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Evaluating Device-Agnostic Properties of Raw Data Preprocessing Metrics in Physical Activity Assessment

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Background and Methods

- Physical activity monitoring devices have built in 'accelerometers sensors' that are used to provide estimates of physical activity behavior. *Several raw accelerometer data preprocessing methods including (**Activity Counts**, **Activity Index**, Euclidean Norm Minus One—**ENMO**, Mean Amplitude Deviation—**MAD**, and Monitor Independent Movement Summary Unit—**MIMS**) have been proposed to standardized how data are processed* but there is no agreement on the most useful summary metric.

- **Objective:** This study compared preprocessing metrics from the ActiGraph wGT3X-BT (±8g) and Pixel Watch 2 (±16g) worn on participants non dominant wrists. Metrics were computed and scored at five different epochs (1-s, 5-s, 15-s, 30-s, and 60-s). To assess the effect of device configurations, ActiGraph data was recorded at two sampling rates (100Hz and 50Hz) while the Pixel Watch was sampled only at 50Hz as the optimum rate that enabled a 24-hour experiment run.

- **Methods:** Agreement between MX values (minimum acceleration of the most active minutes [MX—1-720 min]) of similar processing metric from two devices was facilitated by the mean absolute percent error (MAPE) for individual error, Bland–Altman analysis, and standard radar MX plots. Bland-Altman analysis was conducted on log1p transformed MX values to facilitate cross metric comparisons. The results from this process were interpreted in relative terms of proportional bias. Results from all epochs were pooled and analyzed together.

3D raw acceleration data extracted (X, Y, Z)
Device configurations :
- 100 - 50Hz Non-dominant wrist (n=9)
- 50 - 50Hz (n=7)
- All Hz (n =16)

Findings

Data from 16 participants (25.4 ± 8.9 years) showed strong agreement for MAD and MIMS MX with a total MAPE aggregate of 6.8% ± 7.0% and 7.1% ± 3.5% across all five epochs. The errors for other preprocessing metrics MX values were high AI (8.4% ± 10.7%), ENMO (10.8% ± 11.5%), AC (17.5% ± 8.4%). Standard radar MX plots revealed tighter alignment for MIMS and MAD across all epochs (**see Figure 1).**

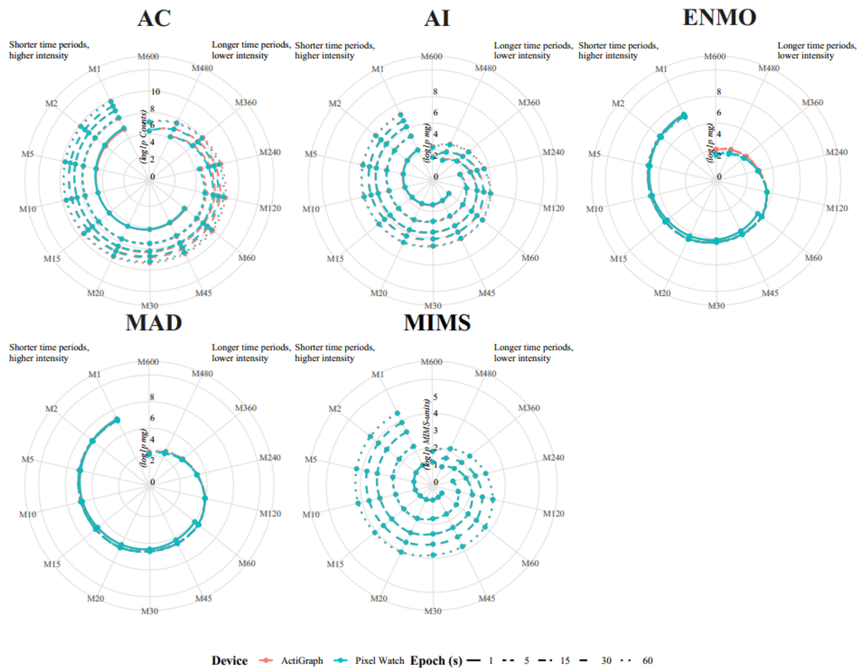

Figure 1. demonstrates standard plots for compared MX averages log1p-transformed values from each metric (n=16). The radar plots show a near-complete overlap for MIMS MX values from both devices across all epochs, whereas MX levels from the other preprocessing metrics display irregularities at different levels.

Lower bias proportion and narrow limit of agreement were observed in MIMS (Bias=0, LoA [- 0.13, 0.14]), followed by MAD (Bias=-0.02, LoA [- 0.13, 0.16]), AI (Bias=0.05 LoA [-0.2, 0.31]), and ENMO (Bias=0.06, LoA [- 0.3, 0.41]). The AC demonstrated largest log1p-transformed bias with (Bias=0.07, LoA [-0.32, 0.47]). See **Figure 2** below fo the Bland-Altman analysis**.**

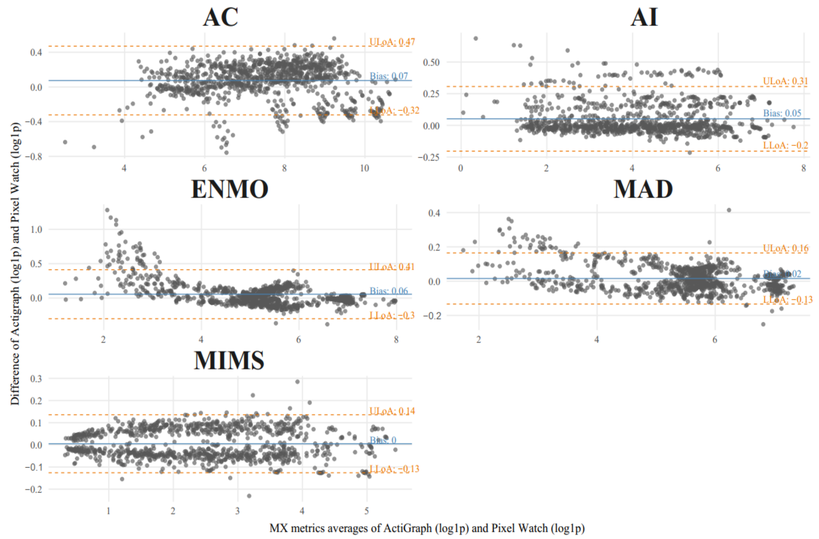

Figure 2. Plots show proportional bias and limits of agreement for log1p-transformed ActiGraph vs. Pixel Watch MX values by processing methods. Differences (log1p[ActiGraph] − log1p[Pixel]) are plotted against their mean; solid lines show mean bias and dashed lines show 95% limits. Positive bias means the Pixel Watch reports proportionally lower MX values. MIMS showed the strongest agreement overall.

Conclusions

- The MIMS preprocessing approach yielded the strongest MX device agreement compared to other methods.
- These results support the use of MIMS for device-agnostic monitoring within the MX framework. Future studies should cross-validate these findings in larger samples.