ system functions

* Integumentary system (skin, nails, hair, etc.) – Protective function, insulates and cushions
* Skeletal system – Body protection and motion
* Muscular system – Contraction, responsible for virtually all body movement
* Nervous system – Control and communication
* Endocrine system – Coordinates and directs cellular activity
* Etc. etc.

## Necessary Life Functions

* Maintaining boundaries
* Movement
* Responsiveness
* Digestion
* Metabolism
* Excretion
* Reproduction
* Growth

Homework: Check lectures and get the directions of the body, inferior posterior etc. for test!

## Diseases that occur more frequently in women than in men:

**Osteoporosis:**

* 80% of patients with osteoporosis are women

**Autoimmune disease:**

* 3-fold more common in women than in men

**Depression:**

* 2-3 times more common in women than men
* Possibly linked to lower production of serotonin(neurotransmitter) in women
* Sex-based differences also present in incidence and expression of schizophrenia, post-traumatic stress disorder, panic disorder, other mental illnesses.

## Sex-Based differences in Disease: found in most (all?) organ systems

**Societal**

* Lifestyle/behaviour
* Environmental
* Healthcare

**Genetic**

* Linked to x- or y- chromosome

**Effects of the sex steroids**

* Androgens, Oestrogens, Progestin’s
* All present in both male and female
* Oestrogens & androgens physiologically important in both males and females.

## Sex hormones and Life Stages

**Prenatal Development**

* Sexual differentiation

**Maturation:** child, adolescent, young adult

**Variation with menstrual cycle in women**

**Pregnancy**

**Abrupt drop in oestrogen & progesterone at menopause**

**Gradual decline in testosterone with aging**

* Both men and women

## Sex-Based Differences in Normal Physiological Function

Cardiovascular system

Liver

* Lipid metabolism
* Drug metabolism

Central nervous system

Other: Gastrointestinal system, immune system, kidney, lung, skin etc.

## Sex-Based differences in Heart Disease

* Leading cause of death in men and women
* Heart disease starts 10 years later in women than men
* Stroke more common in women than men
* Multiple sex-based differences in co-morbidities, symptoms, progression, outcomes.

## Gender & the Heart

* Men have significantly greater left ventricular mass and chamber size
* Women have a lower resting blood pressure, and higher resting heart rate. Reduced tolerance to shifting posture or sudden changes in position
* Similarly, while blood pressure is lower in premenopausal women than in men, blood pressure gradually rises in postmenopausal women to levels equivalent to those men.

## Signs of Hear Attack

1. Chest discomfort or uncomfortable pressure, fullness, squeezing or pain
2. Spreading pain to one or both arms, jaw or stomach
3. Cold sweats and nausea

## Gender may affect symptoms

Women often don’t experience the ‘hallmarks’, instead:

* Shortness of breath
* Nausea
* Vomiting
* Sleeplessness
* Back pain or jaw pain
* Feeling of generalized weakness, fatigue in weeks prior to Acute MI

## Gender & Metabolism

* Females have higher % of body fat, lower muscle mass
* Women metabolise Carbs like glucose at varying rates depending on menstrual cycle
* Females burn more fat and less Carbs and protein during endurance exercise

## Gender & Lund Capacity

* Men have larger lungs, wider airways, greater lung diffusion capacity than women, even when these values are normalized height.
* In contrast to healthy young men, maximal exercise capacity may be limited by pulmonary capacity in women

# Lecture x – Respiration

## Introduction

* External respiration: movement of gasses between environment and the body’s cells
* Cellular respiration: Intracellular reaction of 02 with various molecules to produce CO2, H20 and energy (ATP)

## Airways

* Branching of airways- Trachea branches in to two bronchi, one to each lung. Each bronchus branches 22 more times, ending in a cluster of alveoli.
* Air is humid around Alveoli to keep them from drying out
* Mucus layer on alveoli traps inhaled particles
* Alveoli has Cilia and goblet cells which pass and produce mucus towards pharynx

## Alveoli

* Each cluster of alveoli is surrounded by elastic fibres and a network of capillaries.
* Rich network of capillaries around alveoli to pass oxygen
* Distance between alveoli and blood cells is microscopic, exchange surface
* Alveoli are composed to type I cells for gas exchange and type II that synthesize surfactant.
* Surfactant in between the two cells reduces the surface tension of the liquid in which it is dissolved.

