Erasmus+

Development of innovative training solutions in the field of functional evaluation aimed at updating of the curricula of health sciences schools

TEACH

MODULE BIOMECHANICS: FOUNDATIONS OF BIOMECHANICS APPLIED TO THE LOCOMOTOR SYSTEM

Didactic Unit C: PHYSIOLOGICAL SIGNS AND MORPHOMETRIC PARAMETERS

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AMSE THE ASSOCIATION OF MEDICAL SCHOOLS IN EUROPE

Index

1. Objectives

- To learn what are the common physiological signs and anthropometric parameters for characterizing the patient as a biological object.

- To know what the role of using physiological signs, and anthropometric parameters to asses in non-invasive way the general state of the patient organism and his/her development.

- To be able to select and use chosen physiological signs and anthropometric parameters as a screening examinations indicators for further more specialistic treatment.

2. What is anthropometry and how is described by quantitative parameters?

Anthropometric measurements are a series of quantitative measurements of the muscle, bone, and adipose tissue used to assess the composition of the body. The core elements of anthropometry are height, weight, body mass index (BMI), body circumferences (waist, hip, and limbs), and skinfold thickness.

Anthropometry is the method of measuring the human body or the individual body parts, which involves the quantitative definition of the morphological traits, and insight into an objective image of the state of growth of the person tested. Its also the most common technique used to assess the presence and degree of protein-energy malnutrition.

Anthropometry can be used to measure an individual to determine if he or she needs nutrition intervention or it can be used to measure many individuals to determine if malnutrition is a problem in a population.

The most common anthropometric measurements include:

- Height or length
- Weight
- Mid-upper arm circumference (MUAC)
- Demi-span or arm span
- Knee height
- Sitting height
- Skin fold thickness
- Head circumference

Height (or length) and weight are the most common anthropometric measures used to indicate protein-energy nutritional status in emergencies. Anthropometric measurements are combined with each other or with other data to calculate anthropometric indices. The most common indices used in emergencies include those listed in the table below:

Index	Nutritional problem measured
Weight-for-height	Acute malnutrition (wasting)
Height-for-age	Chronic malnutrition (stunting)
Weight-for-age	Any protein-energy malnutrition (underweight)

If you want to measure the prevalence of acute protein-energy malnutrition, you should use weight-for-height. However, in practice, all three indices are usually available. Most emergency nutrition surveys measure sex, height, weight, and age. From these measurements, all three anthropometric indices can be easily calculated by a computer.

Most common anthropometric index used to measure acute protein-energy malnutrition (sometimes called "chronic energy deficiency") in adults is the body mass index (BMI).

BMI is a descriptive index of body habitus that encompasses both the lean and the obese and is expressed as body **weight divided by height squared [kg/m2]**.

The cut-off point defining malnutrition is the same for all adults, regardless of their age, height, or sex:

Type and level of malnutrition	BMI range (kg/m2)
Obese	30.0+
Overweight	25.0 - 29.9
Normal	18.5 - 24.9
CED* Mild	17.0 - 18.4
CED Moderate	16.0 - 16.9
CED Severe	<16.0

** CED = Chronic energy deficiency*

Abdominal Circumference as an important anthropometric index.

Obesity is commonly associated with increased amounts of intra-abdominal fat. A centralized fat pattern is associated with the deposition of both intra-abdominal and subcutaneous abdominal adipose tissue.

The ratio of abdominal circumference (often referred to incorrectly as “waist” circumference) to hip circumference is a rudimentary index for describing adipose tissue distribution or fat patterning. Abdomen-to-hip ratios greater than 0.85 represent a centralized distribution of fat. Most men with a ratio greater than 1.0 and women with a ratio greater than 0.85 are at increased risk for cardiovascular disease, diabetes, and cancers

Bioelectric Impedance Analysis – complex biomedical measurement method for assessing the anthropometrical measures.

The analysis of body composition by bioelectrical impedance produces estimates of total body water (TBW), fat-free mass (FFM), and fat mass by measuring the resistance of the body as a conductor to a very small alternating electrical current.

Bioelectrical impedance analysers do not measure any biological quantity or describe any biophysical model related to obesity. Bioelectrical impedance analysers use math formulas to describe statistical associations based on biological relationships for a specific population, and as such the equations are useful only for subjects that closely match the reference population in body size and shape. BIA has been applied to overweight or obese and for normal weight individuals too.

