Personal Wearable Devices to Measure Heart Rate Variability:

A Framework of Cloud Platform for Public Health Research

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ABSTRACT

Background: Heart rate variability (HRV) refers to the variation in time interval between heart rates (RR-interval). Studies have demonstrated that emotional disorder is associated with lower HRV. Electrocardiography (ECG) is the conventional HRV measurement conducted by healthcare professionals. Wearable devices with HRV measurement function may be a convenient and low-cost alternative. This study aimed to evaluate the HRV results between a wearable device and ECG. **Methods:** Parents from disadvantaged families were recruited and requested to wear the wearable device, second generation of Microsoft Band (MS band), on their non-dominant hand and a 7-lead ECG simultaneously for 10 minutes. Mean RR-interval was used to measure the level of HRV; subject with mean RR-interval greater than 750ms was defined as normal. Sensitivity and specificity was used to quantify the consistence between the MS band and the ECG. **Results:** A total of 40 subjects were recruited. The mean RR-interval of ECG measurements ranged from 487.87 to 1076.5; 9 of them had abnormal RR-interval. The sensitivity and specificity of the MS band were 88.89% and 77.42% respectively. **Conclusion:** This study showed that wearable device was a reliable instrument for HRV measurement in static posture. Further investigations should look into the accuracy during motion.

DH '17, July 02-05, 2017, London, United Kingdom

ACM ISBN 978-1-4503-5249-9/17/07.
http://dx.doi.org/10.1145/3079452.3079453

KEYWORDS

Heart Rate Variability; Wearable Devices; Cloud Platform

COMPETING INTERESTS

The authors have declared that no competing interests exist

1 INTRODUCTION

Wearable technology for health monitoring is widely available in the market. These portable health monitoring devices usually come with various sensors. Heart rate sensors for heart response monitoring during exercise is one of the essential features. Heart rate variability (HRV) refers to the variation in time interval between heart rates (i.e. the RR interval in Figure 1); it is a well-known indicator of the sympatho-vagal balance of the heart (1). Studies have demonstrated that high frequency HRV could predict depressive symptoms and poor self-esteem; It might be a good predictor for depression symptoms.

Figure 1. An ECG Output to show RR Interval

Electrocardiography (ECG) is the conventional approach to evaluate heart responses; it measures the electrical activity of the heart with leads placed on the skin (2). However, ECG is usually conducted under clinical setting with the supervision of healthcare professionals. In contrast, wearable devices for heart rate monitoring are self-administrated and capable to assess HRV wherever and

whenever they want. This study would like to (1) construct a smartphone application to connect a cloud platform with a wearable device for data collection of HRV; (2) evaluate the HRV results between a wearable device and the ECG.

2 METHOD

2.1 Wearable Device

The second generation of Microsoft band (MS band) was used in this study. This device used an optical technology, photoplethysmography, to capture the reflected light from blood vessels in the wrist as pulse measurement. It is able to connect with smartphone through the Bluetooth network. Data collected from the MS band in every second could be temporarily stored locally on the smartphone then packaged into JSON format and uploaded to the cloud through the smartphone wireless connection in every minute. We have developed our own Android platform to command the sensors of the MS band, data transferal and temporary storage. The outlook of the APP is shown (Figure 2). We are providing this open source software at https://github.com/bddacuhk/MicrosoftBandTestMobileApplication

Figure 2. Outlook of the Microsoft Band and the smartphone application.

2.2 Patients and Evaluation

To compare the MS band HRV readings from that of ECG, parents from disadvantaged families at risk of depression and poor self-esteem were recruited through social workers. Subjects were requested to wear a widely used 7-lead ECG (Holter Recorder DMS300-3A) (3,4) and the MS band on their non-dominant hand simultaneously for 10 minutes in a seating static posture. The readings of ECG with or without MS band have been compared previously in order to confirm that MS band would not affect the performance of ECG.

Data from the MS band and the ECG were analyzed using software called Kubios (5). Mean RR-interval was used to measure the level of HRV; subjects with mean RR-interval greater than 750ms was defined as normal (6). Sensitivity, specificity and area-under-curve were used to quantify the level of consistence between the wearable device and the ECG.

3 RESULTS

A total of 40 subjects were recruited. The mean RR-interval of ECG measurements ranged from 487.87 to 1076.5; 9 of them had abnormal HRV. The mean RR-interval of the wearable device ranged from 638.36 to 1069.4, the sensitivity and specificity of the wearable device were 88.89% and 77.42% respectively. The area under curve was 83.2% (Table 1).

Table 1: Distribution of normal and abnormal HRV by the MS band and ECG results

MS Band \ ECG	Abnormal HRV	Normal HRV
Abnormal HRV	8	7
Normal HRV	1	24

4 CONCLUSIONS

The application of wearable devices becomes a major trend in personalized health monitoring; this platform is potentially important for future clinical studies given that HRV captured from the wearable devices has comparable reliability as those captured by ECG. It will also change the practice of data collection for HRV, as data can be continuously captured by wearable devices. Further investigations should look into the accuracy during motion.

ACKNOWLEDGMENTS

We wish to acknowledge the support of the research grant from Microsoft Research Asia. The Microsoft Band (Band2) is used in this study.

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