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Validity of Freely Available Mobile Applications for Recording Resting Heart Rate

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ABSTRACT

This study examined the accuracy of mobile applications that measure heart rate by comparing results to a Polar heart rate monitor. Volunteers had their heart rate measured via four different methods whilst being simultaneously recorded with the Polar monitor; 1) manual (MAN), 2) Tap the Pulse (TAP), 3) Cardiio (CAR), 4) What's my Heart Rate (WMHR). There were no significant differences between any of the methods and Polar monitor ($p \geq 0.159$), with WMHR having the strongest relationship ($r^2 = 0.918$) followed by MAN ($r^2 = 0.851$), CAR ($r^2 = 0.646$) and TAP ($r^2 = 0.636$) respectively.

Key words Heart rate, mobile application, health, tablet computer

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INTRODUCTION

A high resting heart rate (RHR; ≥ 90 beats per minute)is thought to be related to increased coronary mortality in later life [1, 2, 3]. Moreover,each of these authors also reported increases in total mortality when RHR was high. Such work promotes the importance of knowing one's own RHR, with some heart health charities promoting this message to the general public (Syncope Trust and Reflex Anoxic Seizures (STARS), American Heart Association, and the Arrhythmia Alliance).

There are now a number of mobile health applications (Apps) available on smart phones and tablet computers. The intended purposes of these Apps vary but include medication reminders[4], condition management tools[5, 6], and health education [7]. Some Apps have also been developed to assist therecording and monitoring of physiological measurements,which may present a convenient method by which an individual can successfully measure their RHR at home. However at present there is limited information in the scientific literature with regard to their accuracy and validity. The purpose of this study was to investigate the validity of a selection of heart rate measurement Apps freely available for tablet devices.

MATERIALS AND METHODS

Subjects

Fifteen volunteers took part in the study (11males and 4 females, aged 39 ± 17 years). All procedures were approved by an institutional ethics committee and informed consent was given. Participants were treated in accordance with the Declaration of Helsinki.

Experimental protocol

Each participant had their RHR measured three times via four different methods, whilst it was concurrentlyrecorded by an investigator using a Polar F11 Heart Rate monitor (Polar Electro, Finland). This brand of monitors has been

validated alongside an electrocardiogram (ECG) in previous research[8, 9, 10]. The different methods were as follows;

- Manually (MAN)– participants were instructed to palpate their radial artery and count the number of beats in one minute.
- 'Tap the Pulse' application, Orangesoft LLC (TAP) – participants were instructed to locate their pulse again and tap the tablet screen every time they felt a beat.
- 'What's my Heart Rate' application, ViTrox Technologies (WMHR) – participants were instructed to hold the tablet screen in front of their face and wait to be given a heart rate reading. The manufacturers state that '*Your heartbeat causes micro colour changes on your face. Our software uses camera and advanced software algorithm to detect these micro changes, with beat-to-beat accuracy'*.
- 'Cardiio' application, Cardiio, Inc. (CAR) – procedure the same as previous method. The manufacturers state that '*Every time your heart beats, more blood rushes through the vessels in your face, causing them to expand. The increase in blood volume absorbs more light, resulting in a decrease in the amount of light reflected from your face'*.

Statistical analysis

All statistical analyses were completed using IBM SPSS Statistics 18(SPSS Inc.,Chicago,IL).Central tendency and dispersion of the sample data are represented as the mean ± SD.Differences between the measurements were analysed using an independent samples *t*-test with statistical significance set at $p < 0.05$. Therelationship between the Polar F11 and each other method was analysed using PearsonCorrelation Coefficients, and the coefficient of variation (CV) between measurements (standard deviation divided by the mean, multiplied by 100). Bland-Altman plots were produced by plotting the differences between the two methods against the average. Positive scores represent underestimations and negative scores overestimations compared to the Polar monitor.

RESULTS

There were no significant differences between the average RHR as measured by the Polar monitor or any of the four other methods (Table 1).

Table 1. A comparison of average heart rate between the Polar monitor and all other methods

	Average Heart Rate
MAN vs. Polar	72 ± 13 vs. 74 ± 13 *(t = 0.678, p = 0.499)*
TAP vs. Polar	71 ± 15 vs. 75 ± 13 *(t = 1.421, p = 0.159)*
WMHR vs. Polar	72 ± 12 vs. 73 ± 11 *(t = 0.440, p = 0.661)*
CAR vs. Polar	70 ±15 vs. 72 ± 12 *(t = 1.150, p = 0.253)*

All of the Pearson Correlation Coefficients were significant ($p < 0.001$), with WMHR having the strongest relationship ($r^2 = 0.918$, CV = 2%) followed by MAN ($r^2 = 0.851$, CV = 3%), CAR ($r^2 = 0.646$, CV = 4%) and TAP ($r^2 = 0.636$, CV = 7%) respectively (Fig 1). The Bland-Altman plots (Fig 2) suggest that WMHR had the most accurate results followed by MAN, whereas a proportion of the TAP and CAR results varied greatly from the Polar monitor (up to 36 and 37 beats respectively).