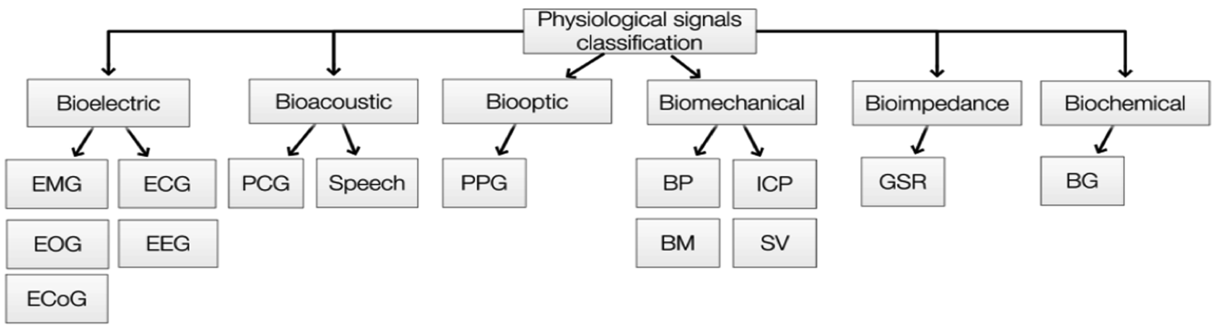
3. Physiological signs as a non-invasive, basic way to asses and monitor patient state in modern, effective, multimodal biosignal acquisition systems.

Physiological signs are measures of various physiological signals of biological objects as e.g. human in order to assess the most basic body functions, what important in non-invasive way. Vital signs are an essential part of both clinical diagnosis as well as monitoring of daily human activities, by means of advance mobile, wearable bio-sensors systems. The act of estimating vital signs, normally entails recording such a signals as:

I. Electrical signals:
- Electrocardiography - ECG,
- Electromyography - EMG,
- Electroencephalography - EEG,
- Electrooculography - EOG,
- Galvanic skin response - GSR,

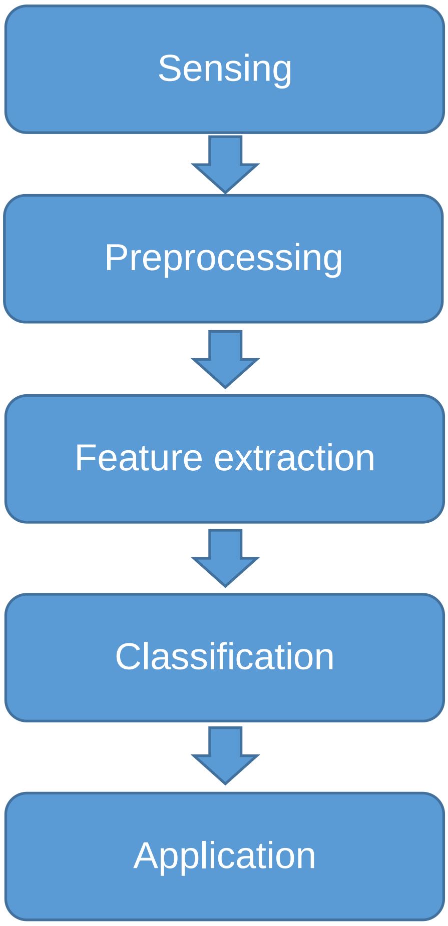
II. Non-electrical signals:
- Pulse wave - PW,
- Body temperature - BT,
- Blood pressure - BP,
- Respiratory rate - RR,
- Body position, body movement mechanical signals.

The analysis of physiological signals is widely used for the development of diagnosis support tools in medicine. The use of multiple signals or physiological measures as a whole has been carried out using data fusion techniques commonly known as multimodal fusion, which has demonstrated its ability to improve the accuracy of diagnostic care systems.



Classification of physiological signals, which can be integrated in muti-modal measurement systems is presented on the tree diagram

General Procedure of bio-signal recognition system.

