OPTIMIZATION AND INDUSTRIALIZATION OF A METABOLIC HOLTER DEVICE AND SOFTWARE DEVELOPMENT

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Introduction

The quantified-self of a person consists in the self-tracking of health and physiological parameters such as (but not limited to) heart rhythm, energy expenditure (EE), and sleep, using technology and devices such as smartwatches or wristbands, without the need of being supervised by clinicians. One of the first devices that came out on the market has been the BodyMedia Armband SenseWear® (SWA) (BodyMedia, Inc., Pittsburgh, PA), which has been proven to provide a valid measurement of EE during periods of physical activity in adults [1]. However, SWA company was acquired by Jawbone in 2013 and since January 2016 the company officially put SWA out of the market. Since then, there has not been a comparably easy-to-use, reliable and accurate way to routinely self-tracking the health and physiological parameters outside the laboratory in a free-living environment; therefore, this study aims to develop, optimize, and preliminarily validate a new metabolic holter device, based on SWA, aimed to analyze sleep tracking, activity level, and EE.

Materials and Methods

Following the SWA structure (enabling the analysis of activity level, sleep, and EE), the following input variables were considered for the device: movement, skin and environment temperature, galvanic skin response, heat flux, and user parameters (as height, weight, age, BMI). As gender and morphology have a direct impact on the subject's metabolism [2] data will be classified by gender and by BMI considering three classes: Normal (BMI<25), Overweight (BMI between 25 and 30), Obese (BMI>30). From the previous data, the metabolic holter prototype uses a machine learning model to obtain EE, quality of sleep, and intensity of physical activity. An internal database of SWA data collected from 3706 patients was used to train each of these models. For each of the six groups, a randomly selected number of subjects (70% of the total) were chosen to train the machine learning, while the remaining 30% was chosen for the test set.

In order to optimize the software and check the measurement accuracy of the machine learning model in-vivo, a clinical study on 12 healthy volunteers has been performed. The aim of this was to compare the results (in terms of EE) measured during a standard clinical protocol by the new device with the ones obtained by the SWA sensor and by a metabolimeter, usually considered the gold standard.

Results

Figure 1 reports the energy expenditure against prediction. It is possible to highlight that the new holter, as the SWA, is able to properly detect the energy expenditure for each patient. The new device is characterized by a closer R^2 and a lower difference of the EE compared to the control (range of variability: 3.3-20.7%); for the 7 patients that have also the SWA measurement, instead, the range of percentile variability is from 6.5% to 36.9%.

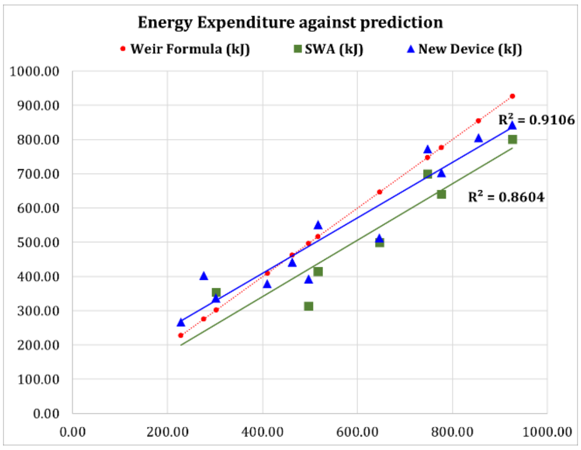

Figure 1: Energy expenditure in kJ against prediction; red dots correspond to the EE measured by the prediction, green squares correspond to the EE measured by the SWA, while blue triangles reported the values measured by the new device. The different lines represent the linear correlation, the R^2 values is also reported for the green and blue lines.

Conclusion

In this study a prototype of a metabolic Holter device was developed and validated. Based on data from a previous commercial device, three machine-learning models were developed, tested and validated enabling the analysis of sleep, energy expenditure and physical activity. The clinical study allowed to check the reliability of the metabolic holter prototype for the energy expenditure evaluation. It has been highlighted that the new device prototype is able to correctly assess the energy expenditure, as shown by the high value of R^2 (R^2=0.91), with an average accuracy of 3.6%.

References

1. Jakicic et al, Med Sci Sports Exer 36(5):897-904 (2004).
2. Wu et al, J Nutr Metab. 391809 (2011).