The Effect of Wearer Motion on Electronic Health Sensor Performance

Hannah Stevens

Centre for Rural Health

The University of Aberdeen and the University of the Highlands and Islands working in partnership

Research and Policy

Background

This study evaluated the effect of wearer motion on physiological monitor performance. It then explored the potential that these physiological monitors have for use in remote and rural locations across the UK, based on the outcome.

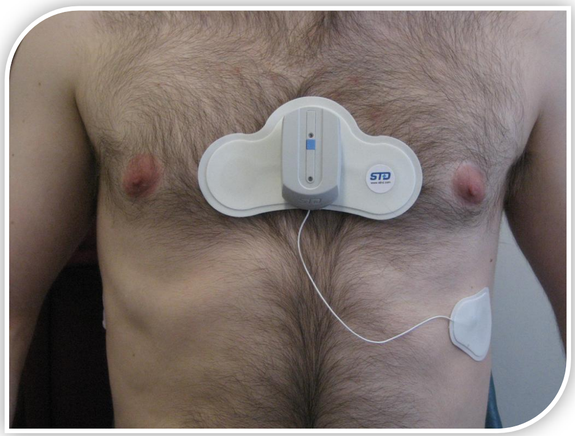
The larger purpose of this investigation was to aid the University of Aberdeen dot.rural **MIME** project – *Managing Information in Medical Emergencies*. This project was designed to **support emergency response** to remote and rural road traffic collisions by designing novel technology to help the first person on-scene.

Error may be derived from incorrect sensor placement or attachment, insufficient skin preparation for some parameters, pulling on wires, and environmental conditions. Wearer motion can also create 'noise' on signals, which may also result in error.

Hypothesis: Wearer motion has a detrimental effect on electronic health senor performance

Monitors

Rathlin – Intelesens (Belfast, www.intelesens.com)



The Rathlin monitor consisted of two adhesive patches and a little box - magnetically attached to the larger patch.

It monitored three physiological variables; **Heart Rate** (HR), **three-lead ECG** and **skin temperature**.

It also included an accelerometer which measured motion in three axes.

Pulse Oximeter – Nonin (nonin.com)

The Pulse Oximeter sits on the end of the finger.

It monitored two physiological variables; HR and Blood Oxygen Saturation (SpO_2).

It took the instantaneous HR every second.

Both Monitors connected to a laptop wirelessly.

Method

Five male volunteers participated in three conditions with varying degrees of motion:

- 5 minutes at rest
- 5 minutes steady walking
- 5 minutes of steady step ups.

Heart Rate is calculated by identifying each individual heart beat peak and then measuring the **peak-to-peak time interval**, which corresponds to the time to complete one cardiac cycle.

Bland-Altman analysis is a statistical technique designed specifically for comparing two methods of measurement.

It shows how much the two methods **agree** by plotting the difference between the two monitors against the average of the two monitors.

Blood oxygen saturation was analysed visually for any effect of motion.

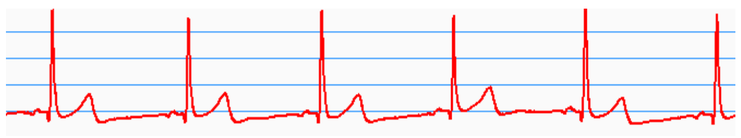
Results

Heart rate and ECG

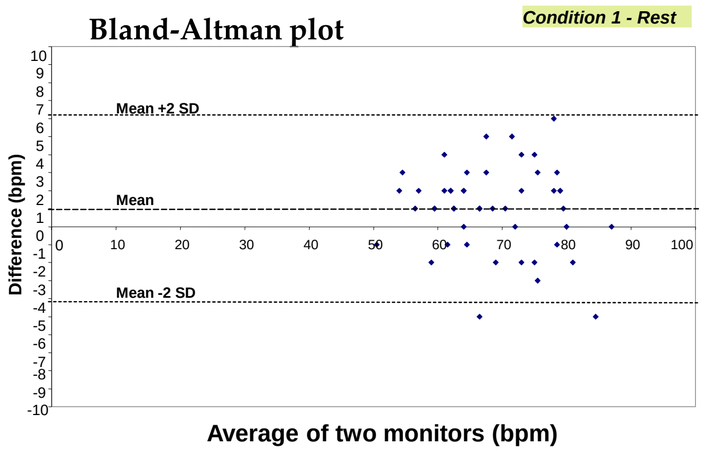
Condition 1. Rest

98% of the data lied between +/- 5 beats per minute (bpm)

Rathlin ECG



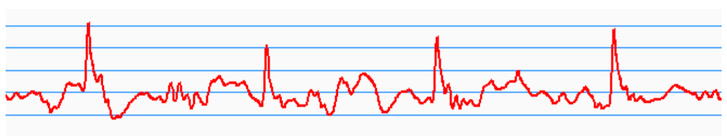
- The quality of this subject's ECG trace is **good**
- The different parts of the wave can be easily identified