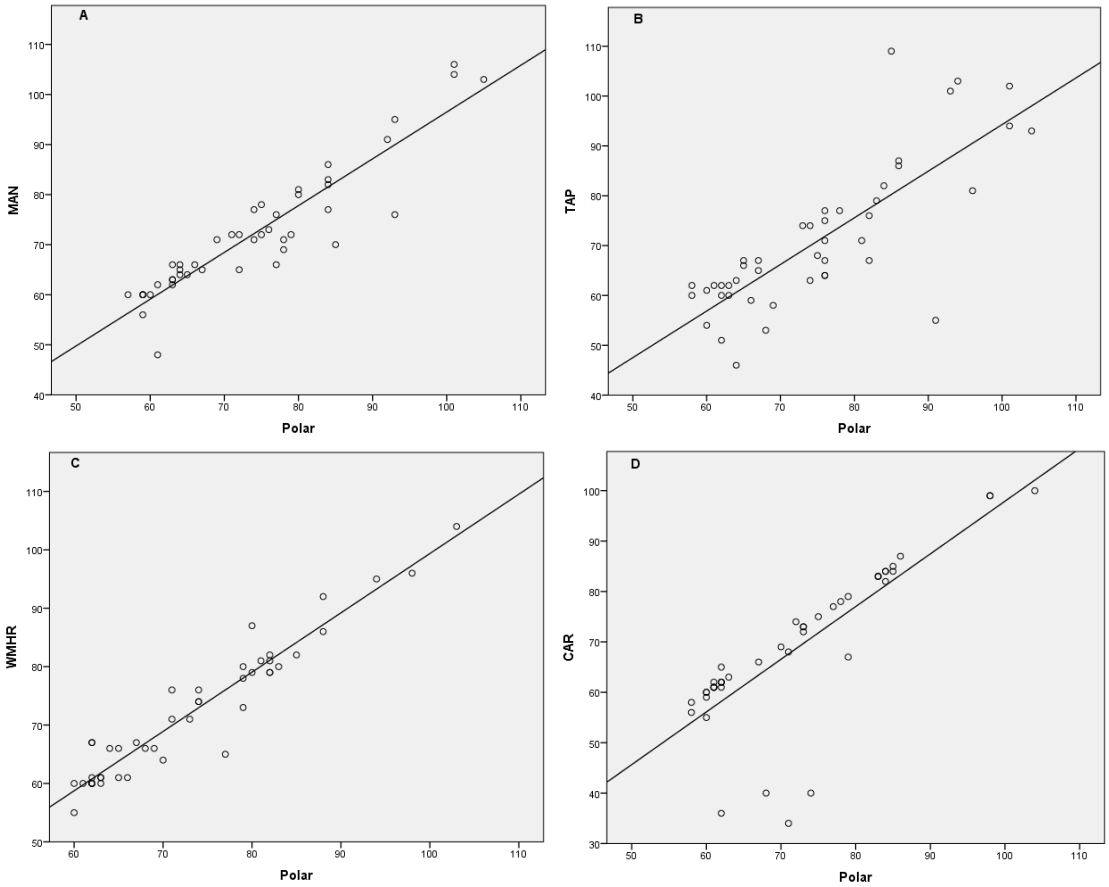
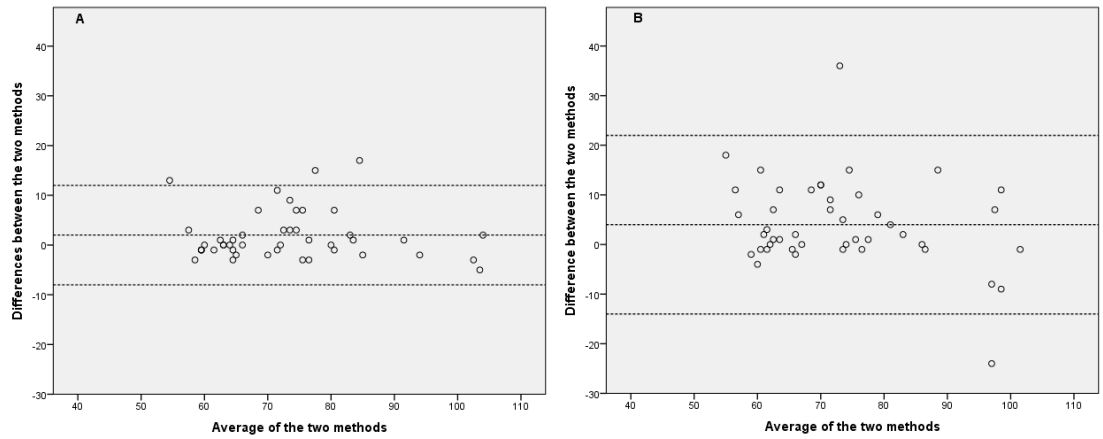


