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Comparison of classical indices of Pulse/Heart Rate Variability from sensor Polar OH1 and ECG

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***Abstract*— In this work, the classic indices of pulse/heart rate variability extracted by the photoplethysmographic signal recorded with the Polar OH1 sensor have been compared with those extracted from an electrocardiographic signal with a high sampling rate. Although the results show a greater error than expected and could make this sensor not suitable for the analysis of the response of the autonomous nervous system, further study should be needed.**

I. INTRODUCTION

Currently a large number of smart wearable that record photopletysmographic signal (PPG) are hitting the market. The use of this technology is currently spreading remarkably in many different everyday applications, such as sports performance, stress indicator, heart rate control, etc.

PPG can been used to calculate the pulse rate as a surrogate for heart rate, as well as the Pulse Rate Variability signal (PRV) is a surrogate measure for the Heart Rate Variability (HRV). The analysis of HRV/PRV is the non-invasive measurement most commonly used to evaluate the activity of the Autonomic Nervous System (ANS).

Polar OH1 records the subject's PPG signal at approximately 135 Hz. Recent studies have shown that using the interpolated midpoint of the PPG as fiducial point allows the PPG sample rate to be reduced to 50 Hz without causing significant changes in the PRV indices [1].

In this work it is studied whether the PRV indices extracted from the PPG signal recorded by Polar OH1 sensor present significant changes compared to the HRV indices extracted from the electrocardiographic signal (ECG) and if this wearable is suitable for ANS response analysis.

II. MATERIALS

A total of 22 subjects (12 males and 10 females) were recorded in this study. During the recordings subjects stayed relaxed and sitting comfortably, remained in silence and without performing movements for four minutes.

The frontal bipolar second lead of the recorded ECG signal was recorded using the Nautilus device developed by the University of Kaunas, Lithuania (f_s = 2000 Hz). PPG signal was recorded with OH1 Polar sensor (f_s approximate of 135 Hz) and was located on the non-dominant arm.

III. METHODS

The heart beats of the ECG signal were detected using an algorithm base on wavelets. In PPG signal, the interpolated medium point defined as the one in which the amplitude has reached the 50% of the pulse amplitude, was used as fiducial point. A previous linear interpolation at 1000 Hz of the PPG up-slope was performed. Classical time and frequency domain indices from the HRV and PRV signals were computed [1].

The relative error obtained in the estimation of the PRV indices with respect to their corresponding HRV indices was calculated. The absolute error was obtained for P_{LFn} and $R_{\text{LF/HF}}$ indices. When the normal distribution (Shapiro-Wilk test) was verified the t-Student paired test was used to quantify statistical significance of error, when not the Wilcoxon paired test was applied.

IV. RESULTS

Results shown as median|interquartile range values. The significance level α is indicated in bold type for $\alpha = 0.05$. (nu:normalized units)

TABLE I
ESTIMATED RELATIVE AND ABSOLUTE (P_{LFn}, $R_{\text{LF/HF}}$) ERRORS

Time parameters			
$\overline{PRM}$	$\overline{SDNN}$	$\overline{RMSSD}$	$\overline{pNN50}$
0.7 | 1.6 %	0.6 | 22.8 %	**32** | **72** %	**66** | **158** %
Frequency parameters			
P_{LF}	P_{HF}	P_{LFn}	$R_{LF/HF}$
31 | **92** %	25 | 79 %	**0.1** | **0.5** nu	**0.3** | **3.4** nu

In agreement with other studies [1], our results showed higher relative errors between PRV and HRV for short-term variability indices RMSSD or pNN50 than for PRM and SDNN. The variations in the RMSDD and pNN50 indices are known to reflect high frequency activity derived from parasympathetic activation. The errors are greater than those obtained in previous studies where the sampling rate of the PPG signal was intentionally reduced, except for P_{LFn} and $R_{LF/HF}$ indices. Further study will be necessary to find out if Polar OH1 sensor is suitable for ANS response analysis.

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