Condition 2. Walking

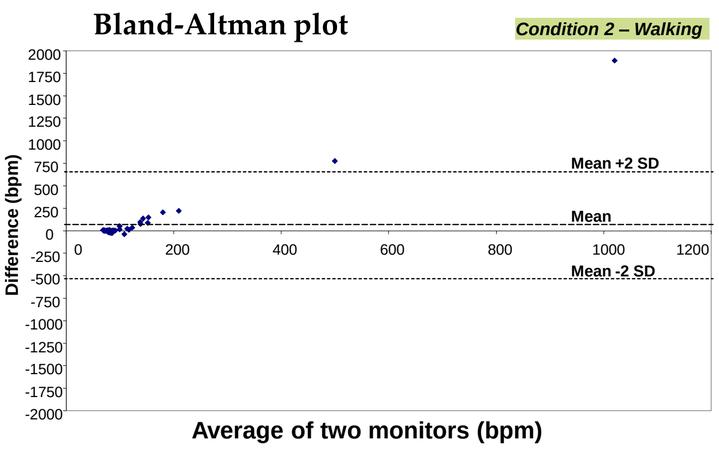
40% of the data lied between +/- 5 bpm

Rathlin ECG



- The quality of this subject's ECG trace is **bad**

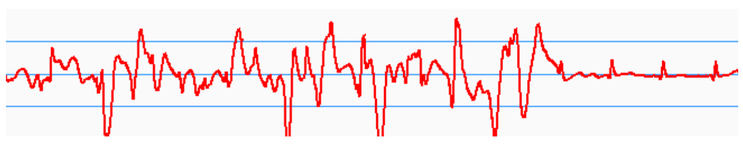
The Rathlin monitor picked up some of the noise that can be seen on the trace and recognised it incorrectly, as a heartbeat. This accounts for the very large HR values. At one point during one subject walking a HR of 1965 arose which is clearly not a real HR value.



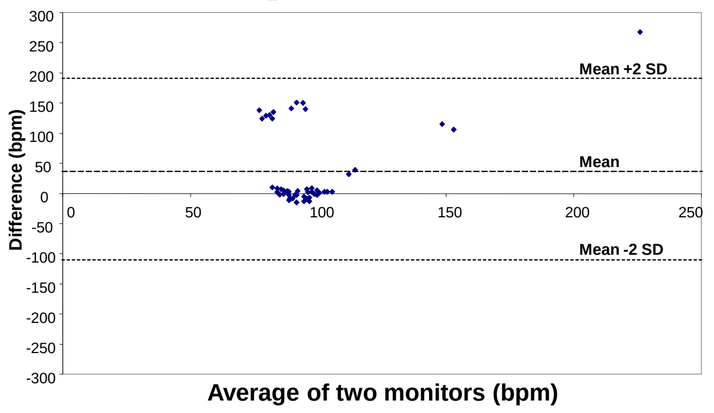
Condition 3. Step-Ups

40% of the data lied between +/- 5 bpm

Rathlin ECG



- The quality of this subject's ECG trace is **very bad**
- A significant effect on the quality of the ECG trace



Pulse Oximetry

The blood oxygen saturation of the subjects did not fluctuate much. There was one odd reading in the 'Walking' condition which was 127%. The Pulse Oximeter had a "traffic light" system in place on the device. This showed how well it was managing to obtain the data. It was noticed visually that when the monitor was moved about the light flashed orange rather than the usual green. However, this did not appear to have a noticeable effect on the quality of the data received.

Discussion

The devices should incorporate 'intelligent' exclusion or filtering out of clear unreal HR values (e.g. a HR >250 BPM) as these kind of values substantially affected the averages. Filtering is a method of making an automatic assumption or prediction about the error and excluding it.

These devices could improve the quality of information being passed onto hospitals in handover reports by First Responders and Paramedics as they could record changes in casualties.

These data could then be printed and handed to the doctor on arrival to the hospital or perhaps sent ahead of the casualty to give a fair warning of what the casualties' physiology is like.

A strength of the study was that data were **actively generated** rather than collected. It was first-hand raw data that was used not second-hand which could potentially be unreliable.

Conclusions

It was found that wearer motion *did* have a substantial negative effect on physiological monitors' performance.

Data produced by the patch-style Rathlin monitor were severely influenced by wearer motion and altered physiology. The laboratory function study motion resulted in considerable sensor noise, which reduced HR accuracy.

Physiological monitors would be a very beneficial addition to the equipment available to Paramedics and First Responders in rural locations across the UK once the technology has been developed further so that the monitors are not so badly affected by wearer motion.

This project was completed thanks to funding and support from the Nuffield Foundation

Nuffield Foundation · dot.rural · University of the Highlands and Islands / Oilthigh na Gàidhealtachd agus nan Eilean · 1495 UNIVERSITY OF ABERDEEN