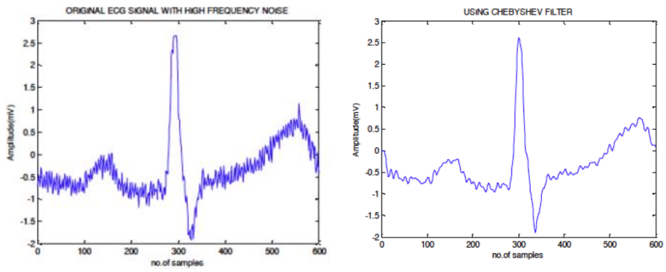


PREPROCESSING:

Purpose: *Eliminate common noises such as inherent equipment noise*

- However, signals may be hindered by moving artifacts
- Filters are required!

Example of effect of filtering procedure on ECG signal is presented below.



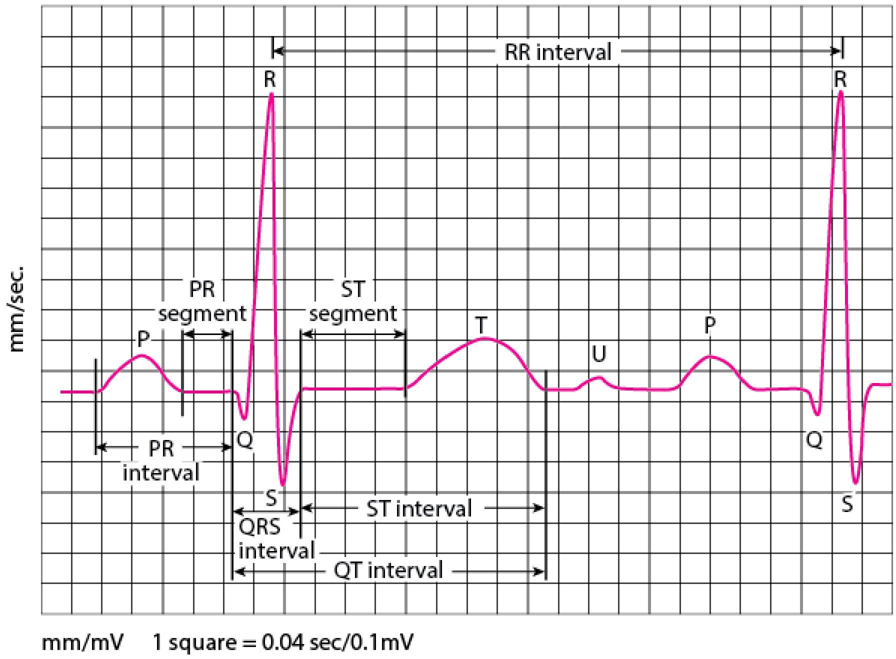
Physiological signs recorded in non-invasive way reflect state of internal organs, systems & processes and have a growing role in following areas:

I. Healthcare
   i. Disease detection
   ii. Therapy & Rehabilitation
   iii. Brain and Body computer interface
II. Cognitive state
   i. Emotion recognition
   ii. Music influence
III. Digital Age
   i. Gaming
   ii. Digital hand

Review of most common physiological signals and their meaning

Electrocardiogram - ECG

An electrocardiogram — abbreviated as EKG or ECG — is a test that reflects and measures the electrical activity of the heartbeat. With each beat, an electrical impulse (or "wave") travels through the heart. This wave causes the muscle to squeeze and pump blood from the heart. A normal heartbeat on ECG will show the timing of the top and lower chambers. It is a graph of voltage versus time of the electrical activity of the heart using electrodes placed on the skin. These electrodes detect the small electrical changes that are a consequence of cardiac muscle depolarization followed by repolarization during each cardiac cycle (heartbeat). Changes in the normal ECG pattern occur in numerous cardiac abnormalities, including cardiac rhythm disturbances (such as atrial fibrillation and ventricular tachycardia), inadequate coronary artery blood flow (such as myocardial ischemia and myocardial infarction), and electrolyte disturbances (such as hypokalemia and hyperkalemia).



The right and left atria or upper chambers make the first wave called a "P wave" — following a flat line when the electrical impulse goes to the bottom chambers. The right and left bottom chambers or ventricles make the next wave called a "QRS complex." The final wave or "T wave" represents electrical recovery or return to a resting state for the ventricles.

