UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

COURSE SYLLABUS

Neurophysiology of Movement

2526-1-I0202D138-I0202D139M

Aims

The course provides the essential notions inherent in the vital functions of man, with particular reference to the functions of which the student is required to have specific knowledge. It analyzes the mechanisms of the cell excitability, the interaction between excitable cells and the physiology of the motor and sensory systems.

The course analyzes the motor control functions at central level with particular reference to the understanding of the physiological behavior and etiology of various neuromotor disorders.

A deep knowledge of the neuromotor control is aimed at understanding the most common physio-pathological clinical issues. The course, organized in a single semester, consists of lectures, exercises and seminars.

1. Knowledge and Understanding: It is essential that all medical students receive sufficient exposure to the physiological concepts underlying the functions of movement control
2. Applied Knowledge and Understanding: The curricular objectives are primarily focused on the normal function of neuromotor control, however, the material is presented in a context that prepares students for the profession. Therefore, whenever possible, clinical examples will be used to illustrate the basic physiological principles.
3. Autonomy of judgment: Correlate the normal structure and function of the central nervous system as a complex system in continuous adaptation, interpreting the morpho-functional abnormalities that occur in different diseases
4. Communication skills: Acquisition of the set of skills that allow one to interact effectively with others, both verbally and non-verbally.
5. Ability to learn: Acquisition of the physiological concepts underlying the functions of neuromotor control that will provide the necessary foundation for further studies in pharmacology, pathology, physiopathology and clinical medicine.

Contents

Structure and function of the plasma membrane: ion channels, resting membrane potential

• Genesis and propagation of the action potential, the receptor potential, the synaptic transmission

• Responses mediated by sensory receptors – mode of action, intensity, localization and duration of the applied stimulus.

• Pain perception - nociceptors: anatomic distribution and function

• The motor system and the motor unit activation

• Postural control

• Control of the spinal cord by the upper motor neurons

• The modulation of movement by the basal ganglia

• The modulation of the movement by the cerebellum

• Eye movements and sensory motor integration

Detailed program

Cell excitability - plasma membrane. Permeability, diffusion, osmosis, active and passive transport through the membrane. Ionic channels. Electrochemical equilibrium and Nernst equation. Resting membrane potential. The Na + / K + pump. Passive electrical properties of the membrane. The action potential: genesis, ionic bases and properties. Conduction of the action potential in the myelinated and unmyelinated nerve fibers. Classification of nerve fibers. Elementary interactions between excitable cells. The synapse. General concepts on synaptic transmission. The neuromuscular junction. The central synapse. Electrical events in postsynaptic neurons. Neuronal integration of synaptic inputs: spatial and temporal integration. Neurotransmitters in the Central Nervous System.

The sarcomere: the contractile and the regulatory proteins. Excitation-contraction coupling: role of the Ca2+. Molecular basis of the muscle contraction. The mechanism of contraction. The isotonic and isometric contraction. Voltage-length and force-speed relationships. Muscle fibers classification. The motor units: force output by the frequency discharge and by recruitment of the motor units. The smooth muscle. Coupling between smooth muscle cells: unitary and multi-unitary muscle.

Sensory system: organization and general mechanisms. Sensory receptors: definition and classification of receptors. Signal transduction and coding. Appropriate stimulation. Adaptation. Receptive fields' dimensions: stimulus location, intensity, duration. Somatic sensitivity: touch, proprioception, pain. Ascending pathways of somatic sensitivity. Somatosensory cortex. Pain. Nociceptors: anatomic distribution, activation and sensitization mechanisms, somatic, deep and visceral nociceptors.

Maintaining equilibrium: the postural reflexes. Feedback and feedforward control mechanisms. Rhythmic movements and locomotion. The organization of the motor system. Cerebellum and Basal Ganglia: general information on the functional organization and their roles in the motor control. The anatomical organization of the cerebellum. Projections to the cerebellum. Projections from the cerebellum. The intrinsic circuits of the cerebellum. The cerebellar circuits and the coordination of the in progress movements. Consequences of most common cerebellar lesions. Projections to the basal ganglia. Projections from the basal ganglia to other brain regions. The intrinsic circuits of the basal ganglia, the role of dopamine. Movement disorders: hypokinesis and hypercinesi. Medial and lateral systems in motor control. Motor functions of the spinal cord: spinal reflexes; muscle spindle and

myotatic reflex; the reverse myotatic reflex; flexor reflexes, the supra-spinal control of the myotatic reflex; posture and its control. Vestibular and cervical reflexes. Eye movements and sensory motor integration. Cortical control of the movement. Motor areas of the cortex and their functional role, neurochemical mediators. Organization of vegetative reflexes. Vegetative functions of the midbrain, medulla and pons. Nerve centers for visceral function control. Level of study: High or intermediate depending on the relevance of the topics.

Prerequisites

Preliminary knowledge: Foundamentals of physics, biochemistry, histology and anatomy of the nervous system, anatomy of the musculoskeletal system.

Teaching form

All lessons are held in person in delivery mode (direct instruction): the teacher begins with a first part in which concepts are exposed (direct mode) and then an interaction opens with the students which defines the next part of the lesson (interactive mode).
The teaching methods will include lectures, videos, and class discussions. Whenever possible, clinical case analyzes will be proposed for the evaluation of the specific physiological parameters.
Lessons in attendance, subject to any ministerial changes.
In case of pandemic restrictions, the courses will be delivered in mixed mode from asynchronous remote with synchronous videoconferencing events (WEBEX)

Textbook and teaching resource

Belfiore et al., FISIOLOGIA UMANA FONDAMENTI, edi-ermes

Bossi et al., FISIOLOGIA UMANA ELEMENTI, edi-ermes

Dale Purve et al., NEUROSCIENZE, Zanichelli

A.C. Guyton & J.E. Hall, FISIOLOGIA MEDICA, Piccin W.J.

Klinke, Pape, Kurtz, Silbernagel, FISIOLOGIA, EdiSes

M. Berne & M. N. Levy FISIOLOGIA, UN APPROCCIO INTEGRATO, Casa Editrice Ambrosiana

Dale Purves, George J. Augustine, David Fitzpatrick, William C. Hall, Anthony-Samuel LaMantia, Richard D. Mooney, Michael L. Platt, NEUROSCIENCE (6th Edition) – eBook - Sinauer Associates (Oxford University Press); 6th edition

E. R. Kandel, J. H. Schwartz, T. M. Jessel, S. A. Siegelbaum, A. J. Hudspeth, PRINCIPLES OF NEURAL SCIENCE, Mc Graw Hill Medical

Susan E. Mulroney, Adam Myers, NETTER'S ESSENTIAL PHYSIOLOGY, Elsevier

Semester

First semester

Assessment method

The exam consists in a written test. Open and closed questions will be posed to the student in order to evaluate the general knowledge of the topics. Moreover, the student will be asked to answer to questions that require the analysis of a complex phenomenon, its rationalization and the application of specific physiology principles and to solve simple exercises. Finally, a clinical case may be presented which will require the analysis of the interconnections between different physiological variables in the light of the theoretical paradigms.

Written exams, in case of pandemic restrictions, will be provided by the platform https://esamionline.elearning.unimib.it, access to which will be activated for the date and time of the exam.

Office hours

By appointment, subject to communication to be sent to giulio.sancini@unimib.it

Sustainable Development Goals

GOOD HEALTH AND WELL-BEING