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Original article

Agreement between Finometer and Firstbeat on heart rate variability data in women: a pilot study

Concordância entre Finometer e Firstbeat na variabilidade da frequência cardíaca em mulheres: um estudo piloto.

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ABSTRACT

Aim: To analyze the agreement of the Firstbeat real-time heart rate monitor in comparison to an ECG in women. **Methods:** 7 physically active women were recruited to realize two recordings of RR intervals on two days separated by 7 days. The recordings were conducted with the volunteers seated on the Leg Press 45 apparatus. For the recording of the RR intervals, a three-lead electrocardiogram (ECG) recording, coupled to the Finometer, and the Firstbeat real-time monitor were used. Statistical analysis was performed using SPSS software (26.0). **Results:** There was no significant difference on both days ($p > 0.05$) in the paired T-test. On day 1, a perfect correlation was found in the Pearson correlation test ($r = 1.0$), and on day 2, a very strong correlation was observed ($r = 0.99$). Additionally, no proportional bias was identified in the Bland-Altman test. The mean of the RR intervals was consistent between the Finometer ECG and the Firstbeat monitor in women.

Keywords: electrocardiography; heart rate determination; autonomic nervous system.

RESUMO

Objetivo: Analisar a concordância do monitor cardíaco em tempo real da Firstbeat em relação a um ECG em mulheres. **Métodos:** 7 mulheres fisicamente ativas foram recrutadas para realizar dois registros dos intervalos RR em dois dias separados por 7 dias. Os registros foram realizados com as voluntárias sentadas no aparelho Leg Press 45. Para o registro dos intervalos RR, foi realizado um registro eletrocardiográfico (ECG) de três derivações, acoplado ao Finometer, e o monitor em tempo real da Firstbeat. A análise estatística foi realizada através do software SPSS (26.0). **Resultados:** Não houve diferença significativa em ambos os dias ($p > 0,05$) no teste T pareado. No dia 1, foi verificada correlação perfeita no teste de correlação de Pearson ($r = 1,0$), e no dia 2, foi observada correlação muito forte ($r = 0,99$). Além disso, não foi identificado viés de proporção no teste de Bland-Altman. A média dos intervalos RR foi concordante entre o ECG do Finometer e o monitor Firstbeat em mulheres.

Palavras-chave: eletrocardiografia; determinação da frequência cardíaca; sistema nervoso autônomo.

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Introduction

Heart rate variability (HRV) is a non-invasive measure that reflects oscillations in the autonomic nervous system [1]. Higher resting HRV values are related to better cardiovascular reflexes and cardiovascular health. Lower HRV values are related to reduce vagal control, slower cardiovascular reflexes, and a higher inclination toward cardiovascular health risks. HRV analysis utilizes indices obtained from beat-to-beat intervals (iRR) [1,2]. These intervals can be measured through ECG, cardiac monitor, and other equipment [1,2]. RR intervals represent the time between each R wave of the ECG, i.e., the interval between each heartbeat. In this sense, shorter RR intervals indicate a higher heart rate (HR), while longer RR intervals signify a lower HR [1].

Although easily accessible, the ECG is considered the standard method for measuring the intervals between heartbeats and, consequently, for analyzing HRV. However, despite its consolidation in the literature, the ECG is associated with a high cost and limited mobility [3].

Thus, alternative equipment is needed that is more accessible and validated in the literature. In this context, equipment for recording iRR, which allows testing outside the laboratory, has been validated. Studies [4–8] examining HR and HRV suggest the potential use of HR monitors or smartwatches at rest [6], for 24 hours [5], during exercise [4,7], and during recovery after exercise [8]. However, Firstbeat's real-time display (RTM) in conjunction with the Elite HRV app has been an unvalidated alternative until now.

Furthermore, women are significantly underrepresented in all newspaper surveys, with their participation being between 35% and 37% of surveys [9]. Notably, when comparing the HRV of men and women, men exhibit higher sympathetic activity in HRV compared to women [10].

