Università degli Studi di Verona
Corso di Laurea in Scienze delle attività motorie e sportive
A.A. 2016-2017

Integrated Course *Physiology* *12CFU*	*Professor* *Enrico Tam (coordinator)* *Antonio Cevese*

Receiving hours: Enrico Tam, on Tuesday 14:00- 15:00; Antonio Cevese, on Thursday 12:00-13:00

Targets of the Course

- Learning the basic functions of the human body intended as a set of organs and systems by integrating and complementing the existing knowledge of physics, chemistry, biochemistry, anatomy and biology.
- Learning how to apply the scientific method to the analysis of physiological responses to stresses such as physical exercise.
- Identifying the functional purpose of the physiological systems understanding their role in the maintenance of homeostasis of human organism.
- Acquire the fundamental physiological basis of motor control in humans, including the physiology of the sense organs.

Course Topics

Preliminary general knowledge

In order to understand the course of Physiology, you must have first assimilated the basics of Chemistry, Physics, Biochemistry and Mathematics, in particular:

- Chemistry: the concept of pH, molarity, colligative properties of solutions, osmolality and osmotic pressure, diffusion.
- Biochemistry: biological macromolecules, their classification and function, the main metabolic pathways, enzyme kinetics and mitochondrial enzymes.
- Physics: physics of gases, electrology, surface tension, Laplace's law, the basics of mechanics, statics and dynamics of fluids, laws of thermodynamics.
- Biology: biophysical characteristics of the cell membrane; transport mechanisms through the membrane; mechanisms of cell regeneration.
- Mathematics: the concept of the logarithm, the concept of function and axes, functions, linear, power, exponential; methods of manipulation of logarithms, the concepts of derivative and integral; units of the international system.

Topics

1. Principles of general physiology and biophysics of the cell

2. Sensory systems
3. Physiology and biomechanics of striated muscle
4. Motor control (spinal and supraspinal mechanisms)
5. The autonomic nervous system
6. Physico-chemical characteristics of the blood; coagulation and hemostasis
7. Cardiovascular physiology: heart and circulation Regulation of acid-base
8. Respiration
9. Renal Physiology: filtration, reabsorption, secretion and excretion
10. Acid-base regulation
11. Fluid and electrolyte balance
12. Metabolism and thermoregulation
13. Gastrointestinal Physiology
14. Physiology of the endocrine system
15. Physiology of muscular exercise

1 Principles of general physiology and biophysics of the cell

Preliminary knowledge: principles of electrophysics: concept of electric charge, potential, electric field, electric resistance, capacitor, potential, potential difference and electric current. The student should learn:

1.1 The definition of cellular homeostasis; identify the main mechanisms that ensure its maintenance, the composition and the biophysical characteristics of the plasma membrane, the importance of passive and active transcellular transport mechanisms for molecules in solution, for ionized substances and water, with explicit reference to **osmosis** and to the osmotic phenomena.

1.2 Understand the importance of ionic equilibria in order to learn the principles of excitability, conduction, synaptic transmission and muscle contraction; achieve a thorough understanding of the cellular resting potential and of action potential, of the morpho-functional model of synaptic transmission (electrical and chemical **synapses**, excitatory and inhibitory), as the basis for the functional integration of the nervous system, neuronal integration (spatial and time summation).

2 sensory systems.

Preliminary knowledge: specific neuroanatomical organization of the somatosensory pathways. Organization of the CNS, the principles of biophysics and physiology general of the cell.

2.1 Sensory receptors and receptor function (receptor types); somatosensory pathways (via the dorsal column and medial lemniscus, spinotalamiche ways, via the trigeminal); somatosensory cortex, the receptive field of the neurons in the somatosensory system, the pain: mechanisms thalamic-cortical, deep and superficial pain, referred pain.

3Physiology and biomechanics of striated muscle.

Preliminary knowledge: anatomy and histology of the striated muscle-skeletal

3.1 Structure of the functional unit of muscle: the sarcomere; thin and thick filaments: structure and organization in the sarcomere; structure and function of the sarcoplasmic reticulum; electro-mechanical coupling; concept of a single twitch, clone and tetanus; mechanical model of muscle: contractile elements, elastic elements in series and parallel; determinants of muscle performance or power: strength and speed; types of contraction (isometric, isotonic, isokinetic, concentric, eccentric); biomechanics dl muscle: force-length curves and curve speed strength; work and muscle power, the concept and definition of motor units; types of motor units and muscle fibers; in vivo regulation of muscle strength.

