

# Capability of accelerometers in wearable devices for measurement of postural tremor, gait and balance, and nocturnal scratching

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**What is the Methodological Question Being Addressed?** To assess whether the accelerometers in an Apple Watch, an iPhone XR and an ActiGraph GT9X can accurately measure upper body postural tremor, gait and balance, and nocturnal scratching.

**Introduction** Motor symptoms in patients with movement disorders are traditionally measured using clinician and patient reported outcome measures such as the UPDRS. Consumer wearables, such as SmartWatches, are becoming increasingly popular for use in clinical trials. The use of accelerometers within such devices may offer an opportunity to do precise measurement of upper body postural tremor, gait and balance, and nocturnal scratching. The accelerations associated with gait and balance are typically of magnitude 0.1g and above (Moore et al., 2008), whereas those for postural tremor and nocturnal scratching can be as low as 0.005g and 0.02g respectively (Calzetti et al., 1987; Moreau et al., 2018). To determine whether an Apple Watch Series 5, an iPhone XR and an ActiGraph GT9X Link might be suitable for digital measures of these symptoms, we analyzed the sensitivity of their accelerometers to determine their ability to measure accelerations observed in the symptoms of interest.

**Methods** A Quanser Shake Table II was used to oscillate the three devices across a range of frequencies and amplitudes representative of postural tremor, gait and balance, and nocturnal scratching. The frequency ranged from 0.5 Hz to 10 Hz and the amplitude from 0.01 cm to 6 cm, corresponding to an acceleration range of 0.005g to 2g. Each amplitude/frequency combination was tested at least 3 times. The degree of agreement, as measured by the intraclass correlation coefficient (ICC), between the output of each device and the reference acceleration of the Shake Table (taken as the gold standard) was assessed. The median ICC across the 3 or more tests of each amplitude/frequency combination was calculated for each device. ICC values greater than 0.90 are considered excellent, between 0.75 and 0.9 good, between 0.5 and 0.75 moderate, and less than 0.5 considered poor (Koo, Li, 2016).

**Results** iPhone XR: agreement is excellent or good for the full range of accelerations tested (median ICC values for each amplitude/frequency combination in range 0.86 to 1)

Apple Watch Series 5: for peak acceleration  $\geq 0.07g$ , agreement is excellent or good (median ICC values in range 0.77 to 0.97); below 0.07g, agreement is moderate or poor (median ICC values in

range 0 to 0.74)

GT9X: for peak acceleration  $\geq 0.04g$ , agreement is excellent or good (median ICC values in range 0.88 to 0.96); below 0.04g, agreement is moderate or poor (ICC values in range 0.03 to 0.75)

**Conclusion** The Apple Watch Series 5 and GT9X are suitable (with good or excellent agreement) for measuring the accelerations associated with gait and balance but are not capable of measuring the full range of accelerations associated with postural tremor and nocturnal scratching, with only poor or moderate agreement at the lower end of the range.

The iPhone XR accelerometer is suitable (with good or excellent agreement) for measuring the full range of accelerations associated with postural tremor, gait and balance, and nocturnal scratching.

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### Keywords

Keywords
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