# Week 3 Lecture 1 – Cardio-Respiratory Physiology

## Overview

Heart creates a pressure gradient in the circulatory system

## Heart- Gross anatomy

Just above the Diaphragm

Left & Right ventricles

Left & Right ventricles

Aorta

Superior vena cava

Pulmonary artery

# Week 3 Lecture 2 Tuesday - Heart

## Heart beat

The membrane potential always rises, from -60mv until it hits the threshold of -40mV, triggering the action potential. This potential creates a rush of calcium channels, which lowers the membrane potential back to resting potential. The pacemaker potential adjusts where the threshold is.

The action potential enters the muscle cells from adjacent cells. The Ca2 enter through the voltage gated channels. As Ca2 enters, more Ca2 enters from the sarcoplasmic reticulum. These ions bind to the troponin protein, which initiate the muscle contraction.

When the contraction happens, the troponin starts relaxation and Ca2 unbinds from it. The Ca2 is pumped back into the Sarcoplasmic Reticulum (SR) for storage. The Calcium leaves the muscle cell, it is exchanged with Sodium, Na+, and the Sodium gradient is maintained by the Na+-K+-ATPase ‘pump’. This pump takes calcium ions, pushes them back and uses ATP for energy.

The concentration of calcium doesn’t stay high in the cytoplasm for a long time, they are pumped out quickly. This begins relaxation of the troponin.

Troponin is made of Actin and Myosin which interact with the Ca2.

Cardiac Electrophysiology 1 & 2

Cardiac muscle cells must undergo action potentials for contraction to occur.

Depolarization in atrium and ventricular cells is due to the increase in cell membrane potential to sodium and calcium.

Calcium, mainly released from SR is the excitation –contraction coupler with the cardiac muscle by combining with troponin.

SR releases Calcium when it enters through the voltage-gated calcium channels in the plasma membrane.

Calcium does not usually engage all troponin.

Cardiac muscle has a long refractory period after a contraction.

Signal starts with both atriums, the wave is called the P wave.

The PR segment is the flat time after the P wave.

The signal enters the bundle, and then enters through the ventricles and they contract. These are all called the QRS complex. R is the highest point.

Then the wave flats out when ventricles relax -> Depolarization.

This whole process repeats each time the heart beats.

SA = the pacemaker node. It manifests a pacemaker potential which makes the threshold for the membrane potential to action potential.

Energy and Power

# Introduction to energy transfer and conversion

**Energy (E) = The capacity for work (W)**

* A dynamic state related to change
* Its presence emerges when a change occurs

SI-Unit

*Joule(J) = Nm = Ws = (kg \* m2) / s2*

Old unit: calorie (cal)

Energy required to heat 1g of water by 1C

1 cal = 4.184J

J and cal are used to describe energy contents of foods.

**Power(P) is the rate at which work is performed or energy is transmitted**

*P = W/S*

SI-Unit: Watt(W) = Nm/s = J/s = (kg \* m2) / s3

Power is used to describe performance of machines- Horsepower, kW, W etc.

## First Law of thermodynamics

* Energy cannot be created or destroyed, but is transformed.
* Conservation of energy
* Energy’s quality can change; it can become ‘diluted’ where it looses it’s ability to do work.

## Potential and Kinetic energy

* Potential energy – bound in a specific form
* Kinetic energy – Harnessing potential energy, biosynthesis

## Forms of energy

Chemical -> combustions, batteries, fuel cells

Mechanical -> Moving, turning masses

Heat

Light

Electric

Nuclear

# Energy Processes

## Biologic work in humans

Biological Hybrid Drive

# Energy Systems

Different energy systems are used regarding to different energetic demands.

* Supply Velocity
* Fuel Availability
* Oxygen supply

Immediate (ATP-PCr), short-term (glycolysis), Long-term (Aerobic) release energy at different times based on exercise duration.

## Phosphocreatine: The energy Reservoir

Immediate energy system

* Working skeletal muscle has a very high ATP turn over
* ATP reserves are too limited
* Fast regeneration of ATP from Creatine phosphate and ADP in situations with an exceeding ADP demand.
* ADP is phosphorylated to ATP
* Creatine is phosphorylated back to PCr during rest.
* Cells store 4-6 times more PCr than ATP

This does not use oxygen – That is why 100m sprinters have no use in breathing during the run.

