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Validation of iriver ON® with PerformTek® sensor Earbud Heart Rate Sensor

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PURPOSE

This report examines the accuracy of Valencell, Inc.'s PerformTek® earbud sensor integrated into the **iriver ON®** relative to a traditional chest strap heart rate monitor.

INTRODUCTION

Healthy living has seen a global resurgence as people place more value on staying active to live more fulfilling, healthier and longer lives. In this environment, fitness applications enjoy a meteoric rise across mobile phones, gaming and consumer fitness products. Workout efforts are optimized when receiving feedback on target heart rate zones and physical activity (Jeukendrup and Van Diemen, 1998). Additionally, heart rate monitoring of training intensity provides more accurate information than self-reports of training intensity (Gilman and Wells, 1993). The American College of Sports Medicine reports that heart rate monitoring has been shown to result in improvements in cardiorespiratory fitness when used for exercise prescription (ACSM, 2011).

The use of heart rate monitors is highly popular with individuals who exercise. Currently continuous heart rate monitors utilize a chest strap that transmits data to a specialized watch. These chest strap units are highly accurate as examined by Goodie et. al. (2000) but somewhat invasive and uncomfortable (Schonfelder et. al., 2011) in that the strap must be applied below any clothing at the level that the rib cage comes together. Earbud technology would eliminate the need for the chest strap. And because 58% of U.S. headphone owners listen to headphones while exercising (NPD Group, 2012) earbud sensors are seamless and compatible with existing consumer behavior.

METHODS

Clinical trials examining validity of **iriver ON®** (iriver Ltd, Seoul, Korea) audio earbuds embedded with PerformTek® sensor technology (Valencell Inc., Raleigh, NC) was completed using 33 exercise trials (8 males, 15 females). Trials consisted of a dynamic 8-minute treadmill session involving resting, walking, and running while heart rate was monitored via iriver ON and a traditional chest strap heart rate monitor (polar cx800, Polar Electro, Kempele, Finland). Heart rate was recorded continuously on both devices and statistical analysis was completed using 5-second data averaging (2976 data points). Statistical analysis was examined validation using bias, 95% limits completed using SPSS and Microsoft Excel.

Table 1. Protocol (at 1% grade)

Time (min)	Protocol (speed in mph)
0:00 – 0:30	Standing
0:30 – 1:15	3.4
1:15 – 2:00	2.2
2:00 – 3:30	Self-selected running speed (ranging from 5.5 to 9 mph)
3:30 – 5:00	3.0
5:00 – 6:00	Self-selected running speed (ranging from 5.5 to 9 mph)
6:00 – 6:20	2.0
6:20 – 8:00	Standing

Figure 1. **iriver ON**®placement in participant's ear.

RESULTS

Overall Data (figures 2 and 3).

Results indicated high correlation between the ECG and **iriver ON**® ($r = 0.99$, $r^2 = 0.99$), the average difference between the two devices (bias) = 0.56 beats, 95% confidence limits of agreement (LOA) as a percentage = 4.99%. Ninety five percent (2556 of 2991) of **iriver ON**® HR measurements fell within ± 5 BPM of chest strap HR measurements.

Peak and Recovery HR. (figures 4 and 5)

An analysis of the highest 15-sec heart rate (peak HR) during each of the trials revealed a peak HR of 156 ± 19 and 155 ± 19 for the chest strap and earbud respectively. Limits of agreement (LOA) as a percentage = 1.94%.

Analysis of the last 15-sec heart rate (recovery HR) during each of the trials revealed a recovery HR of 99 ± 20 and 98 ± 20 for the chest strap and earbud respectively. Limits of agreement (LOA) as a percentage = 3.16%.

Figure 2. Correlation/regression analysis for **iriver ON**® vs. chest strap (2691 data points).

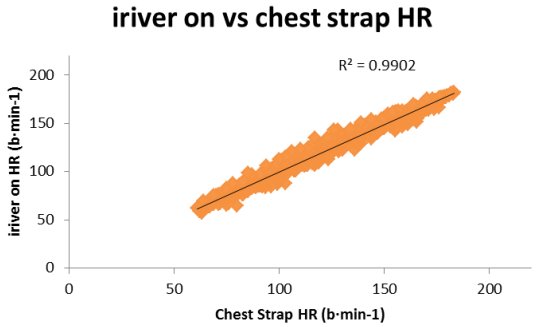


Figure 3. Frequency distribution for **iriver ON**® vs. chest strap (2691 data points).

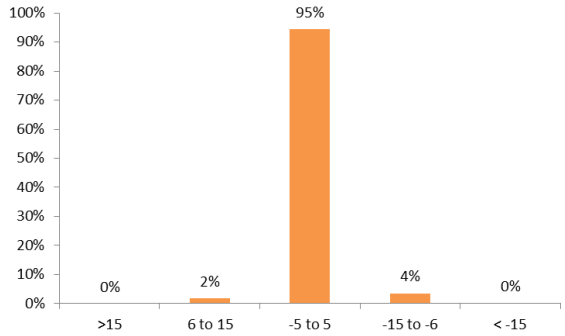


Figure 4. Peak HR comparison for **iriver ON**® vs. chest strap.

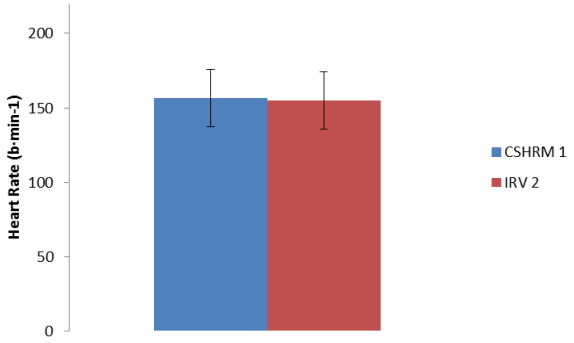
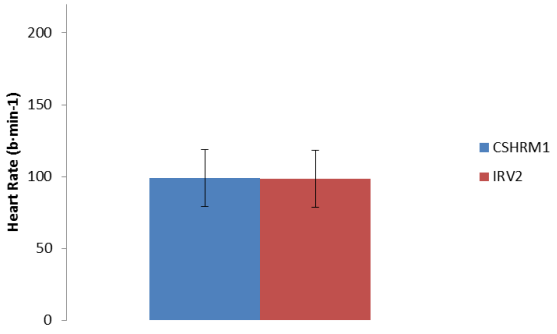


Figure 5. Recovery HR comparison for **iriver ON**® vs. chest strap.



CONCLUSION

High correlations in combination with low LOA during dynamic exercise including assessment of peak and recovery HR indicate the **iriver ON**® with PerformTek® earbud sensing technology is a valid instrument for the measurements of HR. PerformTek® earbud sensing technology may be used effectively as an alternative to ECG or chest strap monitors for assessment of heart rate.

Data Filtering Note

Post processing of heart rate was necessary for both the chest strap heart rate sensor and the earbud sensor when contact loss was apparent. Contact loss may be the result of misplacement of the chest strap or earbud, poor conduction/contact of the chest strap with the skin, or error in the transmission from the devices. In the case of contact loss data was eliminated from analysis. In post process analysis 2 entire data sets each for the chest strap and earbud were eliminated. Additionally, 41 chest strap and 52 earbud individual data points were eliminated.

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Representative Graphs