Philips Wearable Sensing Technologies: relevant 3rd parties publications

1. Spierer, D.K., Rosen, Z., Litman, L.L. and Fujii, K. (2015). "Validation of hotoplethysmography as a method to detect heart rate during rest and exercise," J Med Eng Technol 39(5): 264-271.

Abstract: Despite their enhanced marketplace visibility, validity of wearable photoplethysmographic heart rate monitoring is scarce. Forty-seven healthy participants performed seven, 6-min exercise bouts and completed a valid skin type scale. Participants wore an Omron HR500U (OHR) and a Mio Alpha (MA), two commercial wearable photoplethysmographic heart rate monitors. Data were compared to a Polar RS800CX (PRS). Means and error were calculated between devices using minutes 2-5. Compared to PRS, MA data was significantly different in walking, biking (2.41 ± 3.99 bpm and 3.26 ± 11.38 bpm, $p < 0.05$) and weight lifting (23.30 ± 31.94 bpm, $p < 0.01$). OHR differed from PRS in walking (4.95 ± 7.53 bpm, $p < 0.05$) and weight lifting (4.67 ± 8.95 bpm, $p < 0.05$). MA during elliptical, stair climbing and biking conditions demonstrated a strong correlation between jogging speed and error ($r = 0.55$, $p < 0.0001$), and showed differences in participants with less photosensitive skin.

2. Tamura, T., Maeda, Y., Sekine, M. and Yoshida, M. (2014). "Wearable Photoplethysmographic Sensors—Past and Present," Electronics, 3, 282-302.

Abstract: Photoplethysmography (PPG) technology has been used to develop small, wearable, pulse rate sensors. These devices, consisting of infrared light-emitting diodes (LEDs) and photodetectors, offer a simple, reliable, low-cost means of monitoring the pulse rate noninvasively. Recent advances in optical technology have facilitated the use of high-intensity green LEDs for PPG, increasing the adoption of this measurement technique. In this review, we briefly present the history of PPG and recent developments in wearable pulse rate sensors with green LEDs. The application of wearable pulse rate monitors is discussed.

3. Parak, J. and Korhonen, I. (2014). "Evaluation of Wearable Consumer Heart Rate Monitors Based on Photopletysmography," Proceedings EMBC, 3670-3673.

Abstract: Wearable monitoring of heart rate (HR) during physical activity and exercising allows real time control of exercise intensity and training effect. Recently, technologies based on pulse plethysmography (PPG) have become available for personal health management for consumers. However, the accuracy of these monitors is poorly known which limits their application. In this study, we evaluated accuracy of two PPG based (wrist i.e. Mio Alpha vs forearm i.e. Schosche Rhythm) commercially available HR monitors during exercise. 21 healthy volunteers (15 male and 6 female) completed an exercise protocol which included sitting, lying, walking, running, cycling, and some daily activities involving hand movements. HR estimation was compared against values from the reference electrocardiogram (ECG) signal. The heart rate estimation reliability scores for <;5% accuracy against reference were following: mio Alpha 77,83% and Scosche Rhytm 76,29%. The estimated results indicate that performance of devices depends on various parameters, including specified activity, sensor type and device placement.

4. Yoo, S. (2014). "Study on the Validity of Recently Introduced Wrist Watch Type Heart Rate Monitoring Device," J Korean Acad Pediatr Dent 41(1), 27-33.

Abstract: There are several ways to analyse stress resulting from anxiety and fear within dental treatment for children. Surveying questionnaires and monitoring biologic reaction are the most common ways for evaluating stress. Pulse oximeter is a popular device for detecting heart rate but not appropriate for moving children. In this study, we compared a recently introduced wrist- watch type heart rate monitor (Alpha, MIO, USA) with a pulse oximeter(MP110, MECKIS, Republic of Korea) for 10 attendants with two conditions including resting state and excited state after exercise. Data were analyzed using Wilcoxon Signed Rank test and there is no statistical difference between two devices ($p< 0.05$).