Original article

Validity of Elite-HRV Smartphone Application for Measuring Heart Rate Variability Compared to Polar V800 Heart Rate Monitor

Praghosh Chhetri,[1] Lava Shrestha,[2] Narayan B Mahotra[2]

ABSTRACT

Background: With technological advancement, it has become very easy to obtain heart rate variability data with handy heart rate monitors as well as smartphone applications. This study was conducted to assess the validity of Elite HRV smartphone application to measure time domain heart rate variability indices at rest, in comparison to Polar V-800 heart rate monitor.

Methods: Heart rate variability data were acquired from twenty apparently healthy male medical students in supine position after simultaneously connecting Polar V800 and Elite HRV to chest-worn Polar H7 sensor. Time domain indices viz. Mean RR intervals, mean heart rate, standard deviation of normal to normal intervals and root mean square of successive differences of interval were taken for comparison. Difference, validity and agreement were assessed using students t-test, intraclass correlation coefficient and Bland Altman plot and limits of agreement.

Results: Students t-test showed that there was no significant difference between the data obtained from Elite HRV and Polar V-800 in all the parameters viz. mean RR intervals, mean heart rate, standard deviation of normal to normal intervals and root mean square of successive differences of interval ($p>0.05$). Correlation was excellent as shown by Intra-class correlation coefficient of >0.999 in all the parameters. Bland Altman analysis revealed small bias and narrow limits of agreement with all the parameters: mean heart rate [-0.003 (0.05 - 0.04)], mean RR [0.01 (-0.58 – 0.60)], standard deviation of normal to normal intervals [-0.01 (-0.32 – 0.30)] and root mean square of successive differences of interval [-0.05 (-0.89 – 0.79)].

Conclusions: Elite HRV smartphone application provided reliable time-domain heart rate variability data consistent with the data obtained from validity tested Polar V800 heart rate monitor.

Keywords: Elite HRV; heart rate variability; Polar V800; time domain indices.

INTRODUCTION

Heart rate variability (HRV) has been standing out as a popular non-invasive means of gauging the status of cardiac autonomic functions. [1,2] Multiple fields of research come under the wide purview of HRV analysis like medicine,[3] sports and fitness,[4] neuropsychology and psychiatry,[5] mind-body-medicine.[6] HRV assessment has become easier and more affordable with the advent of hand-held heart rate monitors and smartphone apps.

Polar V800 heart monitor is a wrist-worn device that can be connected via Bluetooth to a chest-worn heart rate sensor for acquiring RR data. Its validity was studied alongside standard electrocardiogram (ECG) by Giles et al. in 2015.[7] Elite HRV is a smartphone app that can be paired via Bluetooth to a chest-worn or finger-worn hear rate sensor for recording RR data. Validity of the smart phone app were studied by Perrotta et al. and Guzik et al. with relatively equivocal results.[8,9]

The aim of our study was to assess the validity of Elite HRV app in measuring time-domain HRV indices at rest, in comparison to Polar V-800 heart rate monitor.

METHODS

It was a quantitative analytical study conducted in the department of Clinical Physiology, Maharajgunj Medical Campus, Institute of Medicine (IOM), Maharajgunj, Kathmandu, in December 2016. Ethical approval was obtained from the Institutional Review Board of IOM for

Correspondence: Dr Lava Shrestha, Department of Clinical Physiology, Maharajgunj Medical Campus, Institute of Medicine, Maharajgunj, Kathmandu, Nepal. Email: lava.shrestha@iom.edu.np.

the study.

A total of 20 young adult males from the first and second year were voluntarily recruited for the study following convenient sampling method. A written consent was taken from the participants after taking a thorough clinical history. Participants having any systemic, neurological or psychiatric diseases or those under any medications influencing cardiac autonomic functions were excluded from the study. The HRV studies were conducted in the morning between 6-9 am inside a well-ventilated, private room of Physiology practical laboratory of Maharajgunj Medical Campus. The participants were asked to refrain from tea, coffee for at least 12 hours and alcohol for at least 24 hours prior to the test and were instructed to avoid any strenuous physical activity for 24 hours before the study.