# Energy Systems

Glycolysis

TCA/Krebs-Cycle

Electron Transport Chain and oxidative phosphorylation

Stage 1. Micronutrient digestion, absorption and assimilation into useful form

Stage 2. Degradation of subunits into Acetyl-CoA

Stage 3. Oxidation of acetyl-CoA to C02 and H20

## Glycolysis

First energy system

Blood Glucose -> Pyruvate > (Fast) LACTATE

* (Flow) KREBS CYCLE

Glycolysis needs ATP to start – activation energy

Lactate is formed when there is not enough oxygen to go around – acid that burns in the muscles

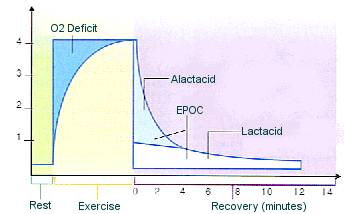
## Why is Pyruvate converted into lactate?

* Glycolysis is an oxidation
* Oxidation needs an electron acceptor
* During aerobic metabolism the final electron acceptor is 02.
* Without 02 the electron carrier NAD+ is recovered by a reduction of pyruvate

## Oxygen Debt – EPOC

= Increased oxygen consumption after exercise

Breathing goes up incrementally, creating lactic acid and a 02 deficit



Two major components of oxygen recovery:

* Alactacid oxygen debit (fast component)
* Lactacid oxygen debit (slow component)

Oxidative Phosphorylation

Uses the energy from generated by the electron transport chain to produce ATP

ADP + Pi -> ATP

## Energy release from fat

* Stored fat is the body’s most plentiful source of potential energy
* Two sources – Triacylglycerol in fat cells / Intramuscular triacylglycerol
* Marathon runners have more fat in their muscles than most people

Force – F

## A force is whatever can cause an object with mass to accelerate

Unit: Newton – N

1N = 1kg\*m/s2

Different forces:

* Gravitational
* Electric
* Magnetic
* Mechanic

Acceleration – a

## Changes of velocity are accelerations – can be positive or negative

Unit: m/sec2

G-Force – gravitational force

9.8 m/sec2

Velocity – v

## Speed of mass

m/s, km/h, mph

Fastest foot-speed: 44.64 km/h

We work against the gravitational force when we move. -> not in space

Torque - T

## Ability to rotate an object around some axis.

T = F x d

Unit = Nm

Torque is a vector: It has a value **and** a direction.

For work, force **and** distance must have the same direction

## For torque force-direction and distance are perpendicular

Torque can be increased by increasing the force **or** by increasing the lever arm.

Law of the lever arm – first described by Archimedes

Equal weights at unequal distances are not in equilibrium but incline towards the weight which is at the greater distance.

* A small force can lift huge weights by using longer lever arms

The load arm of a lever system is 7x longer than the effort arm. To lift the weight of 5kg (50N) a force of \_\_\_\_\_ is required.

350kg

350N \*\*\*\*\* <-

35kg

35N

35N

3.5kg

Muscle Structure

There are three muscle types, although skeletal muscle is almost always focused on.

**Smooth muscle**

**Cardiac muscle**

**Skeletal muscle**

Muscle fibres are connected to the bone with tendons. You have a lot of bundles/fibres with connective tissue to make a full muscle. Connecting tissue surrounds, scaffolds, the fibres. Tissues blends into the tendon and makes a direct connection to the bone.

Capillaries are in between the fibres that bring all the oxygen to get endurance, aerobic work.

Muscle -> Bundles of fibres -> Individual fibres -> Myofibril bundle -> Single myofibril -> Single sarcomere, all surrounded by connecting tissue.

**Sarcoplasmic reticulum** in muscles vs. **endoplasmic reticulum** in normal cells.

How do you actually use myosin and actin to produce movement? They create tension, relax and contract.

## Strength: The greatest amount of force that muscles can produce in a single maximal effort.

Muscle cross-sectional area increases strength.

## Hypertrophy

Muscle hypertrophy is the increase of the diameter of a muscle fibre in response to exersize.

More parallel sarcomeres

## Muscle Fibre Architecture

Different performance:

Fusiform: Fibres are in line with pull

Pennate: Muscle fibres that are not in line with pull

Multipennate: Many fibres in different directions not in line with pull

Nutrition Yo 20.10.16

## Outline

* Definition
* Measurement of food energy – fat, carbs, protein
* Determine a foods macronutrient composition and energy contribution
* Food labels

## Links Between nutrition & Disease

* Coronary heart disease
* Cancer
* Hypertension
* Diabetes mellitus
* Obesity
* Dental Caries
* Osteoporosis etc.