4 Motor control

Preliminary knowledge: detailed knowledge of the anatomy of the spinal cord and CNS anatomy and physiology and biomechanics of striated skeletal muscle.

4.1 Organization of motonuerons and spinal interneurons; spinal motor activity: reflexes and central pattern generator of locomotion.

4.2 Muscle sensory systems: receptors of tension and elongation; the neuromuscular spindles; stretch receptors that detect muscle length and velocity of contraction; gamma MN; Golgi tendon organs (OTG): tension receptors.
4.3 Spinal reflexes (stretch reflex, inverse stretch reflex, flexor reflex of avoidance); functions of the brainstem in the control of posture.
4.4 Neural pathways of the brainstem; localization, somatotopic organization, cellular topography of the motor cortex; descending corticospinal pathways.
4.5 Organization and function of sensory feedback to the motor cortex; the supplementary motor areas and the programming of the movement; the posterior parietal cortex and sensory integration during intentional movements.
4.6 Anatomical and functional aspects of cerebellum: cerebellar lobes, topography of cerebellar function; deep nuclei of the cerebellum; afferent and efferent pathways of the nuclei; general functioning of the cerebellar circuits; cerebellar cortex, purkinje cells, climbing and mossy fibers;
4.7 The basal ganglia.

5 The autonomic nervous system.

Preliminary knowledge: Detailed anatomical knowledge of the schema of the autonomic nervous system.

5.1 Functional anatomy of the SNA; chemical mediators and preganglionic and postganglionic receptors; overview of the functions of SNA; pharmacology of the SNA; the adrenal medulla; the negative feedback control mechanism: examples of autonomic reflexes: the baroreflex.

6 Physical and chemical characteristics of the blood; coagulation and hemostasis.

Preliminary knowledge: concept of osmotic pressure, osmolarity and osmolality, colligative properties of solutions, hydrostatic pressure and osmotic concentration of a solution (Molar and Molal), the concept of equivalent.

6.1 Characteristics of red blood cells: regulation of erythropoiesis, life span,; white series; platelets.
6.2 Physical properties of the blood, density and viscosity, plasma composition (concentration and types of plasma protein, osmotic pressure, cooncotic pressure).
6.3 Coagulation and haemostasis.

7 Cardiovascular Physiology: Heart and circulation.

Preliminary knowledge: functional anatomy of the heart and of circulation; elements of the physics of fluids (static and fluid dynamics, the Hagen-Poiseuille law, Bernoulli's theorem, laws of Stevino and Leonardo, laminar and turbulent flow, viscosity and density of the fluid), the anatomical organization of the brain stem and of the system autonomic nervous.

7.1 General: identifying the functional role of the system and of its elements; understand the simplified model of the circulatory system and the division of the vessels by category: wall morphology and function. Describe the fall in blood pressure in the vascular and the velocity of flow in the different sections; understand the concept of circulatory average pressure and of the distribution of the blood volume in function of the capacitance.
7.2 The Heart - cardiac electrophysiology: knowledge of the details that distinguish cardiac electrical phenomena from those of other excitable cells: divide the myocardial in common, conduction tissue and myocardium of work; understand the basis for the cardiac automatism and conduction of excitation in the heart of the state.
7.3 The Heart - electrocardiography: the essential elements of electrocardiography: definition and explanation of phenomenology; Einthoven's triangle; standard electrocardiographic leads, and precordial amplified; description of the waves of an ECG standard, with analysis of their origin. Practical use of the ECG in the field of motor at rest and under stress; what the EGC says and what it does not say. Sinus rhythm and main rhythm disturbances.
7.4 The Heart – The heart pump: describe analytically, also with graphical representation, the mechanical events of the cardiac cycle: splitting in systole and diastole; further subdivision in different periods, with reference to the development of pressure, to volume changes, the behaviour of the valves. Changes in pump function under stress. Understanding the functioning of the heart as a mechanical

pump: the heart-lung preparation of Starling and law, phenomenology and mechanisms; concept of contractility and its regulation; regulation of cardiac output and frequency; effect of stimulation of the vagus and sympathetic; humoral control. The work of the heart at rest and during different types of exercise (isometric and dynamic); cardiac efficiency (cardiac work, determined in energy consumption of the heart; efficiency of the heart); pathophysiology of heart failure and heart size.