HRV data recording was done with the participants supine. Polar H7 heart rate sensor was connected to the chest strap which was tightly but comfortably applied around the chest with the sensor and electrode at the level of xiphoid process. The heart rate sensor was connected via Bluetooth to Polar V800 heart rate monitor as well as Elite HRV application on an iPad. After 15 minutes of supine rest, the RR recording was carried out for five minutes via both Polar V800 and Elite HRV. The raw RR data from Polar V800 was exported from the Polar Web services. The Elite HRV raw RR data were exported directly to the researcher's email. The raw data from both Polar V800 and Elite HRV were then finally analyzed with Kubios HRV standard version 3.4.1.[10]

The indices chosen for comparative analysis were: mean heart rate (mean-HR), mean of RR intervals (mean-RR), standard deviation of normal to normal intervals (SDNN) and root mean square of successive differences of interval (RMSSD). Normality of the data was assessed using Kolomogorov Smirnov and Shapiro Wilk tests which revealed a normal distribution. Paired sample t-test was used to assess the differences between the data obtained from Polar V800 and Elite HRV application. Relative reliability and agreement of data were assessed using intraclass correlation coefficients(ICC) and Bland Altman Limits of Agreement (LOA).[11,12] Level of significance was set at p value less than 0.05. Data analysis was done using IBM SPSS software version 21.

RESULTS

A total of 20 apparently healthy male medical students from the first and second years of medical program at Maharajganj Medical Campus were recruited for the study. The mean age group was 20.19 ± 0.59 years and mean BMI 21.33 ± 1.87 kg/m^2. The mean resting baseline systolic and diastolic blood pressures taken in supine position were 114±5.23 mmHg and 72±6.58 mmHg respectively and the mean baseline pulse rate assessed from the radial artery of the right hand in supine position was 71.45 ±9.6 beats per minute. All baseline descriptive mean data including BMI, blood pressures and pule rate were on the normal physiological range.

The comparison between values of parameters used viz. mean HR, mean RR, SDNN and RMSSD obtained from the two modes of RR data acquisition with student's t-test have been shown in Table 1. There was no significant difference between the data obtained from the two modes of RR data acquisition (p>0.05).

Further, the relative reliability and agreement of data were tested using intraclass correlation coefficients (ICC) and Bland Altman Limits of Agreement (LOA) as shown in Table 1; and Bland Altman Plots were constructed (Figure 1). Excellent agreement was found between the data obtained from Polar V800 and Elite HRV with respect to all the four indices with Intraclass correlation coefficient >0.999 in all the cases with very small bias and narrow limits of agreement. The bias (LOA) for mean RR and mean HR were 0.01 (-0.58 – 0.60) and -0.003 (0.05 - 0.04) respectively. The bias (LOA) for SDNN and RMSSD were -0.01 (-0.32 – 0.30) and -0.05 (-0.89 – 0.79) respectively.

Table 1. HRV parameters obtained from Elite HRV app and Polar V800 HRM (mean±SD), Intraclass Correlation Coefficient (95% Confidence interval) and Bias (Limits of agreement).

HRV Indices	Elite HRV (Mean±SD)	Polar V800 (Mean±SD)	p-value	ICC (95% CI)	Bias (LOA)
Mean RR	892.05± 112.032	892.04 ± 112.17	>0.05	1.00 (1.00 – 1.00)	0.01 (-0.58 – 0.60)
SDNN	55.85± 29.15	55.86 ± 29.15	>0.05	1.00 (1.00 – 1.00)	-0.01 (-0.32 – 0.30)
Mean HR	68.74 ± 8.97	68.74 ± 8.98	>0.05	1.00 (1.00 – 1.00)	-0.003 (0.05 - 0.04)
RMSSD	64.87 ± 40.85	64.92 ± 40.99	>0.05	1.00 (1.00 – 1.00)	-0.05 (-0.89 – 0.79)