## Energy Intake

**Macronutrients:**

* Protein
* Fat
* Carbohydrate
* Alcohol

**Micronutrients**

* Vitamins
* Minerals
* Trace elements

## Measurements of Food Energy

* Joules, kJ
* Calories, kilocalorie = 4.164kJ
* 1 kcal – energy used to raise temperature of 1L water by 1C

## Gross energy Value of foods

* Heat of combustion – Lipid, Carbohydrate, Protein
* Comparing the energy value of nutrients – Lipid is the most energy dense food.

## Available energy of foods

* Metabolisable energy = (gross energy in food) – (energy lost in faeces, urine, secretations and gases)

Net energy value of foods

* Coefficient of digestibility
* How much is actually digested and absorbed
* 97% Carbs
* 95% Lipids
* 92% Protein

Protein requires the most energy to consume.

## 100 Kcal

* 5 carrots
* 20 stalks of celery
* 6.5 green peppers
* 1 Large grapefruit
* 1.25 eggs
* 1 tablespoon of mayonnaise (!!!)

## Food labels

* Serving vs. package size

More 24.10.2016

# Micronutrients

* Essential vitamins, minerals and trace elements- tiny amounts are needed for normal health.
* Required for health, growth and reproduction
* Amount required can change throughout our lifetime
* Deficiency or excess may cause severe health problems.

## Vitamins

* Organic substances needed in very small amounts
* Vitamins are assigned letters in order of discovery, but may also be known by other chemical names.

## Classification of vitamins

* Fat soluble vitamins: A, D, E and K are transported by lipoproteins. Stored in fatty tissues and the liver.
* Water soluble vitamins: B complex and C, are not stored in the body. Excess is excreted in urine.

# Classification of vitamins & dietary sources

## Fat Soluble

* **A** Whole eggs, milk, liver
* **D** Sun, oily fish, egg yolks
* **E** Vegetable oils, nuts, green leaf veg & fortified cereals
* **K** Green leafy vegetables & some vegetable oils

## Water Soluble

* **B** B6 fortified cereals, beans, meat, fish, b12 from animals like fish, meat
* **C** fruit & veg

## Role of vitamins

Diverse biochemical functions

* Hormones (e.g. vitamin D)
* Antioxidants (e.g. vitamin E)
* Mediators of cell signalling and regulators of cell growth and differentiation (e.g. vitamin A)
* Precursors for enzyme co-factors that help act as catalysts and substrates in metabolism.

## Biological functions of vitamins

* Do lots of things in the body!!!
* Protection from disease – antioxidants and shit

## Excess vitamins

* Once enzyme systems become saturated, excess vitamins function as chemicals, causing:
* Gout
* Kidney stones
* Liver disease
* Nerve damages
* Allergic responses

## Minerals

Inorganic compounds required for a variety of functions including formation for bones, teeth, body fluids and tissues.

* Approximately 4% of body mass
* Metallic elements
* Major minerals
* Trace elements

## Role of minerals

* Provide structure, forming bones and teeth
* Aid function by helping maintain heart rhythm, muscle contractility, neural productivity and acid-based balance

## Calcium

* Combines with phosphorus to form bones and teeth
* Needed for muscle, heart and digestive system health
* Supports synthesis and function of blood cells
* Dietary sources – Dairy, canned fish with bones, green vegs, nuts and seeds
* Inadequate calcium intake: Osteopenia, osteoporosis

25.10.2016

## Obesity

Disease: excess body fat has accumulated to the point where health can be affected.

BMI: Over 30 = obesity. = wt/ht2

Underweight < 18.5

Normal 18.5 – 24.9

Overweight > 25

Pre-obese 25-29.9

Obese > 30

Energy balance = Energy Intake – Energy Expenditure

Intake = Eating food

Expenditure = activity, sports etc.

## Causes of obesity

Lifestyle, societal change, food intake, cheaper food, transport, social interaction, prep time.

## CVD’s: What are they? -> Cardiovascular disease

Class of diseases that involve the heart or blood vessels (arteries and veins)

1. Coronary heart disease (CHD) – heart attack, sudden death, stable and unstable angina
2. Stroke – sudden localised loss of brain function due to ischemia or haemorrhage
3. Peripheral vascular disease – disease of the aorta, iliac and leg arteries

## Main risk factors for CVD

* Genetic
* Plasma lipids
* Blood pressure
* Obesity
* Diabetes mellitus
* Diet
* Alcohol
* Smoking
* Physical activity

Fuck my life vol 2

# Optimal nutrition for performance

Outline

* Exercise & energy metabolism
* Nutrient requirements CHO, protein, Fat
* Hydration

## Function of nutrients for training

* **Promote growth and development** – tissue adaptation, growth and repair
* **Provide energy** – maintain energy supply to the working muscles & other tissues
* **Regulate metabolism** – immune function and resistance to illness and infection

## Exercise and energy metabolism

At low exercise intensities, energy demand is low. Main fuel used by muscle is fat

As the exercise intensity increases, fuel selection changes. CHO, especially muscle glycogen becomes the main fuel used.

