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VIEW POINT

# THE HIDDEN VALUE OF CLINICAL PHYSIOLOGY TESTS UTILITY IN MEDICAL PRACTICE FOR A BETTER UNDERSTANDING: A MESSAGE FOR THE DECISION MAKERS

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## ABSTRACT

Clinical physiology department in well-organized university hospitals has three important roles: 1) it can be considered the best link between the basic sciences that have been taught in the undergraduate curriculum and clinical practice. 2) several techniques are practiced in the clinical physiology department operating in close collaboration with other clinical specialties which are very helpful in providing health care such as Pulmonary Function Test, Electroencephalogram, Nerve Conduction Studies, Auditory Brainstem Response, Electrocardiogram, Exercise-based "stress tests," etc. 3) it has a strong relation with research disciplines and its participation in this field cannot be neglected. The aim of this viewpoint is to unravel the hidden importance of the clinical physiology department and its utility in both basic sciences and clinical teachings, both for health care and research.

Therefore, assuring clinical physiology as an independent part of the basic sciences physiology department with the decision-maker support could guarantee the survival and continuation of the link between undergraduate teaching and clinical practice. The practical sessions of the undergraduate curriculum should be updated so that students get knowledge of techniques utilized in their clinical careers. This is beyond the conventional theory bases irrelevant teaching curriculum. Recruitment of well-qualified and specialized specialists in clinical physiology techniques, technicians, and nurses who can perform and interpret these tests effectively as well as supplying the unit with modern and sophisticated equipment is of great value. Research funds have to be directed toward clinical physiology that can boost the development of medical evolution ahead.

**KEYWORDS:** Physiology (MeSH); Clinical physiology (Non-MeSH); Education, Medical (MeSH); Physiological diagnostic tools (Non-MeSH); Diagnosis (MeSH); Research (MeSH); Respiratory Function Tests (MeSH); Electroencephalography (MeSH); Nerve Conduction Studies (MeSH); Evoked Potentials, Auditory, Brain Stem (MeSH); Electrocardiography (MeSH).

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## INTRODUCTION

In highly well-organized university hospitals, the clinical physiology department is considered an independent department or a unit with highly qualified staff and sophisticated equipment. On the other hand, in some hospitals, clinical physiology diagnostic tools have minor roles and are scattered between hospital departments. Therefore, it is very important for the hospital's decision-makers, especially educational hospitals, to know the role of clinical physiology in order to have the complete benefits of its facilities. Unless clinical physiology is treated as an independent department and controls its own discipline, the integrative physiology teaching model as a base for problem-based education, patient health, and research discipline will be severely affected. As members of the physiology and clinical physiology department, the light should be shed to emphasize several roles and tasks that can be afforded by this unique department and encourage decision-makers to pay more attention to it.

The clinical physiology department has three important roles:

**1) Bridging the gap between basic sciences and clinical applications:** No one can deny the efforts that have been exerted by several frontiers toward more integration between basic and clinical departments for better preparation of future physicians.[1,2] Clinical physiology can be considered as the best link that can bridge the gap between the basic sciences that have been taught to the students during their undergraduate degree and the clinical applications of these scientific basic sciences facts. As part of this unique department, clinical physiologists can take this advantage and take the burden to teach and subsequently transfer knowledge and methods of techniques that are performed in the department to healthcare providers. Not only that but also to help them to choose the appropriate diagnostic tools that are needed for the respective patients and not waste the patient's money and have them loitering around. To achieve this task, students, as well as clinical physiologists, must gain a strong knowledge of physiology and pathophysiology and be sagacious enough to help them exercise prudence and ensure ending up with the right diagnosis. One of the methods that are very useful in this field, based on our experience in teaching physiology, is bringing students closer to the clinical applications of the basic sciences through the efficient practical sessions in the undergraduate medical curriculum (preparing very efficient and equipped physiology laboratories) for the students, exposing them to various clinical physiological techniques. The physiology practical sessions conducted in medical schools are more sort of archival, not updated, too conventional, lack applied or clinical part, and do not connect well to the common diseases witnessed in clinics. This requires a refurbishment of all practical labs. Clinical physiology can cover almost all areas of basic physiology with its applications. It also fills the gap between

