Using SenseWear® Armband to Evaluate Energy Expenditure in Manual Wheelchair Users

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Abstract.
Accelerometry-based devices have been studied in measuring activities and predicting energy expenditure (EE) for ambulatory populations. However, research involving wheelchair users utilizing multi-sensor based devices to estimate EE is missing. The purpose of the study is to examine the validity of SenseWear® Armband (SenseWear), a multi-sensor activity monitor, in assessing EE in manual wheelchair users during wheelchair related activities. This paper presents the preliminary data obtained from five subjects (n=5) with spinal cord injury performing three physical activities, including wheelchair propulsion, arm-ergometer exercise and deskwork. The analysis presented here compares the EE estimated from the SenseWear with the EE measured from a portable metabolic cart, used as the criterion measure. It was found that the SenseWear underestimated EE for resting (-0.49%), overestimated EE for wheelchair propulsion (+87.48%, +47.14%, and +124.77% respectively for the three trials respectively), arm-ergometer exercise (+57.64%, +30.50%, and +42.94% for the three trials respectively) and deskwork (+10.12%). In future other sensor data from SenseWear will be utilized to model an energy expenditure equation for manual wheelchair users with spinal cord injury (SCI).

Keywords: energy expenditure, spinal cord injury, activity monitor

Introduction

In the recent times, there has been a growing interest in the assessment of daily physical activity and energy expenditure (EE, kilocalories expended) using various activity monitors ranging from simple mechanical pedometers to multi-sensor based wearable armbands. Accelerometry-based devices have been studied in measuring activities and predicting energy expenditure (EE) for ambulatory populations [1-3]. Researchers have assessed the validity of a uniaxial accelerometer worn on the wrists as a measure of EE during wheelchair propulsion at three different speeds [4]. Warms and Belza assessed the suitability and validity of a uniaxial accelerometer as a measure of community living physical activity for wheelchairs users with SCI [5]. However, research involving wheelchair users using multi-sensor based activity monitors to estimate energy expenditure is missing. The purpose of this study is to examine the validity of SenseWear® Armband, a multi-sensor monitor, in assessing EE in manual wheelchair users. This paper describes the preliminary data obtained from five subjects

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(n=5) with spinal cord injury performing three physical activities, including wheelchair propulsion, arm-ergometer exercise and deskwork.

1. Methods

1.1. Participants

The study was approved by the Institutional Review Board at the University of Pittsburgh. Subjects were recruited based on inclusion criteria and were asked to produce a physician release form to participate in the study. The subjects were consented on their arrival. Following which the subjects participated in resting and three activity sessions including wheelchair propulsion, arm-ergometer exercise, and desk work. The activity sessions were counterbalanced to counter order effects. Subjects wore an armband on the upper right arm and a portable metabolic cart with a face mask while performing the activities. The subjects performed each activity trial for a maximum period of eight minutes and rested for a period of 5 to 10 minutes between each trial and a period of 30 to 40 minutes between the activity sessions. In the wheelchair propulsion activity the subject's wheelchair was restrained on a stationary dynamometer. The speed feedback was provided via a monitor in front of the subject. After practicing, the subjects propelled their wheelchair for two trials of two miles per hour (2mph Dyno) and three miles per hour (3mph Dyno), respectively. In the third trial, the subjects propelled their wheelchair at three miles per hour on a flat tiled floor (3mph on tile). The arm-ergometer exercise was performed by the subjects seated in their manual wheelchairs. The activity included three trials of 20 watts resistance at 60 rpm (20W at 60rpm), 40 watts resistance at 60 rpm (40W at 60 rpm) and 40 watts resistance at 90 rpm (40W at 90rpm), respectively. The desk work involved the subjects to use a computer for four minutes and read a book retrieved from a shelf for four minutes.

1.2. Data Collection

The subjects were asked to wear the devices to experience and feel comfortable prior to the activities. The two devices were time stamped at the start and end of each trial in the wheelchair activities. The data collected from the metabolic cart included volume of oxygen consumed in mL/kg, EE in kcal per minute, and heart rate data at each breath. The data collected from the SenseWear included transverse and longitudinal acceleration components were sampled eight times a second (8Hz), EE in kcal per min, heat flux, galvanic skin response and skin temperatures were sampled every minute.

1.3. Data Analysis

The energy costs in kcal per min from the armband were compared with those obtained from the portable metabolic cart. The collected data from the metabolic cart and SenseWear were aligned in time using the timestamps and also reduced to a minute data using MATLAB® data analysis software. The comparison between the EE measured (EE_{MET}), using the metabolic cart, and the EE estimated (EE_{SW}), by the SenseWear, was found by the following equation,

$$\Delta EE\% = \frac{EE_{SW} - EE_{MET}}{EE_{MET}} * 100.$$

2. Results

It was found that the SenseWear underestimated EE for resting (-0.49%), overestimated EE for wheelchair propulsion (+87.48%, +47.14%, and +124.77% for the three trials respectively), arm-ergometer exercise (+57.64%, +30.50% and +42.94% for the three trials respectively) and deskwork (10.12%).

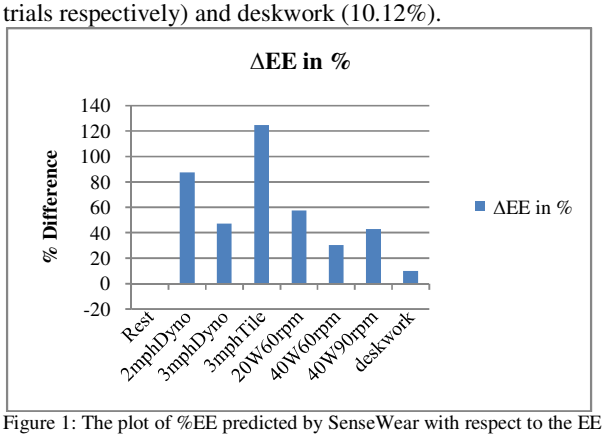

Figure 1: The plot of %EE predicted by SenseWear with respect to the EE measured by metabolic cart versus activity. Positive values indicating overestimation of EE and negative values indicate underestimation of EE by the SenseWear.

3. Conclusion

Though the data collected is only from five subjects, the results have shown that SenseWear predicts the resting EE very closely (0.49%) to the metabolic cart, used as criterion measure, while overestimating in other activity trials. The study is aiming to recruit forty five individuals with SCI who use manual wheelchairs. Utilizing the multi-sensor data available in SenseWear we could potentially develop an EE model to predict accurate EE in people with SCI using manual wheelchairs. The development of such models can aid people with spinal cord injury to better measure their physical activity and energy expenditure.

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