Electromiogram – EMG

Electromyography (EMG) is a diagnostic procedure to assess the health of muscles and the nerve cells that control them (motor neurons). EMG results can reveal nerve dysfunction, muscle dysfunction or problems with nerve-to-muscle signal transmission.

Motor neurons transmit electrical signals that cause muscles to contract. An EMG uses tiny devices called electrodes to translate these signals into graphs, sounds or numerical values that are then interpreted by a specialist. During a needle EMG, a needle electrode inserted directly into a muscle records the electrical activity in that muscle. A nerve conduction study, another part of an EMG, uses electrode stickers applied to the skin (surface electrodes) to measure the speed and strength of signals traveling between two or more points.

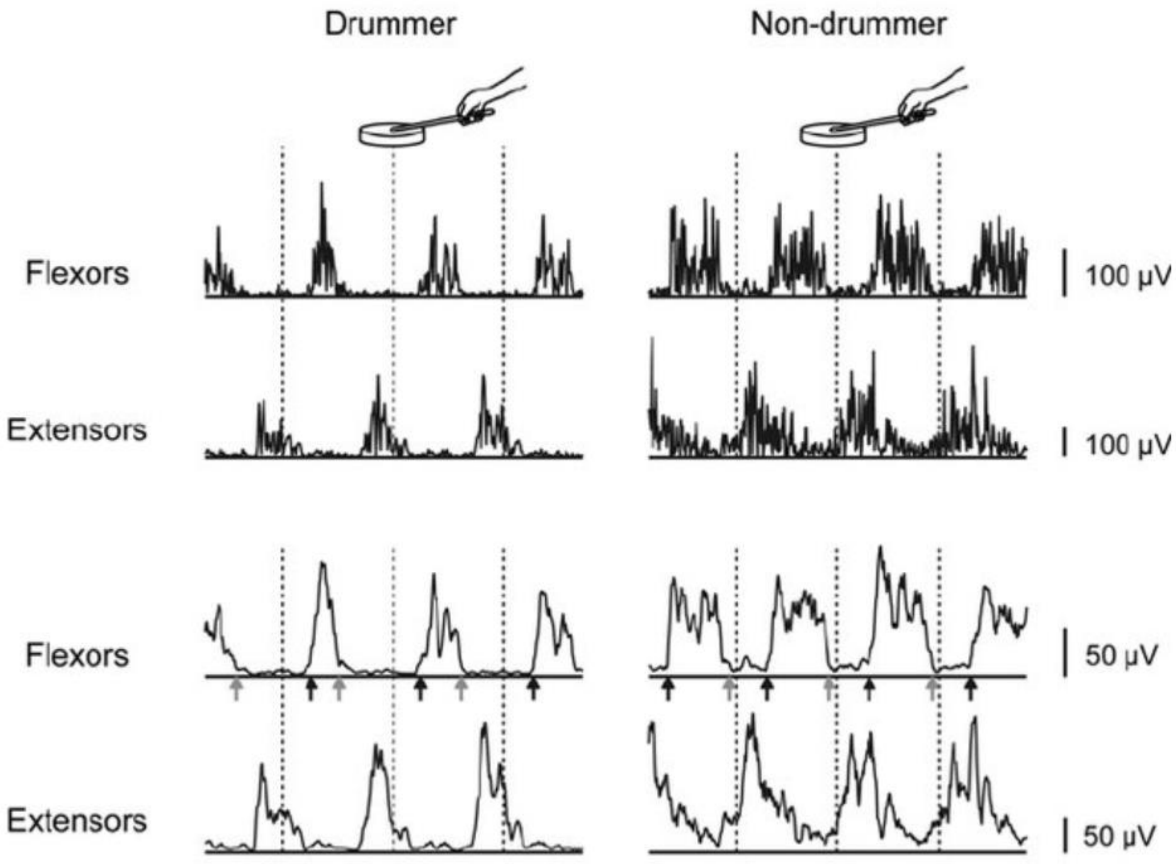
An EMG examination can be ordered if you have signs or symptoms that may indicate a nerve or muscle disorder. Such symptoms may include e.g.:

- Tingling
- Numbness
- Muscle weakness
- Muscle pain or cramping
- Certain types of limb pain

EMG results are often necessary to help diagnose or rule out a number of conditions such as:

- Muscle disorders, such as muscular dystrophy or polymyositis
- Diseases affecting the connection between the nerve and the muscle, such as myasthenia gravis
- Disorders of nerves outside the spinal cord (peripheral nerves), such as carpal tunnel syndrome or peripheral neuropathies
- Disorders that affect the motor neurons in the brain or spinal cord, such as amyotrophic lateral sclerosis or polio
- Disorders that affect the nerve root, such as a herniated disk in the spine
- More Information
- Acute flaccid myelitis (AFM)
- Amyotrophic lateral sclerosis (ALS)
- Back pain

An interesting case of EMG recording for Drummer and Non-drummer person during arm movement test is presented below.



