Chemical Engineering Doctoral Defense

A Smart Home Medical Device for Accurate Metabolic Assessment

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Abstract

Energy Expenditure (EE), a key diagnostic measurement for treatment of obesity, is measured via indirect calorimetry method through breath biomarkers of CO2 production and/or O2 consumption rates (VCO2 and/or VO2, respectively). Current technologies are limited due to prevailing designs requiring wearable facial accessories that present accuracy, precision, and usability concerns with regards to free living measurement. A novel medical device and smart home system, named Smart Pad, has been developed, with the capability of energy expenditure assessment via VCO2 measured from a room's CO2 concentration. The system has 3 distinct capabilities: contactless EE measurement, air quality optimization via actuation of room ventilation, and efficiency optimization via ventilation actuation of only human-occupied environments. The Smart Pad shows accuracy of 90% for 14-19 minutes of resting measurement and accuracy of 90% for 4.8-7.0 minutes of exercise measurement after calibrating for air exchange rate (λ [hour-1]) using a reference method. Without reference instrument calibration, the Smart Pad system shows average accuracy of nearly 100% with correlations of Y=1.02X, R=0.761 for high resolution measurements and Y=1.06X, R=0.937 for averaged measurements over 50-60 minutes. In addition, the Smart Pad validation for contactless EE measurement has been performed in different environments, including a vehicle, medical office, a private office, and an ambulatory enclosure with rooms, ranging in volume from 3.1 m3 to 18.8m3. We concluded that contactless EE measurements can be accurately performed in all tested scenarios with both low and high air exchange environments with λ ranging from 1.5 Hours-1 to 10.0 Hours -1. The system represents a new way to assess EE of individuals under free-living conditions in an unobstructive, passive, and accurate manner, and it is comparable or better in single breath gas measurement accuracy (with comparisons sourced from FDA data) than other medical devices (e.g. Vyntus CPXTM, MasterScreen CPXTM, Oxycon ProTM, and MedGemTM) which were 510(k) cleared by the FDA for prescription use in metabolic/cardiopulmonary diagnostics.

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Zoom Link: https://asu.zoom.us/j/87188454516