**TABLE I: SHOWS A BRIEF ACCOUNT OF KEY CONCEPTS THAT CAN BE COVERED WITH CLINICAL PHYSIOLOGY PROCEDURES AND TESTS**

| Clinical Physiology Tests | Concepts Covered | Most relevant discipline |
|---|---|---|
| Pulmonary function tests (PFTs) | -Lung Functions<br>-Gas exchange<br>-Lung Mechanics | -Pulmonology<br>-Sport medicine<br>-Ear, nose, and throat. |
| Electroencephalogram (EEG) | -Reticular activating system<br>-Sleep physiology | -Neurology<br>-pediatrics |
| Nerve Conduction Studies and EMG | -Peripheral nerve disorders<br>-Trauma<br>-Entrapment syndromes<br>-Plexopathies<br>-Radiculopathies | -Neurology<br>-Neurosurgery<br>-Orthopedics<br>-Endocrine |
| Auditory brainstem evoked potential (ABR) | -Auditory pathways | -Ear Nose and Throat |
| Visual Electrodiagnostic testing (VEP).<br>Electroretinogram (ERG) | -Visual pathway<br>-Retinal functions | -Ophthalmology<br>-pediatrics |
| Somatosensory evoked potentials (SSEPs) | -Motor and sensory pathways | -Neurology<br>-Neurosurgery |
| Cardiopulmonary exercise testing (CPET) | Body adaptations to exercise<br>-Exercise physiology<br>-Physical fitness | -Cardiology<br>-Sports medicine<br>-Fitness clinics |
| Heart rate variability (HRV) | -Autonomic function and dysfunction | -Cardiology |
| Respiratory sinus arrhythmia (RSA) | -Autonomic function and dysfunction | -Cardiology<br>-Pulmonology |
| Postural hypotension (orthostatic hypotension) | -Autonomic function and dysfunction | -Internal Medicine<br>-Cardiology |

anatomical structures, imaging, and functional assessments. When decision-makers would like to change the methodology of medical education and teaching curriculum from conventional teaching methods to problem-based learning, they should not target only theoretical levels and neglect practical and applied aspects. The role of basic human physiology in medical practice is a well-known established fact without any doubt but the real role and values of clinical physiology and its applications in medical practice have not been given the recognition that it deserves.

**II) Clinical physiology contributions to hospitals and patient's health care:**

One of the important aspects and functions of the clinical physiology department is its various physiological diagnostic tools such as Pulmonary Function Test, Electroencephalogram (EEG), Nerve Conduction Studies (NCS), Auditory Brainstem Response (ABR), Electrocardiogram, Exercise Based "stress tests," and others. These are some examples of the clinical physiology tools, while the list will go on and on, that can be so helpful in health care practice as well as medical education if they are enclosed in the undergraduate curriculum properly.

It is possible, by using these techniques, to detect and determine the dysfunction of an individual patient. Nowadays, several clinical physiology techniques have been provided by very sophisticated devices with the help of modern technology.[3] Simple, computerized, and well-equipped devices have been developed to cope with the modern healthcare systems. As a result of this fast development, the diagnosis of various impairments such as hearing, vision, respiratory, and neurological disorders, etc. entered a new soft, and promising era. Not only that but several diagnostic techniques can also be performed during different living situations which are so helpful for precise diagnosis.[4] Several techniques or key topics (Table 1) are practiced in the clinical physiology department operating in close collaboration with various clinical specialties which refer their cases to the department. Most common referrals are from Orthopedics, General Medicine, Neurology, Pediatrics, ENT, Ophthalmology, Pulmonology, and Cardiology.

In the following few paragraphs, we will give a brief account of a few clinical physiology techniques which are frequently performed as a routine in the clinical physiology department. Several clinicians, students, and researchers perform these tests without knowing their basic sciences, and this section is aimed at them to improve the understanding of the mechanisms of these tests. It is also worth mentioning that explaining these techniques in detail is beyond the aim of this viewpoint. Moreover, we also discuss the key concepts that are encompassed in relation to the basic sciences.

