Development of the 'BreathEasy' Contactless Portable Respiratory Rate Monitor (CPRM)

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Background

Respiratory rate (RR) is a vital physiological measurement used in the immediate assessment of acutely ill patients.[1] It is used as a predictor of serious deterioration in a patient's clinical condition.[2] Convenient electronic devices exist for measurement of pulse, blood pressure, oxygen saturation and temperature. Although devices which measure RR exist, many require physical contact with the patient and none have entered everyday clinical practice.[3] We have developed a contactless portable respiratory rate monitor (CPRM). We aimed to measure agreement with existing methods of RR measurement.

Methods

RR data was collected from 51 adult volunteers from Sheffield Children's Hospital and Sheffield Hallam University. All recordings were performed with the individual sitting and at rest. We measured respiratory rate by three different methods. Respiratory Impedance Plethysmography (RIP), the established contact method and gold standard, visual counting of chest movements, the established method used in everyday clinical practice, and with the CPRM, our new method. Measurements were all recorded simultaneously and three to four data sets were collected for each volunteer. A total of 178 recordings were taken.

The CPRM

The CPRM (Image 1 + 2) uses thermal anemometry to measure instantaneous fluid velocity. A thermistor in the device detects the rate of heat loss from the subject's breath. The analogue signal is digitalised and passed through a signal processing algorithm. This extracts the dominant frequency and passes it as a numerical value to a display. The CPRM takes a reading over 52 seconds and converts this to a respiratory rate in breaths/minute. Different funnels were trialled to channel the airflow to the thermistor.

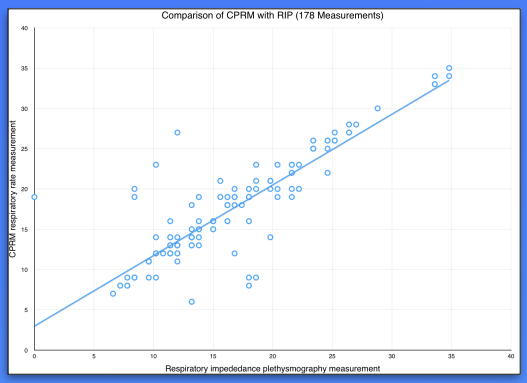

Figure 1: Correlation of the CPRM with the gold standard RIP method

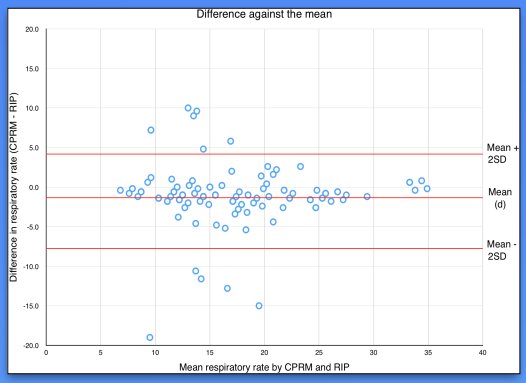

Figure 2: Difference between the 2 measurements and the mean

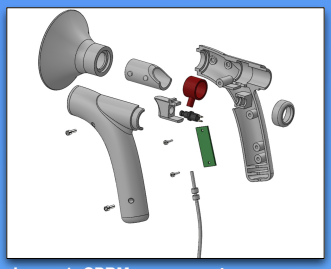

Image 1: CPRM components

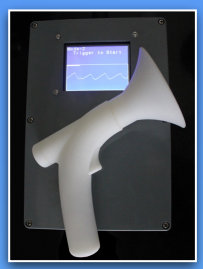

Image 2: Prototype CPRM

Image 5: CPRM in use in child

Results

The correlation between the respiratory rate measured by the CPRM and the gold standard RIP method was strong with a correlation coefficient of r = 0.874 (Figure 1). The 95% limits of agreement are -6.98 to 4.78, suggesting that the CPRM may read almost 5 breaths/min above and 7 breaths/min below the RIP method (Figure 2).

When separately analysing results from the two different funnels (Image 3 + 4) the correlation coefficient for Funnel A was r = 0.532 and Funnel B, r = 0.876.

Image 3: Funnel A

Image 4: Funnel B

Conclusions

Respiratory rate is an important vital sign in prioritising care and for diagnosing and managing many illness. A contactless device for accurately and quickly measuring RR will be an important tool in the assessment of unwell patients. This will be of particular use in children where subjective RR measurements can be difficult to obtain and contact methods may be distressing to the child.

The results obtained are encouraging with a high degree of correlation seen. However more testing is needed to explore the reasons for the outlying measurements and the most appropriate funnel size and shape.

Future plans

Further testing is required to evaluate the use of the CPRM in the paediatric population (Image 5). Testing in the acute clinical setting will also be useful in assessing the robustness of the device. Further development and modification of the device and software is planned including wireless data transfer, airflow optimisation, improved portability and miniaturisation of electronic components.

References

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3. Al-Khalidi F Q, Saatchi R, Burke D, Elphick H and Tan S. Respiration rate monitoring methods: a review. Pediatric Pulmonology, 2011 46 (6), 523-529.