7.5 The circle - principles of haemodynamics: the fundamental laws of fluid dynamics. Poiseuille's law and the determining role of viscosity and radius of the vessels; resistors in series and in parallel; laminar and turbulent flow; blood velocity in the different sections of the circulatory system. Compliance and capacitance. Filling volume and the volume in excess.

7.6 The circle - blood pressure: determinants of blood pressure; systolic, mean and diastolic; role of the elasticity of the arteries in the maintenance of pressure in diastole; arterial compliance; pulse wave: definition, origin and propagation; monitor performance; short-and long-term blood pressure control (baroreflex, chemoreflex); response to postural changes; blood pressure normal and diseases.

7.7 The circle - the microcirculation: identifying the functional pfunction of capillaries of the circulatory system, through an analysis of the structural elements that allow the exchange and the forces that govern them; concept of capillary permeability and application of the laws of diffusion; Starling equilibrium for the exchange of liquids: the four pressures that come into play; pore pressure; notes on the formation, composition and lymph circulation.

7.8 The circle - the peripheral circulation and its control: vascular smooth muscle as effector control mechanisms of resistance and capacitance vessels; auto-regulation of the blood vessels; metabolic regulation; nervous regulation: vasoconstriction and vasodilation; bulbar vasomotor activity.

7.9 The circle – other vascular districts: acquire general concepts on the elements that characterize the regulation of the flow to each organ, studying in detail:

- skin circulation, with reference also to the temperature control function;
- circulation of skeletal muscle, with reference to adaptation during muscular work and the effects of training;
- the coronary circulation, with reference to the work and the return rate;
- cerebral circulation;
- the renal circulation;
- the pulmonary circulation (pulmonary haemodynamics: a low-resistance circuit; distribution of the output of the right ventricle; recruitment and distension of the capillaries; model of the three zones of West; regulation of pulmonary circulation: role of innervation, localized or general response to hypoxia , pulmonary circulation in the fetus and changes in structural and functional at birth).

8 Respiration

Preliminary knowledge: functional anatomy of the respiratory system, physical - chemical properties of the blood (haematocrit, haemoglobin concentration, coefficient of oxygen binding to haemoglobin), the structure of haemoglobin, the basic concepts of physics and mechanics of fluid physics, the lung circulation, concept of pH, buffer substances, anatomical organization of the brainstem and of autonomic nervous system.

8.1 General: concepts of the physics of gas (Avogadro's law, Henry's law, equation of state, Dalton's law, correction of gas volumes (ATPS; STPD; BTPS), Fick's law applied to gas), air composition environment.

8.2 Ventilation: lung volumes and methods of determination, total pulmonary ventilation, alveolar ventilation, dead space (anatomical, physiological and alveolar) and its determination (method of Fowler and Bohr equation).

8.3 Pulmonary mechanics: inspiratory and expiratory muscle and their mechanism of action; static pulmonary pressure - volume curve of the thoraco-pulmonary system, of the lung, of the chest wall (pleural or esophageal, transpulmonary, transthoracic, alveolar pressures); lung compliance and respiratory system; role and function of alveolar surfactant; determinants of lung compliance; regional distribution of ventilation. Dynamics; resistance to airflow; volume of closure; analysis of alveolar, transpulmonary and intrapleural pressures in the spontaneous respiratory cycle; work of breathing.

8.4 Alveolar - capillary transfer: Fick equation applied to the diffusion of gases, diffusing capacity for carbon monoxide and oxygen; alveolar - capillary transfer limitation by diffusion and perfusion; alveolar - capillary transfer of oxygen in normal conditions, during exercise in hypoxia and pulmonary capillary transit time.

8.5. Transport of oxygen and carbon dioxide: the oxyhaemoglobin dissociation curve, the total transport capacity of the blood for oxygen, physiological factors that affect the allosteric affinity for oxygen; CO poisoning. Transport of carbon dioxide in the blood, blood dissociation curve of total CO_2, Haldane effect.

8.6 Gas exchanges: alveolar air equation (simplified); he cascade of oxygen; composition of the alveolar air and of the blood (oxygen cascade); causes of hypoxemia: hypoventilation, veno-arterial shunt anatomical and physiological hypo-diffusion, alveolar-capillary ratio and its distribution curve (normal ad in diseases). Arterio-venous differences of oxygen and carbon dioxide; oxygen consumption, carbon dioxide production, and respiratory quotient; determination of cardiac output by the Fick principle.