In this study, the aimed was to assess HRV agreement between the 3-lead ECG of the Finometer (Finapres Medical System, BV Netherlands) and real-time monitor by Firstbeat in young women.

Methods

Sample

This is a cross-sectional study involving a sample of seven physically active women. Participants were informed about the study procedures, importance, relevance, and duration. All participants read and signed the informed consent form. The short version of the IPAQ questionnaire was used to characterize the level of physical activity. Inclusion criteria required volunteers to be physically active, without cardiovascular or metabolic disease, and available for research meetings. Exclusion criteria included the ingestion of beverages or food that could negatively or positively affect HRV, as well as any type of physical exercise.

The procedures conducted in this study adhered to resolution 466/12 of the National Health Council, as approved by the Human Research Ethics Committee of the Federal University of Espírito Santo (n. 90076218.0.0000.5542/2018).

Data collection

The study was conducted at the Center for Research and Extension in Body Movement Sciences of the Physical Education and Sports Center (CEFD) at the *Universidade Federal do Espírito Santo* (UFES).

The first session with the volunteers involved anamnesis, signing of the informed consent form, IPAQ questionnaire, and familiarization with the equipment where the iRR was collected. In the second meeting, after arriving at the laboratory, the participants were instructed to sit and rest on the bench of the Leg Press 45 device (with 90 degrees of hip flexion and 90 degrees of knee flexion) for at least 10 minutes, maintaining an ambient temperature of 21°C. After the rest period, volunteers remained in the Leg Press device, and the iRR was recorded for 10 minutes using the Finometer ECG and the Firstbeat real-time monitor. During the third session, we replicated the procedures conducted in the second session (Figure 1).

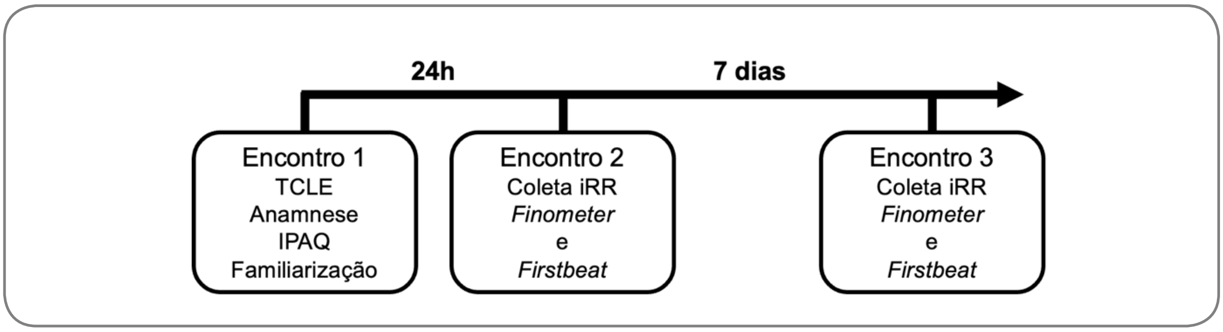
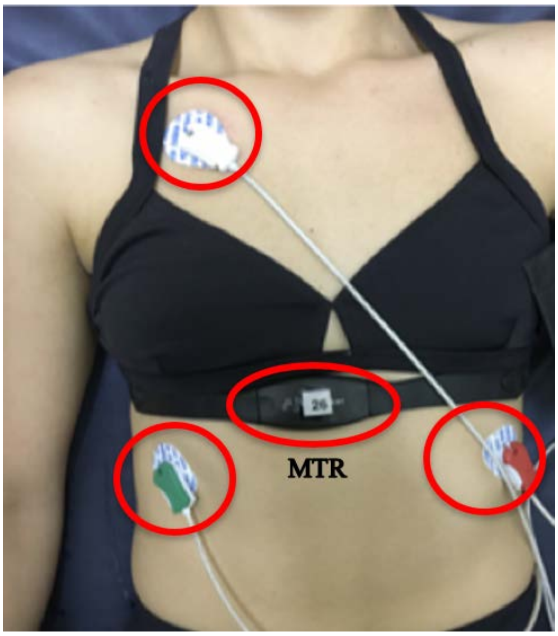


Figure 1 - Study design

The iRR was recorded on the Leg Press device due to exercise performance following collection. The present study aimed to verify the agreement between equipment for HRV analysis. Another study focused on analyzing the effects of exercise performing [11].

