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Short Communication

Construct Validity Screening Biometrics

Construct validity of the BARABAZ-scan to screen biometrics in employees

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Abstract

Objective: Preventive screenings and services to assess and monitor health-status in employees give valuable insights for individuals and increase health-consciousness. This may influence health-related behaviour. The BARABAZ-scan is a non-invasive test that is used to screen physiological measures. This study describes the construct validity of the signals from the BARABAZ-scan compared to signals from a golden standard instrument for the variables galvanic skin response, oxygen saturation of the blood and heath rate variability.

Methods: In the spring of 2018 three consecutive measurements per subject were conducted in a private practice. The room where measurements took place was decorated quietly and calming music was played.

Results: Of all 75 participants, 56 were female. The median age of the participants was 50 (21–82) 34 years of age. GSR-scores varied between the BARABAZ-scan and Shimmer and showed a median (range) of respectively µS = 50 (19–60) and µS = 32 (3–80). A strong correlation was found on GSR-scores between both devices ϱ = 0.75 (p < 0.001). Oxygen saturation showed a mode of SpO2 = 99 and ranged from SpO2 = 95 to 99 on both instruments. The correlation between the measurements was strong with a ϱ = 0.97 (p < 0.001). HRV gave a median (range) score for the RR-intervals from the BARABAZ-scan and Mobi 8 of respectively 0.867 (0>618–1.163) and 0.877 (0.651–1.052) seconds, the RMSSD was calculated at 28 ± 10.8 and 28 ± 9.4. The agreement was found at ICC = 0.98.

Conclusions: Based on this research, strong correlations were found between signals from the BARABAZ-scan and the golden standard references. The measurements from the BARABAZ-scan are useful to gain insight into physiological measures within a working age population.

Keywords: *physiology, biometry, employment*

Background

Good health of employees is a precondition for sustainable engagement. Preventive screenings and services to assess and monitor health-status in employees give valuable insights for individuals and increase health-consciousness. This may influence health-related behaviour. When risk factors can be identified an early intervention may be prominent to prevent negative health outcomes.

The BARABAZ-scan is a non-invasive test that is used to screen body functions related to personal capacity and stress resilience criteria. Physiological measures like the electrical resistance of the skin also referred to as galvanic skin response (GSR), oxygen saturation of the blood and heart rate variability (HRV). These measures will be explained in the next paragraphs.

The Galvanic Skin Response (GSR) is defined as a change in the electrical properties of the skin as a parameter of the sweat gland function. The signal can be used to describe the function of the autonomous nervous system [1]. The electrical properties of the skin are influenced by emotions and stress. As a result of an emotional stress reaction, there is a small change in the activity of the sweat glands in the skin. As the sweat glands release sweat, small changes of the skin's moisture change the skin and tissue conductance, which is measured by the GSR-sensor.

Recent studies show that GSR provides diagnostic information of autonomic dysfunction as well as small somatosensory nerves [2,3]. This information is particularly of interest for diabetics, patients with metabolic syndrome, and patients with micro-vascular complications [4–6]. Sudomotor dysfunction is associated with significant peripheral artery disease, vascular inflammation, and impaired glycaemic status [4–6]. Finally, an autonomic dysfunction can be used as an early detection of neuropathy in high- risk populations like diabetics. The clinical importance of GSR measurement now became ever greater, due to the diagnostic value that such a measurement can have.

Oxygen saturation (SpO2) in the blood is monitored by pulse oximetry. A pulse oximeter shines red and infrared light through a part of the body that is relatively translucent and has good arterial pulsed blood flow. The ratio of wavelengths of the red to infrared light that passes through the body part and is received by the oximeter's detector depends on the percentage of oxygenated versus deoxygenated hemoglobin through which the light passes. The percentage of oxygen saturation thus calculated is normally greater than 95%.

This noninvasive method offers useful insights in a range of patient groups. Pulse oximetry is used for diagnosis in case of acute respiratory failure in patients with chronic obstructive pulmonary disease [7]. Furthermore, low oxygen saturation is associated with a higher risk of cognitive impairment in elderly adults [8]. Finally, pulse oximetry is commonly used in detecting sleep disorders such as apnea and hypopnea [9].

The heart rate variability (HRV) describes the changes in the time intervals between successive heartbeats. Therefore, the accurate detection of heartbeats' timing is of crucial importance for the HRV analysis. This detection is, generally, accomplished using the ECG signal. An alternative method of measuring HRV is using blood volume pulse (BVP) signals, which seems to be a promising alternative [10]. Detecting beat-to-beat intervals (RR-intervals) using BVP is based on a principle called photopletysmography which consists of measuring the changes in volume using an optical method [11]. Changes in blood volume are caused by the change in blood pressure following every pulse. Compared with an ECG sensor, the BVP sensor can be considered more 'user-friendly' and less obtrusive.

The HRV is an indirect measure of the activity of the autonomous nervous system and especially the short-term measurements are suitable for ambulatory care and patient monitoring providing immediate test results [12]. A low HRV is a strong indicator of compromised health in the general population. Reduced regulatory capacity may contribute to functional gastrointestinal disorders, inflammation, and hypertension [13]. Furthermore, low HRV contributes to the prediction of all-cause mortality in prognostic modelling [14,15].