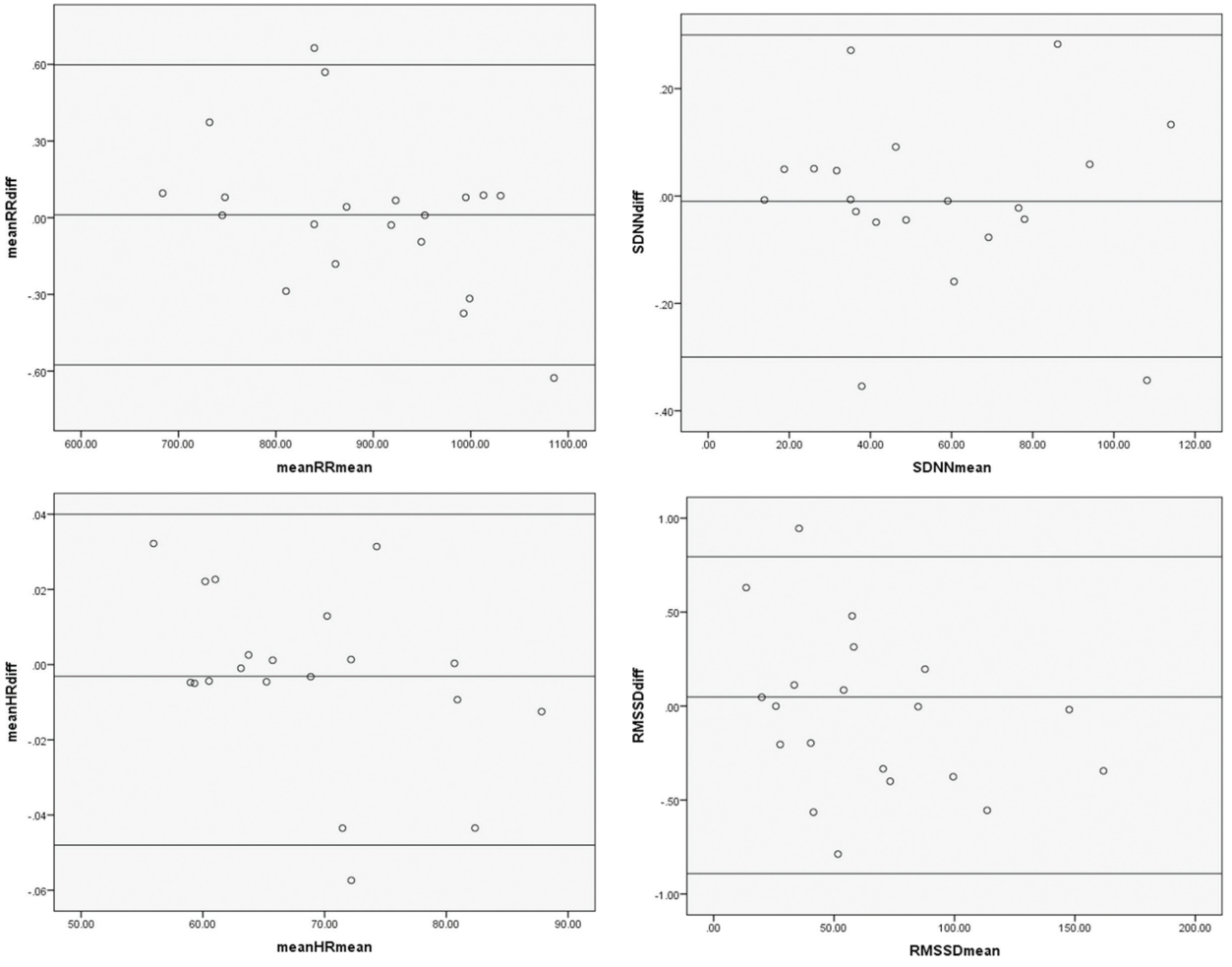

Figure 1. Bland Altman Plots for HRV parameters acquired from Elite HRV smartphone app and Polar V800 HRM (X-asis: mean, Y-axis: mean difference).

DISCUSSION

The purpose of the study was to assess the validity of short-term time domain HRV data obtained from Elite HRV smartphone application in comparison to Polar V800 heart rate monitor using the common HRV analysis software Kubios. HRV measurement was done simultaneously from both the methods and the time domain HRV parameters viz. Mean RR, mean HR, SDNN and RMSSD acquired from both the means of data acquisition were compared. Paired sample t-tests revealed no significant differences ($p>0.05$) between the data obtained from both the means in respect to all the parameters of HRV assessed. Moreover, excellent intraclass correlation, small bias and narrow limits of agreement in reference to all the parameters showed a strong agreement between the data obtained from the two methods. The results suggested that Elite HRV smartphone app can produce time domain HRV data viz. meanRR, meanHR, SDNN and RMSSD consistent with the data obtained from Polar V800 Heart rate monitor.

Study by Giles et al showed that Polar V800 was a reliable and valid tool in detecting RR data and HRV parameters when compared to the data obtained from a standard ECG.[7] The validity was confirmed with strong intraclass correlation (ICC ≥0.99), small bias, narrow limits of agreement and small effect size (ES ≤ 0.029).

The findings of this study are in line with the study done by Boos et al. where the validity of another smartphone HRV-app ithlete™ in measuring RMSSD was compared with CheckMyHeart™, an electrocardiographic device. A significant correlation was shown between the two methods as shown by Pearson Correlation coefficient ($r > 0.8$).[13]

Perrotta et al assessed the validity of RMSSD obtained from Elite HRV smartphone app in comparison to Kubios HRV software. Pearson's correlation revealed a

significant correlation between the two data (r = 0.92). However, limits of agreement were not met as seen from Bland Altman analysis.[9]

Guzik et al assessed standard time domain HRV parameters obtained from Elite HRV app with ECG based HRV data. Correlation and agreement tested with Pearson's Correlation and Bland Altman Analysis showed a weak correlation and larger biases especially with RMSSD.[8]

