Earbud-Based Sensor for the Assessment of Energy Expenditure, Heart Rate, and VO_2 max

Introduction/Purpose: The goal of this program was to determine the feasibility of a novel noninvasive, highly miniaturized optomechanical earbud sensor for accurately estimating total energy expenditure (TEE) and maximum oxygen consumption (VO_2 max). The optomechanical sensor module, small enough to fit inside commercial audio earbuds, was previously developed to provide a seamless way to measure blood flow information during daily life activities. The sensor module was configured to continuously measure physiological information via photoplethysmography (PPG) and physical activity information via accelerometry. This information was digitized and sent to a microprocessor where digital signal processing (DSP) algorithms extract physiological metrics in real-time. These metrics were streamed wirelessly from the earbud to a computer.

Methods: In this study, 23 subjects of multiple physical habitus were divided into a training group of 14 subjects and a validation group of 9 subjects. Each subject underwent the same exercise measurement protocol consisting of treadmill-based cardiopulmonary exercise (CPX) testing to reach VO2max. Benchmark sensors included a 12-lead electrocardiography (ECG) sensor for measuring heart rate, a calibrated treadmill for measuring distance and speed, and a gas-exchange analysis instrument for measuring TEE and VO2max. The earbud sensor was the device under test (DUT). Benchmark and DUT data collected from the 14-person training dataset study were integrated into a preconceived statistical model for correlating benchmark data with earbud sensor data. Coefficients were optimized, and the optimized model was validated in the 9-person validation dataset.

Results: It was observed that the earbud sensor estimated TEE and VO2max with mean +/- SD percent estimation errors of -0.7 +/- 7.4% and -3.2 +/- 7.3% respectively.

Conclusion: The earbud sensor can accurately estimate TEE and VO2max during CPX testing.

http://journals.lww.com/acsm-msse/Abstract/publishahead/Earbud_Based_Sensor_for_the_Assessment_of_Energy.98160.aspx