**1. Pulmonary Function Tests (PFTS):** are vital measurements in the diagnosis, prognosis, and treatment strategy of pulmonary disorders. In addition, it can be used as a preoperative assessment tool as well.[5,6] It is not only a noninvasive and practical technique but also a very reliable test.[7] PFT consists of both static and dynamic spirometry with, flow-volume loops recording and bronchodilator challenge. It depends significantly on subject performance at given instructions during the forced inspiration and expiration. The findings provide three patterns: obstructive, restrictive, or mixed patterns. Spirometry provides information regarding Forced Vital Capacity (FVC), Forced Expiratory Volume in the First Second (FEV1), and Forced Expiratory Ratio (FEV1/FVC ratio). Flow–volume loop: A given graph after a subject performance with a negative inspiratory and a positive expiratory part. It provides useful information about Peak Expiratory Flow Rate (PEFR), 25% of Forced Expiratory Flow (FEF25%), 50% of Forced Expiratory Flow (FEF50%), and 75% of Forced Expiratory Flow (FEF75%).[6]

Any changes in the shape of the graph have a special indication. If FEV1 decreases below the predicted value, decreases in total lung capacity (TLC), airway obstruction, a decrease in lung elasticity, or weakness of respiratory muscles might be the causes. Nevertheless, the most common cause is airway obstruction. When FEV1 increases due to bronchodilator usage, it indicates reversibility of the obstruction.[8]

Although people pay more attention to disorders` diagnosis, medical treatment,

and health care, the utilization of PFT is still underestimated.[9] In the future, more attention should be directed toward the standardization and generalization of PFT as part of pulmonary disorders' diagnosis criteria.

**2. Electroencephalogram (EEG):** over the last decade, many advances in the diagnosis, prognosis, and evaluation of treatment of several neurological disorders such as: epilepsy and nerve dysfunctions, have been acknowledged to clinical neurophysiology. For instance, epilepsy cannot be diagnosed, followed up, and controlled without the guidance of an electroencephalogram (EEG).[10] Interestingly, EEG can also help in the differentiation between different genetic epileptic syndromes as well.[11] EEG waves are formed due to the summation of inhibitory and excitatory postsynaptic potentials of cortical neurons and are subsequently recorded by the electrodes on the scalp. In addition, thalamus and thalamocortical neurons participate in the formation of EEG waves. It is important to mention in this regard that the action potential of the neurons has less contribution to EEG waves due to its short duration (1 ms while postsynaptic potentials 15-200 ms). EEG recordings should be performed in different patients` situations (awake, sleep) in order to have a complete picture of brain activity. Any disturbance in the normally recorded waves, changes in the amplitude, or spikes might indicate abnormal findings.[12] Among physicians, one of the reasons for the misdiagnosis of epilepsy is due to the lack of knowledge in EEG interpretations. Therefore, the intensive training of neurology residents can decrease the misdiagnosis of epilepsy.[13]

**3. Auditory Brainstem Evoked Potential (ABR):** is also one of the milestones of the diagnosis and assessment of the pathway of the auditory impulse and it can precisely point to the lesion site in the nerve.[14,15]

It is recorded by a surface electrode as a result of auditory (click) stimuli that generate impulses through the auditory neural pathway. One of ABR features is that it is not affected by the general condition of the patients (awake or asleep) so it can be performed in several situations.[16]

**4. Visual Evoked Potentials (VEP):** provides a method to examine the abnormalities of the retina and the visual pathway. The VEP assesses the normal integrity of the visual pathway starting from the retina, then the optic nerve, optic chiasm until it reaches the occipital cortex but if you would like to examine the retina specifically, Electroretinogram (ERG) is the best electrophysiological test to be used.[17] There are two types of VEPs; flash VEP and Pattern VEP. Scalp electrodes will record the wave on the scalp. Even in infants or children, Flash VEP gives an especially useful visual assessment information. Pattern VEP is produced by using a reversal black and white checkerboard stimulus and it is mostly used in adults.[18]