8.7 Neural and chemical control of ventilation. Nervous control: respiratory centers, generation of the respiratory rhythm. Chemical control: central and peripheral chemoreceptors; functional responses to hypoxia, acidosis and hypercapnia.

8.8 Responses ventilatory exercise: hyperventilation, ventilatory equivalent for oxygen and carbon dioxide during exercise; reduction of vascular resistance and recruitment of alveolar-capillary units; optimization of the ventilation / perfusion ratio; relative reduction of the velocity of blood in the capillaries.

9 Renal Physiology

Preliminary knowledge: functional anatomy of the kidney and urinary tract, the concepts of osmotic pressure, osmolarity and osmolality, concept definition of pH, buffer substances.

9.1 Filtration: definition, functional organization of the nephron; vascularization, innervation. Structure and function of the glomerulus; ultrafiltration; filtration pressure; GFR: inulin clearance, filtration fraction.

9.2 Tubular function in the proximal tubule; distal tubular reabsorption and secretion; clearance of PAI; resorption of AA, glucose, sodium, potassium and water; secretion of hydrogen ions, bicarbonate reabsorption.

9.3 Obligatory and optional Reabsorption of water: loop of Henle and counter current multiplication mechanism, function of vasa recta and of collecting ducts; role of urea, antidiuretic hormone: mechanism of action, function and regulation of the release.

9.4 Adjustment of renal function: self-regulation of flow and of filtration rate; functions of the juxtaglomerular apparatus; sympathetic nervous control.

10 fluid and electrolyte balance

Preliminary knowledge: Concepts of osmotic pressure, osmolarity and osmolality.

10.1 Water compartments; application of the method of dilution for the determination of the volume of water compartments; role of ion pumps and membrane permeability in the control of the composition of liquids; principle of isotonicity and passive movement of water; control of extracellular fluid volume and sodium excretion.

11 Regulation of acid-base

Preliminary knowledge: concept and definition of pH, buffer substances.

11.1 Henderson-Hasselbalch equation, buffering capacity and buffers of the body, bicarbonate-CO2 system.

11.2 Diagram of Davenport; normal values, respiratory acidosis and alkalosis, metabolic acidosis and alkalosis.

11.3 Integrated control of pH by the kidney and respiratory system.

12 Metabolism and Thermoregulation

Preliminary knowledge: strong knowledge of the main metabolic pathways for the resynthesis of ATP; concepts of heat, energy, work, power and related measurement units.

12.1 Warm-blooded animals and poikilotherms, normal body temperature, factors that determine the body temperature: i) heat production (metabolism); ii) physical and physiological mechanisms of heat exchange between organism and environment (evaporation, convection, radiation, conduction); iii) transport of heat within the body (circulatory convection and conduction).

12.2 Neural regulation of maintain homeothermy (hypothalamic centers, temperature set point, thermoceptors for the hot and cold); defense against the cold; protection from heat; circulation of the skin, fever, hyperthermia and heat stroke; hypothermia, muscle exercise, body size and temperature.

12.3 Metabolism: the concept of internal energy of the food; gross, net and delta efficiency of muscular performance; measure of the available energy of food (bomb calorimeter, energy equivalent of oxygen for individual substrates), resting metabolic rate.

12.4 Measurement of energy expenditure in vivo: direct methods (human calorimeter) and indirect (gas exchange, energy equivalent in vivo ofoxygen).

12.5 Dailiy energy intake, hunger and thirst.

13 Gastrointestinal Physiology

Preliminary knowledge: strong knowledge of the biochemical processes of absorption and utilization of proteins, lipids and carbohydrates; organization and function of the ANS; anatomical and functional organization of the gastro intestinal system.

13.1 Gastrointestinal motility: electric and mechanical activity, extrinsic nervous regulation and the enteric nervous system, types of motor activity, swallowing, oesophageal transit, gastric motility and stomach emptying rate, intestinal motility: small and large intestine, gastrointestinal hormones.

13.2 Secretion: salivary glands and thei functional unit, functions and composition of the saliva, amylase, control of salivary secretion, gastric secretion, parietal cells and the control of acid secretion, the cephalic, gastric and gastro-intestinal phase, other components of gastric juice, protection of the mucosa, exocrine pancreas, the composition of the pancreatic juice, activation of zymogens, control of pancreatic secretion, bile secretion, composition of bile, entero-hepatic circulation.

