2021 43rd Annual International Conference of the
IEEE Engineering in Medicine & Biology Society (EMBC)
Oct 31 - Nov 4, 2021. Virtual Conference

Development and Validation of an Optimal Attachment Position Selection System for a Patch Type Wireless R-R Interval Telemeter

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***Abstract*—A highly accurate, compact, and inexpensive patch type wireless R-R interval (RRI) telemeter is being developed to monitor heart rate with a smartphone application. In order to perform stable RRI measurements for a long time using such a device, it is necessary to determine the optimal electrode configuration. However, people with little or no expertise in analyzing heart rate variability (HRV) may have difficulty in attaching a patch type sensor, where the electrode placement is already fixed, to an appropriate position according to individual differences. In this study, we developed a system as a smartphone application for selecting the optimal position of a patch type measurement device to improve usability for non-experts. The RRIs of 10 male subjects in four posture were measured by attaching the device at the position determined by an optimal attachment position selection system. By comparing the RRIs of the patch type device and the reference electrocardiogram measurement system, the measurement accuracy of the proposed devices was confirmed to be sufficient for HRV analysis.**

I. INTRODUCTION

Currently, we are developing a patch type measurement device that can be attached to the body for R-R interval (RRI) measurements, aiming at miniaturized, wireless technology. To perform stable RRI measurements for a long period using this device, it is necessary to determine the optimal electrode placement; this is difficult for people with no specialized knowledge. Therefore, a system that instructs the user on the optimal placement of the device is essential to improve usability for non-experts.

II. METHODS

The developed system instructs the user on the optimal attachment position of the patch type device using a smartphone application. This system records the electrocardiogram (ECG) measured at four attachment positions, as shown in Fig. 1, and considers the position with the highest score as the optimal position.

We measured the RRIs of 10 male subjects in four postures, namely, supine, seating, standing, and walking (3 km/h), using the developed system by attaching the patch type device to each subjects. The measurements were performed for 5 min in each position. The R-wave detection rate and RRI measurement accuracy were evaluated using the reference ECG measurement system. As evaluation indices, we used the R-wave detection rate, which has been proposed as a criterion showing the stability of RRI measurement, and Bland-Altman analysis, which quantifies the error between the two methods [1][2].

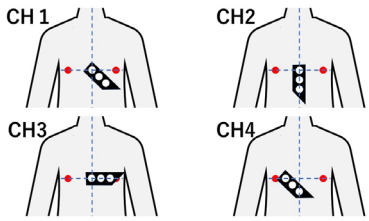

Figure 1. Channel and attachment position

III. RESULTS

The R-wave detection rates for the supine, sitting, standing, and walking positions were more than 95% for 34 of the 40 measurements. The selection rate of each channel was 47.5%, 37.5%, 15.0%, and 0% for ch1, ch2, ch3, and ch4, respectively. The limit of agreement calculated using the Bland–Altman analysis showed that 33 of the 40 measuring epochs were within the bias ± 4 ms range.

IV. DISCUSSION & CONCLUSION

The 33/44 measuring epochs were sufficiently accurate to be used for HRV analysis. As the selection rate of ch4 as the optimal attachment position was 0%, this channel was considered unnecessary. In this case, the patch type device could not detect the R-wave because of myoelectric interference. To achieve the sufficient stability and accuracy in all subjects, another mounting position that can measure R-waves with larger amplitude and less myoelectric interference should be proposed instead of using ch4 in the future work.

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