Normal waves are predicted and well known and deviation from normal suggests abnormalities. VEP amplitude is recorded but is less informative. There are some variables that affect VEP waves such as age, gender, smaller pupillary diameter, Visual acuity, level of alertness, stimulus field size, and location of scalp electrodes.[18]

**5. Somatosensory Evoked Potentials (SSEPs):** is a widely used test to detect the normal activation of somatosensory pathways and their neuronal compartments by administering electrical stimulation of the somatosensory peripheral nerves, to elicit huge and strong responses. SSEPs can be used as a prognostic test for a patient in a coma, a monitoring tool during the surgical procedure to maintain the integrity of the somatosensory pathways when it is under risk, and a neurological diagnostic tool for neurological disorders. Any abnormalities in the somatosensory pathways starting from the peripheral nerve, plexus, spinal root, spinal cord, brain stem, thalamocortical projections, or primary somatosensory cortex can be detected by using SSEPs.[19]

SSEPs are produced by a stimulus to the somatosensory pathways which give a series of positive–negative potentials. The stimulus can be mechanical or electrical. The most common sites of stimulation are the median nerve at the wrist and the posterior tibial nerve at the ankle.[20]

**6. Cardiopulmonary Exercise Testing (CPET):** a task based useful test to assess multiple functions of the cardiovascular, respiratory, skeletal muscles, and nervous systems under well controlled physiological conditions.[21] CPET can be used when other tests fail to detect the dysfunction during rest. So, any abnormalities that do not appear at rest can be detected with CPET under stressful situations. It can be performed by using a cycle ergometer or treadmill with an analysis of collected expired gas [oxygen uptake ($VO_2$), ventilation (VE), and carbon dioxide output ($VCO_2$)]. It usually starts with low effort and subsequently reaches the maximum limitation effort. This takes from 8-12 minutes.[22]

**7. Heart Rate Variability (HRV):** is a slight fluctuation of heartbeats upon the time that needs special software. Normal HRV ranges in adults between 20-200 milliseconds. They are used as an indicator of current or future heart disorders, anxiety, and depression. More importantly, it can be used to detect autonomic nervous system disorders due to cardiovascular diseases.[23] HRV can be used as a reliable, simple, and non-invasive method which reflects the changes in cardiac rhythmicity by the effect of both compartments of the autonomic nervous system (sympathetic and parasympathetic). In addition, it can measure the autonomic nervous system modulation during cardiovascular events and can be used to screen for sudden cardiac death.[24]

**8. Respiratory Sinus Arrhythmia (RSA):** is the change of heart rate variability simultaneously with inspiration and expiration by which the R-R interval on ECG is becoming shorter during inspiration and longer during expiration. RSA can be used as a reflection of respiratory-circulatory interactions even though it is used as an index of cardiac vagal nerve dysfunction.[25]

RSA is very obvious in infants and athletes and become weaker with age and with coronary artery diseases with or without myocardial infarction and congestive heart failure. There is an inverse correlation between attenuation of RSA and poor prognosis of coronary artery diseases. It also can be used as a predictor index of autonomic neuropathy in diabetic patients.[25]

**9. Postural Hypotension (orthostatic hypotension):** is an abnormal decrease in the systole of blood pressure more than 20mmHg and/or more than 10mmHg in diastole of blood pressure which usually happens within 3 minutes of changing the patient's position from lying or sitting to standing position. It can increase the risk

of falls and subsequently might lead to fractures, depression, dementia, and death.[26] It occurs due to failure in blood pressure response to postural changes and it could be acute, chronic, symptomatic, or asymptomatic. It could be caused by several reasons such as dehydration, blood loss, medication, neurological, cardiovascular, and endocrine disorders. Symptoms are dizziness, blurred vision, weakness, fatigue, nausea, palpitations, headache, syncope, dyspnea, chest pain, and neck and shoulder pain. Head-up tilt table can be used as a standard test to elicit orthostatic hypotension. [27]

In this regard, one should not forget the importance and need for professionally qualified and specialized technicians, nurses, and clinical physiologists that can perform and interpret these tests effectively for both patient care, teaching, and research.