The acquisition of iRR through the Finometer ECG adhered to the three-lead configuration, following the Einthoven triangle. The three electrodes were positioned in accordance with the manufacturer's guidelines (Finapres Medical System, BV Netherlands) [12]. The ground electrode was placed on the right side of the volunteer's thorax, near the sternum, while the positive electrode was positioned on the left side of the thorax, at the level of the fifth intercostal space. Additionally, a second positive electrode was placed on the right side of the thorax, below the nipple, in the V5 position (Figure 2) [11].



Source: [11]
Figure 2 - Positioning of the Finometer electrodes and Firstbeat RTM

At the same time, the iRR was recorded using the Firstbeat MTR positioned towards the xiphoid process, connected via Bluetooth to a mobile device. For iRR recording, the BeatScope software (Ontario, Canada) was employed for the Finometer, and the Elite HRV app was utilized for the Firstbeat MTR data.

Data analysis

The ECG data was transferred from the computer using a mobile storage device, while the Elite HRV files were transferred via a USB cable. The analysis of the iRR was conducted using the Kubios HRV Standard® software, which calculated the average of the intervals in milliseconds.

After computing the mean iRR, normality was assessed using the Shapiro-Wilk test. After confirming the normal distribution of the data, a paired T-test was used for mean comparisons. Pearson correlation coefficients were interpreted as follows: 0 = none; 0.1-0.3 = weak; 0.4-0.6 = moderate; 0.7-0.9 = strong; 1 = perfect [13]. Futhermore, linear regression and Bland-Altman plots were conducted to evaluate the correlation and concordance of HRV data.

In the Bland-Altman analysis, the horizontal and central line represents the mean of the difference between the instrument measurements. The upper and lower limit lines represent the 95% confidence intervals (mean of the differences ± 1.96 x standard deviation of the differences). Excel was used as a database and IBM SPSS Statistics 26.0 was used for data analysis.

Results

The research participants were aged 24.6 ± 3.8 years, body mass of 60.3 ± 6.9 kg, height of 1.64 ± 0.09 m, and a body mass index of 22.3 ± 0.9 kg/m².

On both days, there were no significant differences in mean iRR scores between the instruments used (Day 1: p = 0.715; and Day 2: p = 0.178). On day 1, a perfect correlation was identified (r = 1), while on day 2, a very strong correlation was observed (r = 0.994). Morever, no proportion bias was detected in the linear regression test on day 1 (p = 0.6) and day 2 (p = 0.942) using the Bland-Altman analysis (Figure 3 and 4).