Galvanic skin response (GSR)

The galvanic skin response (GSR, known also to term of electrodermal activity, or EDA) refers to changes in sweat gland activity that are reflective of the intensity of our emotional state, otherwise known as emotional arousal. Our level of emotional arousal changes in response to the environment we're in – if something is scary, threatening, joyful, or otherwise emotionally relevant, then the subsequent change in emotional response that we experience also increases eccrine sweat gland activity.

There is a proved link between mental state and GSR activity, finding an association with the level of sedation in patients and skin resistance. This connection of emotional response to GSR signal has been explored in thousands of articles in the 120+ years since this seminal finding [review article]. While sweat secretion plays a major role for thermoregulation and sensory discrimination, changes in skin conductance are also triggered robustly by emotional stimulation: the higher the arousal, the higher the skin conductance.

Skin conductance is not under conscious control. Instead, it is modulated autonomously by sympathetic activity which drives aspects of human behaviour, as well as cognitive and emotional states. Skin conductance therefore offers direct insights into autonomous emotional regulation. It can be used as an additional source of insight to validate self-reports, surveys, or interviews of participants within a study.

4. Key ideas

- Both morphometric and anthropometric as well as physiological signs, recording in non-invasive way by means of multi-modal biosignal recording systems carry very important information on the functioning of the human internal systems and organs.

- Combined sets of anthropometric and physiological paramters are increasingly being used both in health care units as well as in everyday usage to support diagnosis, treatment and what important also ‚healthy' lifestyle, monitored by body sensor networks.

5. References

[1] Frisard MI, Greenway FL, Delany JP. Comparison of methods to assess body composition changes during a period of weight loss. Obes Res. 2005;13(5):845-54.

[2] Lohman T, Martorell R, Roche AF. Anthropometric standardization reference manual. Champaign, IL: Human Kinetics Books; 1988.

[3] de Onis M., W. O.W.A., Van den Broeck J., Chumlea WC, Martorell R. Measurement and standardization protocols for anthropometry used in the construction of a new international growth reference. Food Nutr Bull. 2004;25(1 Suppl):S27-36.

[4] Sebo P, Herrmann FR, Haller DM. Accuracy of anthropometric measurements by general practitioners in overweight and obese patients. BMC Obes. 2017;4:23.

[5] Gabbett T, Georgieff B. Physiological and anthropometric characteristics of Australian junior national, state, and novice volleyball players. J Strength Cond Res. 2007 Aug;21(3):902-8.

[6] Vasconcelos AP, Cardozo DC, Lucchetti AL, Lucchetti G. Comparison of the effect of different modalities of physical exercise on functionality and anthropometric measurements in community-dwelling older women. J Bodyw Mov Ther. 2016 Oct;20(4):851-856.

[7] Kidy FF, Dhalwani N, Harrington DM, Gray LJ, Bodicoat DH, Webb D, Davies MJ, Khunti K. Associations Between Anthropometric Measurements and Cardiometabolic Risk Factors in White European and South Asian Adults in the United Kingdom. Mayo Clin Proc. 2017 Jun;92(6):925-933.

[8] Pryzbek M, Liu J. Association between upper leg length and metabolic syndrome among US elderly participants-results from the NHANES (2009-2010). J Geriatr Cardiol. 2016 Jan;13(1):58-63.

[9] Smits MM, Boyko EJ, Utzschneider KM, Leonetti DL, McNeely MJ, Suvag S, Wright LA, Fujimoto WY, Kahn SE. Arm length is associated with type 2 diabetes mellitus in Japanese-Americans. Diabetologia. 2012 Jun;55(6):1679-84.