**III) Connections between clinical physiology and research:** another important aspect of the clinical physiology department is its relation to research disciplines and its participation in this field intensively. Students, interns, and specialists can apply their basic knowledge, which have been gained during their undergraduate program, to the clinical practice through clinical physiology research disciplines.[4] One of the advantages of clinical physiology research is the extension of basic science findings to the clinical settings, then to clinical practice, and subsequently to health policy. This is called: translational research.[28] Collaborations among multiple clinical disciplines with clinical physiology would lead to a better understanding of basic sciences knowledge, its application, and clinical utility in both teaching and research.

## CONCLUSION AND RECOMMENDATIONS

Assuring clinical physiology as an independent well-equipped department with full decision-maker support could guarantee the survival and the continuation of the link between the human integrative systems curriculum that is taught to the students in schools and their clinical practice. In addition, well-prepared physiology laboratories in the medical undergraduate program, in order to link the students to their future useful diagnostic tools, are of great value.

The practical sessions of the medical undergraduate curriculum should be revised and updated so that students get knowledge of techniques utilized in their clinical practice. We propose that the clinical physiology department should be a part of each physiology department in all medical schools working in close collaboration with clinical departments.

Recruitment of well-qualified and specialized specialists in clinical physiology techniques, technicians, and nurses who can perform and interpret these tests effectively as well as supplying the unit with modern and sophisticated equipment are of great value.

Research funds have to be directed toward clinical physiology thoughts and ideas that can boost the development of medical evolution ahead.

## REFERENCES


1. Institute of Medicine (US) Committee on the Health Professions Education Summit, Greiner AC, Knebel E, editors. Health Professions Education: A Bridge to Quality. Washington (DC): National Academies Press (US); 2003. https://doi.org/10.17226/10681
2. Li AS, Berger KI, Schwartz DR, Slater WR, Goldfarb DS. Facilitating the transition from physiology to hospital wards through an interdisciplinary case study of septic shock. BMC Med Educ 2014;12:14:78. https://doi.org/10.1186/1472-6920-14-78
3. Seals DR. Translational physiology: from molecules to public health. J Physiol 2013;591(14):3457-69. https://doi.org/10.1113/jphysiol.2013.253195
4. Arheden H. Clinical physiology: a successful academic and clinical discipline is threatened in Sweden. Adv Physiol Educ 2009;33(4):265-7. https://doi.org/10.1152/advan.00072.2009
5. Wanger JS, Culver BH. Quality standards in pulmonary function testing: past, present, future. Ann Am Thorac Soc 2016;13(9):1435-6. https://doi.org/10.1513/annalsats.201604-300ed
6. Ranu H, Wilde M, Madden B. Pulmonary Function Tests. Ulster Med J 2011;80(2):84-90.
7. Fei L, Zhi-wen H, Xiao-fei W, Hui-wen X, Hua Y, Yan-bin C, et al. Safety and use of pulmonary function tests: a retrospective study from a single center over seven years' clinical practice. BMC Pulm Med 2019;19:259. https://doi.org/10.1186/s12890-019-1019-z
8. Husain A, Syed Shahid S. Pattern identification of obstructive and restrictive ventilatory impairment through flow volume curves. Pak J Physiol 2008;4(1):30-4.
9. Swanney MP, O'Dea CA, Ingram ER, Rodwell LT, Borg BM. ANZSRS Spirometry training course working group. Spirometry training courses: content, delivery and assessment - a position statement from the Australian and New Zealand society of respiratory science. Respirology 2017;22(7):1430-5. https://doi.org/10.1111/resp.13133
10. Lopes da Silva FH. "The Impact of EEG/MEG Signal Processing and Modeling in the Diagnostic and Management of Epilepsy,". IEEE Rev Biomed Eng 2008;1:143-56. https://doi.org/10.1109/rbme.2008.2008246
11. Seneviratne U, Hepworth G, Cook M, D'Souza W. Can EEG Differentiate Among Syndromes in Genetic Generalized Epilepsy? J Clin Neurophysiol 2017;34(3):213-21. https://doi.org/10.1097/wnp.0000000000000358
12. Fisch BJ, Spehlmann R. Fisch and Spehlmann's EEG primer: Basic principles of digital and analog EEG. 1999 Amsterdam: Elsevier
13. Amin U, Benbadis SR. The Role of EEG in the Erroneous Diagnosis of Epilepsy. J Clin Neurophysiol 2019;36(4):294-7. https://doi.org/10.1097/wnp.0000000000000572
14. Wilson W, Mills P, Bradley A, Petoe M, Smith A, Dzulkarnain A. Fast assessment of canine hearing using high click-rate BAER. Vet J 2011;187(1):136-8. https://doi.org/10.1016/j.tvjl.2009.10.009
15. Lilian C, Luis O, González G, Randy K, Tatiana F, Gabriela P, et al. Exposures

