Comparing accuracy of accelerometers for measurement of gait and balance, and upper body postural tremor

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BACKGROUND

- Motor symptoms (e.g. walking and gait difficulties, tremors) in patients with movement disorders (e.g. Parkinson's disease) are traditionally measured using surveys (e.g. MDS-UPDRS [1])
- The use of accelerometer sensors offer an opportunity to do precise measurement of gait & balance [2], and upper body postural tremor [3,4] to improve understanding of disease symptoms
- However currently the accuracy of the accelerometers in mobile or wearable devices is uncertain and unverified
- To facilitate the development of a digital biomarker to measure gait & balance and postural tremor, we analyzed 3 devices to verify their accelerometer accuracy
  - iPhone 8 Plus (iPhone)
  - ActiGraph GT9X Link (GT9X) [5]
  - ActiGraph CentrePoint Insight Watch (CPIW) [6]

METHODS

- The device accuracy is determined by assessing the agreement between their accelerometer output and the gold standard of known acceleration across a range of amplitudes and frequencies
- Quanser Shake Table II system controller (Shake Table) [7] is used as the gold standard to define the amplitude (range 5 to 60 mm) and frequency (range 0.5 to 10 Hz) of acceleration
  - The Shake Table underwent installation qualification & operational qualification before use [8]
- Agreement is quantified by intraclass correlation coefficient (ICC): ICC value below 0.5 is deemed as poor agreement, between 0.5 and 0.75 to be moderate, between 0.75 and 0.9 to be good, and above 0.9 to be excellent [9]

RESULTS

Accuracy as measured by agreement between device output and gold standard (Shake Table)

- **iPhone** vs Shake Table:
  - over all acceleration values tested: agreement **excellent (94.6%** of tests**)**
- **GT9X** vs Shake Table:
  - acceleration **≥ 0.1g**: agreement **excellent (69.1%)** or good (19.8%)
  - acceleration **< 0.1g**: agreement **poor (97.4%)**
- **CPIW** vs Shake Table:
  - acceleration **≥ 0.1g**: agreement **excellent (74.2%)** or good (14.7%)
  - acceleration **< 0.1g**: agreement excellent (16.9%), good (41.6%), moderate (11.7%), or poor (29.9%)

CONCLUSIONS

- The iPhone 8 Plus is suitable for measuring acceleration of gait & balance and postural tremor
- The ActiGraph GT9X and CPIW are suitable for measuring gait & balance, but are not suitable to detect the full range of postural tremor movements

A	F	accel
10	9	3.261
10	8	2.577
5	10	2.013
10	7	1.973
5	9	1.631
10	6	1.449
5	8	1.288
20	4	1.288
30	3	1.087
10	5	1.006
5	7	0.986
30	2.5	0.755
5	6	0.725
20	3	0.725
10	4	0.644
40	2	0.644
60	1.5	0.544
5	5	0.503
30	2	0.483
50	1.5	0.453
10	3	0.362
40	1.5	0.362
5	4	0.322
20	2	0.322
30	1.5	0.272
60	1	0.242
50	1	0.201
5	3	0.181
10	2	0.161
40	1	0.161
30	1	0.121
5	2	0.081
20	1	0.081
60	0.5	0.06
50	0.5	0.05
10	1	0.04
40	0.5	0.04
30	0.5	0.03
5	1	0.02
20	0.5	0.02
10	0.5	0.01
5	0.5	0.005

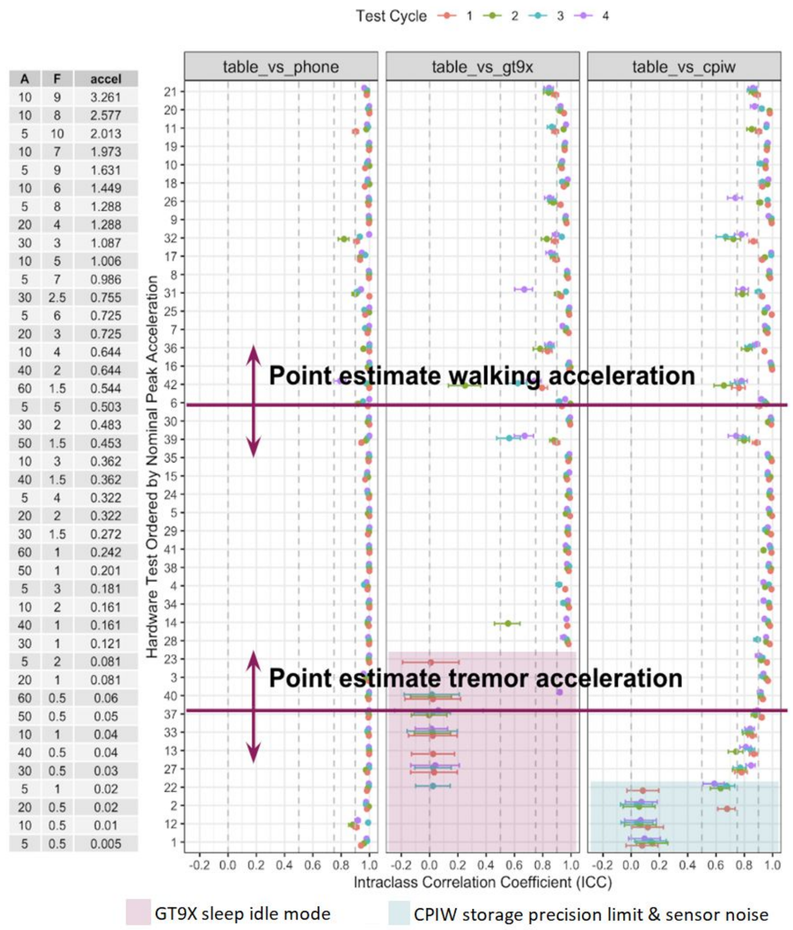

Figure 2. ICC values for 42 combinations of amplitude (A) in mm, frequency (F) in Hz, and acceleration (accel) in g. Each combination was run once manually and 3 times automated. Point estimates for walking [2] and tremor [3,4] are shown.

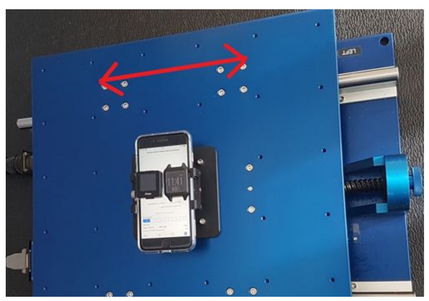

Figure 1. Shake Table with the 3 devices attached. Arrow indicates direction of movement.

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