Fig 1. Correlations between Polar heart rate monitor and (A) MAN, (B) TAP, (C) WMHR, (D) CAR



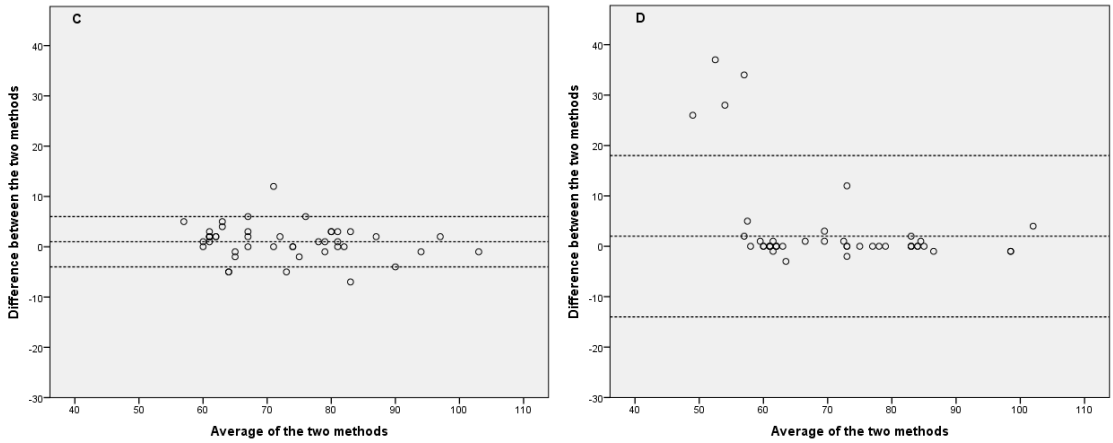


Fig 2. Bland-Altman plots for Polar heart rate monitor compared to (A) MAN, (B) TAP, (C) WMHR, (D) CAR

DISCUSSION

The purpose of this study was to investigate the accuracy of freely available mobile applications compared with a Polar heart rate monitor. Results from the WMHR app were highly comparable to the Polar monitor, with an average difference of one beat between measurements and a CV of only 2% (Table 1). Moreover WMHR was more accurate than manual measurements in the sample of participants volunteering for this study. The relationship between TAP and CAR with the Polar monitor was only moderate in comparison with WMHR and MAN (Fig 1), but whilst this was the case it must be noted that neither of these measures were significantly different to the Polar monitor (Table 1). Furthermore if the four outliers evident in Fig 2D are removed the CAR results are much more agreeable (r^2 = 0.9657, CV = 1%). However such anomalous results may lead individuals to misinterprettheir RHR at home.

Although the methods investigated in this research appear to have moderate to strong accuracy when compared with the Polar monitor, there are some general limitations when consideration is given to their use in practice. WMHR represented the most accurate of the methods with a strong correlation coefficient and low CV, however on a number of occasions it stated that a relatively high to high resting heart rate (i.e. 80-100 beats per minute) was ‘excellent’ or ‘good’. This is not particularly appropriate advice given that resting heart rates within this range have been linked with increased mortality [2].Some medical and health professionals go further than simply recommending recording resting heart rate at home, and suggest that individuals can facilitate the identification of arrhythmias such as atrial fibrillation by checking manually for ‘irregular irregularity’ [11]. The methods investigated in this study do not report on the regularity of the pulse and so are not suitable for recording arrhythmias or heart rate variability. Furthermore it is currently unclear as to whether the technology used by the WMHR and CAR apps would be sensitive enough to distinguish between beats at a higher heart rate. Further research should examine this possibility, as they may present an accurate alternative measurement method for the estimation of aerobic capacity following short exercise tests (e.g. Harvard step test) in the absence of more sophisticated laboratory equipment (e.g. at home, fitness centre etc.).

CONCLUSION

In conclusion the methods investigated in this study had moderate to high agreeability with the Polar monitor, with WMHR in particular appearing to be an accurate free alternative to recording resting heart rate manually at home. However it must be considered that such apps cannot record arrhythmias or heart rate variability, and it is unclear at present whether they are sensitive enough to collect heart rate following light to heavy exercise.

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