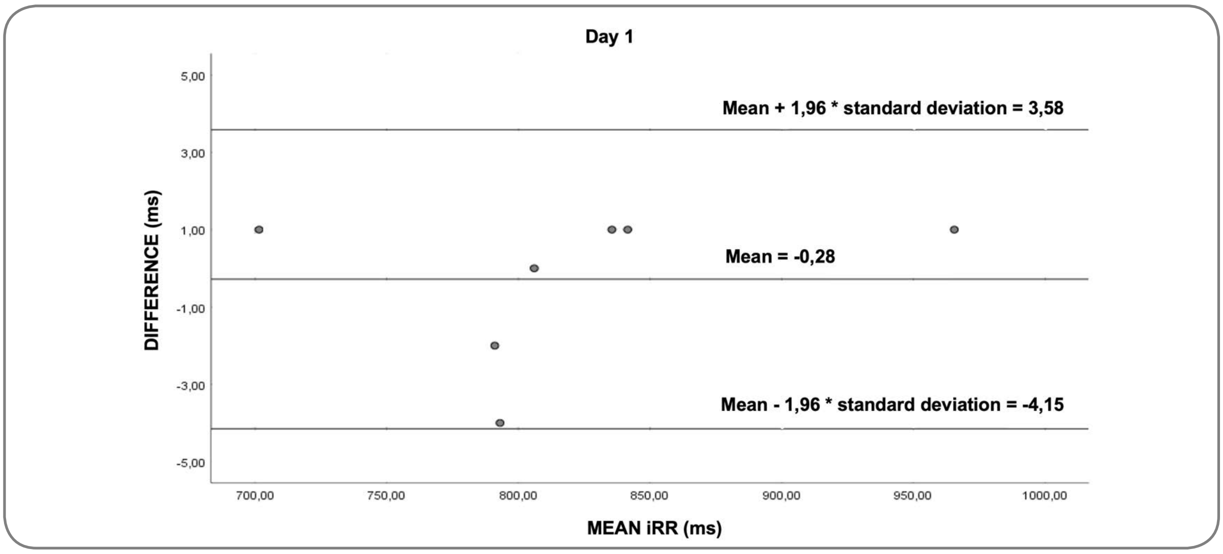


Figure 3 - Bland-Altman analysis day 1. Each data point in the graph represents the difference between the mean RR intervals of the Finometer and the Firstbeat real-time monitor (in milliseconds)

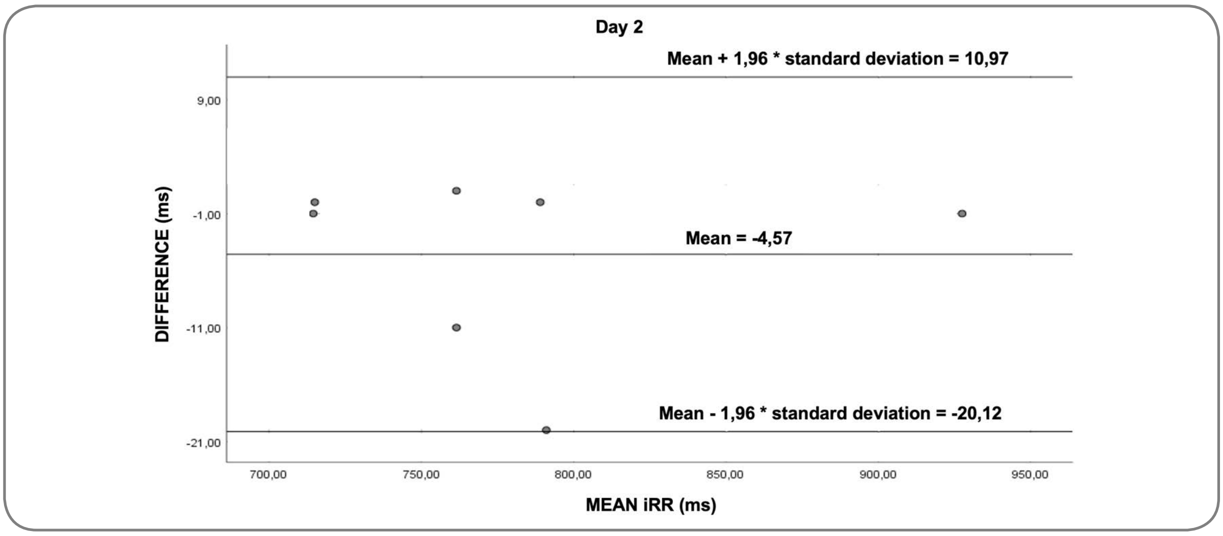


Figure 4 - Bland-Altman analysis day 2. Each data point in the graph represents the difference between the mean RR intervals of the Finometer and the Firstbeat real-time monitor (in milliseconds)

Discussion

This study aimed to analyze the HRV concordance between the Finometer ECG and the Firstbeat MTR. The primary finding of the study was that the Firstbeat MTR demonstrated concordant measurements of RR intervals when compared to the gold standard (ECG). Therefore, the Firstbeat MTR can serve as a reliable tool for collecting iRR both at rest within laboratories and in non-laboratory settings.

