Abdel-Hamid R., Lightwala Z.J.

CLINICAL PHYSIOLOGY CALCULATOR SUITE: A COMPREHENSIVE DIGITAL PLATFORM FOR MULTI-SYSTEM CLINICAL ASSESSMENT AND DECISION SUPPORT

Tutor: PhD, associate professor Alexandrov D.A.
Department of Normal Physiology
Belarusian State Medical University, Minsk

Relevance. Clinical physiology assessment requires integration of complex, multi-system parameters across cardiovascular, respiratory, renal, endocrine, autonomic, and hemodynamic domains. Traditional bedside calculation methods remain fragmented, time-consuming, and error-prone, requiring manual reference to multiple guidelines (ACC/AHA, KDIGO, GOLD, ADA, ESC) and individual formula application. While isolated calculators exist for specific parameters (e.g., BMI, eGFR, cardiac output), a comprehensive, unified platform that synergistically integrates all major clinical physiology domains with real-time interpretation and evidence-based recommendations remains undeveloped. This study investigates the impact of such an integrated digital platform on clinical assessment efficiency, diagnostic accuracy, and medical education.

Aim: to develop and validate a comprehensive digital platform integrating 50+ clinical calculators across 8 physiological systems with real-time interpretation, clinical visualization, and evidence-based recommendations aligned with current clinical guidelines.

Materials and methods. The CLINICAL PHYSIOLOGY CALCULATOR SUITE was developed using Streamlit framework with modular microservices architecture, integrating 8 complete clinical modules: Cardiovascular, Respiratory, Renal, Fluid & Electrolytes, Endocrine, Autonomic Function, and Cardiac Mechanics (fractional shortening normal 25-45%, ejection fraction via Teichholz method with HF classification HFrEF/HFmrEF/HFpEF, stroke work, minute work, cardiac efficiency normal 20-25%). The platform features professional medical interface, real-time calculation engine, interactive Plotly visualizations (gauge charts, bar charts), and comprehensive reference range database derived from ACC/AHA, KDIGO, GOLD, ADA, and ESC clinical practice guidelines.

Results and their discussion. The integrated platform demonstrated superior clinical utility and operational efficiency. Time-motion analysis revealed an 86% reduction in multi-system assessment time (from 35-50 minutes to 5-7 minutes per patient, $p<0.001$), eliminating manual calculation errors inherent in 50+ separate formulas and reference range lookups. The cardiovascular module provided complete hemodynamic profiling with automated BP classification across six categories (Normal, Elevated, Stage 1 HTN, Stage 2 HTN, Hypertensive Crisis, Hypotension) with corresponding ACC/AHA guideline-based management recommendations. The respiratory module successfully calculated predicted FEV_1 and FVC values based on patient demographics (gender, height, age), with automated GOLD COPD staging (GOLD 1-4) for obstructive patterns and complete ABG interpretation identifying primary acid-base disorders (respiratory acidosis/alkalosis, metabolic acidosis/alkalosis, mixed disorders) with Winter's formula validation for metabolic acidosis (expected $PaCO_2 = 1.5 \times HCO_3^- + 8 \pm 2$ mmHg). The renal module integrated three eGFR equations (CKD-EPI 2021 race-neutral, MDRD, Cockcroft-Gault) with automated CKD staging (G1-G5) and management recommendations per KDIGO guidelines.

Conclusion. The CLINICAL PHYSIOLOGY CALCULATOR SUITE represents a paradigm shift in multi-system clinical assessment, delivering substantial time efficiency (86% reduction), enhanced diagnostic accuracy through automated guideline-based interpretation, and improved medical education through real-time visualization of complex physiological relationships. The platform's integrated approach enables rapid, accurate clinical assessment across cardiovascular, respiratory, renal, endocrine, autonomic, hemodynamic, and cardiac mechanics domains, making it an invaluable tool for clinical practice, medical education, and research applications. Further development should address electronic health record integration, mobile platform deployment, and expansion to additional physiological systems including neurological and gastrointestinal assessment.