13.3 Absorption of iron, calcium absorption.

14 Physiology of the endocrine system

Preliminary knowledge: strong knowledge of anatomical and functional organization of the endocrine system, knowledge of the metabolic pathways.

14.1 General principles of endocrine physiology, mechanisms of intercellular communication, the endocrine system and the nervous system, the main endocrine glands: types of hormones, synthesis and action of peptide hormones, synthesis and action of the steroid hormones, mechanisms of regulation of hormones.

14.2 Adeno pituitary: functional unit of the hypothalamic - pituitary portal system, metabolic and neuroendocrine actions of the pituitary cells their structure, hypothalamic-pituitary axis, regulation of function of adenohypophysis, rhythmicity and pulsatility of secretion, tropinse, specific tropines, growth hormone, GH and exercise muscle action of GH, GH and growth, acromegaly, prolactin, posterior pituitary.

14.3 Adrenal gland: secretion in the various zones of the adrenal gland, the synthesis of adrenal hormones, aldosterone-mineralocorticoid, aldosterone and renin-angiotensin system, aldosterone action and physiological effects of aldosterone, androgens, glucocorticoids – cortisol, regulation of the synthesis of cortisol, cortisol and stress, cortisol secretion and light-dark cycle, the permissive action of cortisol, catabolic action of cortisol, cortisol and hepatic gluconeogenesis, the adrenal medulla, adrenal medulla and SNA, hyperglycaemic effect, action of catecholamines, integration of the response to stress.

14.4 Thyroid: thyroid and thyroid follicles, biosynthesis, cellular mechanisms, iodine thyroid, transport of T3 and T4 in plasma, control of the synthesis and secretion, mechanism of action, actions of thyroid hormones, pathophysiology (hyperthyroidism and hypothyroidism).

14.5 Endocrine pancreas: physiological anatomy of the islands of Langerhans, human insulin molecules, control the secretion of the endocrine pancreas, synthesis and secretion of insulin receptors for insulin,

hypoglycemic effect; insulin: muscle and anabolic effect, insulin and lipid metabolism, biological effect of insulin, pathophysiology of insulin, diabetic keto-acidosis, hypersecretion of insulin, glucose tolerance curve; glucagon ratio insulin-glucagon, pancreatic hormones and metabolism of carbohydrates, pancreatic hormones and intermediary metabolism, pancreatic hormones and exercise, somatostatin.

14.6 Metabolism of calcium and phosphorus and vitamin D; calcium body distribution and plasma calcium and phosphorus concentrations, physiological actions of calcium and phosphorus, daily balance of calcium, bone tissue and calcium and phosphate homeostasis, bone formation and remodeling , bone mass and age, calcium metabolism - parathyroid hormone synthesis and secretion of PTH, calcium metabolism and PTH, vitamin D, D3 and Ca++ concentration regulations, calcitonin, calcium and phosphorus metabolism, bone metabolism and the endocrine system.

15 Physiology of muscular exercise.

Preliminary knowledge: strong knowledge of the main metabolic pathways, mitochondrial respiration, metabolic pathways for the resynthesis of ATP, the concepts of power and mechanical work, physiology of respiration and circulation.

15.1 Model of muscle energetics, definitions of work and power, energy bases of muscle contraction, power and capacity of the mechanisms of energy production.

15.2 The aerobic metabolism, maximal oxygen consumption, factors limiting maximal oxygen consumption, V'O2 kinetics, principles and methods of measurement of maximal oxygen uptake: direct and indirect methods.

15.3 Cardiovascular and respiratory responses during dynamic and isometric exercise.

Examination methods

A written test with multiple choice quizzes followed by an oral interview in the event of an overrun with the sufficiency of the written test.

Teaching materials

All course materials covered in class will be made available on the student teacher's page / course. The students are invited to look at it.

Recommended reading

- Human Physiology, e.g. Prampero and A. Veicsteinas, Edi-Ermes Milan 2002
- General and Human Physiology II edition on American IV, Rhoades - Pflanzer, Piccin, Italy

Other Reference Books

- Fundamentals of human physiology, Sherwood L., 4° ed – Piccin, Italia, 2012
- Human Physiology, Sherwood L., Zanichelli, Italia – 2008
- Human Physiology, Dee Unglaub Silverthorn, 6° ed-Pearson, 2013
- Physiology, Vander, Casa Editrice Ambrosiana, Italia, 2011
- From the Abyss to the Space Environments and human limitations, edited by G. Ferretti and Capelli C, Edi-Ermes, Milan, 2008.