[10] Ververs MT, Antierens A, Sackl A, Staderini N, Captier V. Which anthropometric indicators identify a pregnant woman as acutely malnourished and predict adverse birth outcomes in the humanitarian context? PLoS Curr. 2013 Jun 07;5

[11] Hiremath R, Ibrahim J, Prasanthi K, Reddy HT, Shah RS, Haritha C. Comparative Study of Ultrasonographic and Anthropometric Measurements of Regional Adiposity in Metabolic Syndrome. J Clin Diagn Res. 2017 Aug;11(8):TC01-TC05.

[12] Brouse, Andrew. "A Young Person's Guide to Brainwave Music: Forty years of audio from the human EEG." eContact! 14.2 — Biotechnological Performance Practice / Pratiques de performance biotechnologique (July 2012). Montréal: CEC.

[13] Ortiz, Miguel. "A Brief History of Biosignal-Driven Art: From biofeedback to biophysical performance." eContact! 14.2 — Biotechnological Performance Practice / Pratiques de performance biotechnologique (July 2012). Montréal: CEC.

[14] Tanaka, Atau. "The Use of Electromyogram Signals (EMG) in Musical Performance: A Personal survey of two decades of practice." eContact! 14.2 — Biotechnological Performance Practice / Pratiques de performance biotechnologique (July 2012). Montréal: CEC.

[15] "Definition of EKG by Lexico". Lexico Dictionaries. Retrieved 20 January 2020.

[16] "15.3.1 Electrocardiographic Terms", AMA Manual of Style, American Medical Association

[17] Kamen, Gary. Electromyographic Kinesiology. In Robertson, DGE et al. Research Methods in Biomechanics. Champaign, IL: Human Kinetics Publ., 2004.

[18] Electromyography at the US National Library of Medicine Medical Subject Headings (MeSH)

[19] Kobylarz, Jhonatan; Bird, Jordan J.; Faria, Diego R.; Ribeiro, Eduardo Parente; Ekárt, Anikó (2020-03-07). "Thumbs up, thumbs down: non-verbal human-robot interaction through real-time EMG classification via inductive and supervised transductive transfer learning". Journal of Ambient Intelligence and Humanized Computing. Springer Science and Business Media LLC. doi:10.1007/s12652-020-01852-z. ISSN 1868-5137.

[20] Harvey AM, Masland RL: Actions of durarizing preparations in the human. Journal of Pharmacology And Experimental Therapeutics, Vol. 73, Issue 3, 304-311, 1941

[21] Botelho, Stella Y. (1955). "Comparison of simultaneously recorded electrical and mechanical activity in myasthenia gravis patients and in partially curarized normal humans". The American Journal of Medicine. 19 (5): 693–6. doi:10.1016/S0002-9343(55)80010-1. PMID 13268466.

[22] Christie, T.H.; Churchill-Davidson, H.C. (1958). "The St. Thomas's Hospital nerve stimulator in the diagnosis of prolonged apnoea". Lancet. 1 (7024): 776. doi:10.1016/S0140-6736(58)91583-6. PMID 13526270.

[23] Engbaek, J.; Ostergaard, D.; Viby-Mogensen, J. (1989). "Double burst stimulation (DBS): A new pattern of nerve stimulation to identify residual neuromuscular block". British Journal of Anaesthesia. 62 (3): 274–8. doi:10.1093/bja/62.3.274. PMID 2522790. S2CID 32733775.

[24] Boucsein, W. (2012). Electrodermal Activity. New York, Berlin: Springer, 2nd edition

[25] Salimpoor, V.N., Benovoy, M., Longo, G., Cooperstock, J.R. & Zatorre, R.J. (2009). The rewarding aspects of music listening are related to degree of emotional arousal. PLoS ONE 4, e7487

[26] Critchley, H. D. (2002). Electrodermal responses: What happens in the brain. Neuroscientist, 8, 132-142

[27] Newman, E., Blanton, R., 1968. The early history of electrodermal research. Psychophysiology 6, 453–475

[28] Vigouroux, R, De la resistance Electrique comme signe clinique, Progres Medicate, 1879, No. 7, 336

[29] Naït-Ali, Amine, ed. (2009). Advanced Biosignal Processing. Berlin, Heidelberg: Springer Berlin Heidelberg. doi:10.1007/978-3-540-89506-0. ISBN 978-3-540-89505-3.