In medium intensity more energy sources are used. – Glycolysis

High intensity – Creatine – aerobic glycolysis

Immediate energy system: ATP-PCr

Short term – Glycolysis

Long term – Aerobic

## Nutrient requirements

**Protein**

* 1.2-1.8g/kg body weight
* 10-15% total kcal

**Fat**

* < 30% total kcal

**Carbohydrate**

* 60% total kcal
* Increased need for endurance athletes

Daily energy intake (kcal)

Different sports & men/women use different amounts of energy throughout the day

## Carbohydrate & exercise

* Muscle glycogen levels are depleted by short repeated stints of high intensity exercise.
* During prolonged high intensity CHO stores are used and must be refilled ASAP.
* A high CHO intake is essential for maintaining hard training and good performance.
* 7-10 grams/kg of body weight

## Not eating sufficient Carbs

Wont replace muscle

Lower energy levels, fatigue, prevent poor performance etc.

## Protein or carbs?

* Carbs are the main energy nutrient
* Replenish liver and muscle glycogen
* Carb digestion and absorption are faster
* High-protein meals elevate resting metabolism
* Protein breakdown facilitates dehydration

## Protein supplements

Not required in athletes with a balanced diet

Intakes above optimal requirement will not result in further muscle mass or strength gains.

Little evidence that high doses of proteins helps anything

## How much fat is too much?

Ideal body fat content of athletes depends on many factors

Most dietary fat should come from unsaturated fats in vegetable oils, nuts and oily fish.

## Hydration

* Lose fluid through sweating and water vapour in the air breathed out to cool down the body. 75% of energy is heat.

Losses depend on:

* Genetics
* Body size
* Fitness
* Temperature and humidity of surroundings
* Duration and intensity of exercise

A loss of 2% body weight from fluids will diminish performance (aerobic capacity reduces by 10-20%)

Drink water!

Large fluid volume impairs carbohydrate uptake

Concentrated sugar solutions impair fluid replacement

Isotonic drinks

* Ideal for rehydrating and refuelling.
* Contain 5-7% sugar ad electrolytes
* For optimal get like 150% of sweat loss with drinks and shit

Match energy intake with energy expenditure. Otherwise you will not optimise performance.

Water of life

## Water balance

* Makes up of 60% of body weight
* Fruits are made of water
* Homeostatic maintenance of water is crucial as it affects everything in the body.
* Water is gained from drinking, eating and metabolic shit
* Foods have water

## Water lost

* Skin
* Lost as evaporation in lungs
* Sweat

Intake should = output

Water intake regulates shit

Input is regulated by thirst mechanism

Output by regulation of urinary losses

Kidneys and shit

Urinary system: Kidneys, ureters, bladder, urethra. Kidney does an amazing job at producing urine which is excreted.

## Renal Functions

Homeostatic maintenance of ECF volume and composition

Regulates Na+, K+, Ca2+, Mg20, H+ etc.

Eliminates endogenous waste products.

## Eliminate foreign substances

Such as drugs, food additives and pesticides.

## Endocrine functions

Erythropoietin EPO acts on bone marrow to enhance the synthesis and release of red blood cells. Anaemia can develop due to inadequate red cell synthesis.

## Kidney

Nephron is the basic unit of the kidney. About 2.5 million in the 2 kidneys. We can survive with only one kidney and only see effects on homeostatic maintenance when 75% of nephron function is lost. -> Lots of reserve capacity

## Blood supply to the kidneys

Kidneys receive 20-25% of total cardiac output. 1200ml of blood flows through each minute. Blood comes through renal artery.

## Basic renal processes

Filtration

Reabsorption

Secretion

## Continuation from last week – 10.11.16

Thrist

Salt appetite – craving for salty foods when our plasma Na+ concentration is low. Controlled by angiotensin II, salt centre is also in the hypothalamus.

Temperature – proteins become denatured at certain heats, which ends metabolism.

Core temp of 37, normal range 35.5-37.7.

When temperature > 41, body looses it’s shit.

* Sun - radioation
* Evaporation
* Conduction
* Internal heat production