To the best of our knowledge, the present study is the first to compare the agreement between the Firstbeat MTR with the ECG. However, previous studies have already validated other equipment for heart rate and HRV collection and analysis. Nunan *et al*. [7] assessed the validity of resting HRV measurements using the Polar S810 compared to the 12-lead ECG on three different days, with a 1-week interval between days. The Polar S810 showed a high correlation (0.85 - 0.99) with the ECG. In this sense, the Polar S810 appears to exhibit an agreement with the gold standard similar to the result found for Firstbeat's MTR.

In addition to heart monitors, Nelson *et al*. [8] examined the accuracy of the HR measurement from the Apple Watch 3 and Fitbit Charge 2 smartwatches during five daily activities (sitting, walking, running, activities of daily living, and sleeping) compared to 24-hour ambulatory ECG. This study found high accuracy in the 24-hour condition for both devices, with an average difference of -1.8 beats per minute (bpm) for the Apple Watch 3 and -3.47 bpm for the Fitbit Charge 2 compared to the gold standard. Similarly, our study revealed comparable results when comparing mean RR intervals to the gold standard, showing -0.28 on day 1 and 4.57 on day 2.

In addition to the tools for acquiring RR intervals, the present study utilized the Elite HRV application on a smartphone for recording. This app was previously validated for supine resting and orthostatic challenge in a study by Gambassi *et al*. [4], where it compared recording made through the Elite HRV app connected to the Polar H7 transmitter with the 3-lead ECG. This validation supports the use of the Polar H7 app and transmitter, at least for measurements in the supine position or during orthostatic challenges. In this study, demonstrated an almost perfect correlation of r = 0.99 in the supine position. In our study, a perfect correlation was observed on day 1 (r = 1), and a very strong correlation was found on day 2 (r = 0.99).

However, Horton *et al*. [12] have demonstrated that variations in exercise intensities can impact the accuracy of heart monitors. Furthermore, concordance between ECG and other devices may fluctuate based on equipment calibration, software updates, and measurement conditions. A limitation of this study includes the modest sample size, measurements performed only in women, and assessments carried out only in a resting condition. Additionally, the data in this study are constrained by the inability to compare with studies conducted in sitting or supine positions, as well as during exercise.

Nevertheless, the study is advantageous as it establishes that, in a state of preparation for a physical exercise protocol, involving heightened alertness, Firstbeat's RTM showed agreement with the gold standard method (ECG). This demonstrates the method's feasibility for applications in studies requiring pre-exercise HRV measurements.

We also highlight the significance of validating the measurements from various heart monitors and smartwatches compared to the gold standard in diverse conditions (rest and exercise). Addittionally, we examined the consistency across various exercise intensities, encompassing both aerobic and resistance exercise, and in male individuals.

Conclusion

The mean RR intervals exhibited concordance between the Finometer 3-lead ECG and the Firstbeat real-time monitor in women. These findings provide opportunities for the utilization Firstbeat in studies where portability plays a crucial role in facilitating HRV recording at rest, especially in women.

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Academic affiliation
This article represents part of the scientific initiation study of Lucas Rangel Affonso de Miranda, supervised by Professor PhD Richard Diego Leite at the Federal University of Espírito Santo.

Conflict of interest
No known financial conflicts of interest or personal relationships that might have influenced the work reported in this article exist.

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Authors' contributions
Conception and design of the research: Miranda LRA, Reis CBF, Leite RD; **Data collection:** Miranda LRA, Reis CBF, Bergatini TC, Gasparini-Neto VH; **Data analysis and interpretation:** Miranda LRA, Reis CBF, Gasparini-Neto VH; **Statistical analysis:** Miranda LRA, Reis CBF, Gasparini-Neto VH; **Writing of the manuscript:** Miranda LRA, Reis CBF, Bergatini TC, Carletti L, Leite RD; **Critical revision of the manuscript for important intellectual content:** Miranda LRA, Reis CBF, Bergatini TC, Ribeiro ALB, Gasparini-Neto VH, Carletti L, Leite RD.

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