To determine the construct validity, every signal from these physiological measures retrieved from the BARABAZ-scan is compared with a golden standard measurement device. This study aims to under scribe the use of the BARABAZ-scan in daily use answering the following research question: What is the construct validity of the signals from the BARABAZ-scan compared to signals from a golden standard instrument for the variables galvanic skin response, oxygen saturation of the blood and heath rate variability?

Methods

In the spring of 2018 healthy volunteers between 18 and 67 years of age were recruited in a network of joint companies in the south of The Netherlands were invited for the study by email. One week after receiving the invitation people were called to ask for their willingness to participate. Participants were planned on one of five measurement days until a maximum of 75 study subjects was achieved. Exclusion criteria for participation were cardiovascular diseases, a pacemaker, significant skin damage, excessive sweating; metal prostheses in the fingers or limbs; pregnancy; use of medication that can affect the heartbeat. This study was approved by the Ethics Committee in Maasstad Hospital under protocol 2018–20.

Instruments

The bio-impedance sensor of the Barabaz-scan measures electrodermal activity. Besides that, the Barabaz-scan has two sensors placed on the participants' forehead, which allows the device to measure GSR over different circuits1. A golden standard for this measure was the Shimmer 3 GSR+ which was placed on proximal part of the index- and middle finger. Measurements were taken simultaneously. This instrument was found valid in multiple research situations [16–18].

Signals from the digital pulse oximeter in the Barabaz-scan (Contec CMS 50H) are compared to the measures taken with the Onyx Vantage 9590 oximeter by Nonin. A medical device validated for clinical use and scientific research [19]. Arterial blood gas measurements, obtained by arterial puncture, remain the gold standard for measurement of oxygen saturation [20]. However, this device is able to accurately measure in challenging conditions like when people move, have dark skin pigmentation or poor peripheral blood circulation [21]. The device uses pulse-by-pulse filtering to provide precise oximetry measurements. A good accuracy (difference $< 1.5\%$) was shown during rest and exercise [21]. Measurements were taken straight after each other on the same index finger.

A 3-lead ECG from a TMSi Mobi 8 was used to collect data on the HRV of the participants and compare these signals with the Barabaz-scan on the RR-intervals and RMSSD. ECG sensors were placed on both clavicula and a ground electrode on the hand. The same oximeter was used on the index finger. To evaluate the correlation between the HRV parameters computed from BVP and ECG signals measures were acquired simultaneously. The ECG directly detects the R-peek, the BVP needs to be converted into a heart signal [13]. For further analysis of the ECG signal the Pan- Tompkins QRS algorithm was applied for QRS detection.

Procedure

Participants were asked not to drink alcohol or train intensively a day before the measurements, not to eat an hour before the measurements but drink sufficiently. All tests were conducted in a controlled environment following a standardized protocol. The protocol was pilot-tested and trained by all testers prior to data collection. Prior to the measurements, the study protocol was explained, and Participants subjects gave their informed consent. Measurements took place in a private practice in a quietly decorated room where calming music was played. Three consecutive measurements were conducted to secure a useful dataset. Measurements lasted two minutes, the participants didn't speak during the measurements to minimize the chance of artifacts.

Statistical Analysis

The first dataset is being used, unless there is missing data due to possible artifacts, it that case the second or third dataset was used. Descriptive statistics are used to present baseline characteristics and collected measures. The Kolmogorov-Smirnov test showed that data is not normally distributed. Hence, Spearman's correlation coefficient is used to test the association between instruments for GSR and oxygen saturation. The HRV was compared using intra class correlation (acceptable, 0.75- 0.89, excellent ≥ 0.9) [22]. A sample size calculation according to Bonett and Wright (2000) was performed and showed a minimum required number of 62 subjects [23]. The correlation was classified as poor (0.00 to ± 0.25), fair (± 0.25 to ± 0.50), moderate (± 0.50 to ± 0.75), or strong (± 0.75 to ± 1.00) [22]. All statistical analyses were performed using SPSS 24 for Windows.

Results

Of all 75 participants, 56 were female. The median age of the participants was 50 (21–82) years of age. GSR-scores varied between the BARABAZ-scan and Shimmer and showed a median (range) of respectively μS = 50 (19–60) and μS = 32 (3–80). A strong correlation was found on GSR-scores between both devices $\rho = 0.75$ ($p < 0.001$). Oxygen saturation showed a mode of SpO2 = 99 and ranged from SpO2 = 95 to 99 on both instruments. The correlation between the measurements was strong with a $\rho = 0.97$ ($p < 0.001$). HRV gave a median (range) score for the RR-intervals from the BARABAZ-scan and Mobi 8 of respectively 0.867 (0.618–1.163) and 0.877 (0.651–1.052) seconds, the RMSSD was calculated at 28 ± 10.8 and 28 ± 9.4. The agreement was found at ICC = 0.98.

Discussion

Based on this research, strong correlations were found between signals from both the BARABAZ- scan and the golden standard references. The measurements from the BARABAZ-scan are valid and therefore useful to gain insight in physiological measures within a working age population. These measures are relating to personal health status which could be a valuable way to increase sustainable engagement for organizations.

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