to fine particulate matter (PM2.5) and ozone above USA standards are associated with auditory brainstem dysmorphology and abnormal auditory brainstem evoked potentials in healthy young dogs. Environ Res 2017;158:324-32. https://doi.org/10.1016/j.envres.2017.06.026

16. Habib SH, Habib SS. Auditory brainstem response: An overview of neurophysiological implications and clinical applications -A Narrative Review. J Pak Med Assoc 2021;71(9):2230-36. https://doi.org/10.47391/jpma.03-432
17. Odom JV, Bach M, Brigell M, Holder GE, McCulloch DL, Mizota A, et al. International Society for Clinical Electrophysiology of Vision. ISCEV standard for clinical visual evoked potentials: (2016 update). Doc Ophthalmol 2016;133(1):1-9. https://doi.org/10.1007/s10633-016-9553-y
18. Bradley and Daroff's Neurology in Clinical Practice,2022, 2-Volume Set, 8th Edition
19. Baker A, Widrich J. Somatosensory Evoked Potentials. StatPearls [Internet]. January 2022. [Accessed on: August 14, 2021]. Available from URL: https://www.ncbi.nlm.nih.gov/books/NBK544358/
20. Yamada T. Somatosensory Evoked Potentials. Encyclopedia of the Neurological Sciences (Second Edition), 2014, pp:230-38. https://doi.org/10.1016/B978-0-12-385157-4.00544-3
21. O'Donnell DE, Neder JA. Why Clinical Physiology Remains Vital in the Modern Era. Clin Chest Med 2019;40(2):13-4. https://doi.org/10.1016/j.ccm.2019.03.001
22. Tran D. Cardiopulmonary Exercise Testing. Methods Mol Biol 2018;1735:285-95. https://doi.org/10.1007/978-1-4939-7614-0_18
23. Alalyan MJ, Alkahtani SA, Habib SS, Flatt AA. Suitability of Ultra-Short-Term Heart Rate Variability in Military Trainees. Healthcare (Basel) 2020;8(4):409. https://doi.org/10.3390/healthcare8040409
24. Campos M. Heart rate variability: How it might indicate well-being. Harvard health Publishing. 2021; Accessed on: December 22, 2021, Available from URL: https://www.health.harvard.edu/blog/heart-rate-variability-new-way-track-well-2017112212789
25. Yasuma F, Hayano J. Respiratory sinus arrhythmia: why does the heartbeat synchronize with respiratory rhythm? Chest 2004;125(2):683-90. https://doi.org/10.1378/chest.125.2.683
26. Gilani A, Juraschek SP, Belanger MJ, Vowles JE, Wannamethee SG. Postural hypotension. BMJ 2020;373:n922. https://doi.org/10.1136/bmj.n922
27. Lanier JB, Mote MB, Clay EC. Evaluation and management of orthostatic hypotension. Am Fam Physician 2011;84(5):527-36.
28. Michael Joyner. "Why Physiology Matters in Medicine". Physiology (Bethesda) 2011;26(2):72-5. https://doi.org/10.1152/physiol.00003.2011

## AUTHOR'S CONTRIBUTION

Following authors have made substantial contributions to the manuscript as under:

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*Authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.*

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