This study shows that Elite HRV can give reliable time domain HRV indices viz. meanHR, meanRR, SDNN and RMSSD because the data are in consistency with validity tested Polar V800 HRM. The study adds value to existing knowledge in the context of scanty literature available in Nepali population. It is suggested that the same data analysis software be used for the analysis of data obtained from both the methods (In this study Kubios) and same artifact correction mode be applied (In this study Medium) for consistency. Due to relatively small sample size and a narrow study population, the results of this study may have limited large scale public health and clinical applicability. However, the results can definitely reinforce the usefulness of such software apps for laboratory setups. More extensive studies can be conducted with larger sample size, wider study populations, better randomization and comparison with standard Electrocardiographic HRV data for getting results which can be extrapolated to larger populations with public health and clinical significance,

CONCLUSIONS

In conclusion, Elite HRV smartphone application provides reliable time-domain heart rate variability data consistent with the data obtained from validity tested Polar V800 heart rate monitor when the same data analysis software is used. There was a strong congruity between the data obtained from the two methods as shown by strong intraclass correlation, small bias and narrow limits of agreement. Hence, Elite HRV smart phone application can be considered a valid means to assess time domain HRV indices in a laboratory setup.

Author Affiliations

[1]Department of Osteopathy, Sri Sri University, Cuttack, Odisha, India

[2]Department of Clinical Physiology, Maharajgunj Medical Campus, Institute of Medicine, Maharajgunj, Kathmandu, Nepal.

Competing interests: None declared

REFERENCES

1. Saul J. Beat-To-Beat Variations of Heart Rate Reflect Modulation of Cardiac Autonomic Outflow. Physiology. 1990 Feb 1;5(1):32–7.[Article]

2. Malik M. Heart Rate Variability.: Standards of Measurement, Physiological Interpretation, and Clinical Use: Task Force of The European Society of Cardiology and the North American Society for Pacing and Electrophysiology. Ann Noninvasive Electrocardiol. 1996 Apr;1(2):151–81.[PubMed]

3. Thayer JF, Yamamoto SS, Brosschot JF. The relationship of autonomic imbalance, heart rate variability and cardiovascular disease risk factors. Int J Cardiol. 2010 May;141(2):122–31.[PubMed]

4. Makivić B, Nikić M, Willis M. Heart rate variability (HRV) as a tool for diagnostic and monitoring performance in sport and physical activities.. 2013;16(3):103-27. J Exerc Physiol. 2013;16(3):103–31.[Article]

5. Oldehinkel AJ, Verhulst FC, Ormel J. Low Heart Rate: A Marker of Stress Resilience. The TRAILS Study. Biol Psychiatry. 2008 Jun;63(12):1141–6. [PubMed]

6. Pal G. Yoga and Heart Rate Variability. Int J Clin Exp Physiol. 2015;2(1):2.[Article]

7. Giles D, Draper N, Neil W. Validity of the Polar V800 heart rate monitor to measure RR intervals at rest. Eur J Appl Physiol. 2016 Mar;116(3):563–71.[PubMed]

8. Guzik P, Piekos C, Fenech N, Pierog O, Krauze T, Piskorski J, et al. Heart Rate Variability by mobile app "ELITE HRV" is not the same as computed from an ECG. EP Eur. 2017 Jun;19(suppl_3):iii 257–9. [Article]

9. Perrotta AS, Jeklin AT, Hives BA, Meanwell LE, Warburton DER. Validity of the Elite HRV Smartphone Application for Examining Heart Rate Variability in a Field-Based Setting. J Strength Cond Res. 2017 Aug;31(8):2296–302. [PubMed]

10. Tarvainen MP, Niskanen J-P, Lipponen JA, Ranta-aho PO, Karjalainen PA. Kubios HRV – Heart rate variability analysis software. Comput Methods Programs Biomed. 2014 Jan;113(1):210–20.[PubMed]

11. Weir JP. Quantifying test-retest reliability using the intraclass correlation coefficient and the SEM: J Strength Cond Res. 2005 Feb;19(1):231–40.[PubMed]

12. Bland JM, Altman DG. Statistical methods for assessing agreement between two methods of clinical measurement. The Lancet. 1986 Feb;327(8476):307–10. [PubMed]

13. Boos CJ, Bakker-Dyos J, Watchorn J, Woods DR, O'Hara JP, Macconnachie L, et al. A comparison of two methods of heart rate variability assessment at high altitude. Clin Physiol Funct Imaging. 2017 Nov;37(6):582–7.[PubMed]