Accuracy and repeatability of smartphone sensors for measuring Shank-to-Vertical Angle

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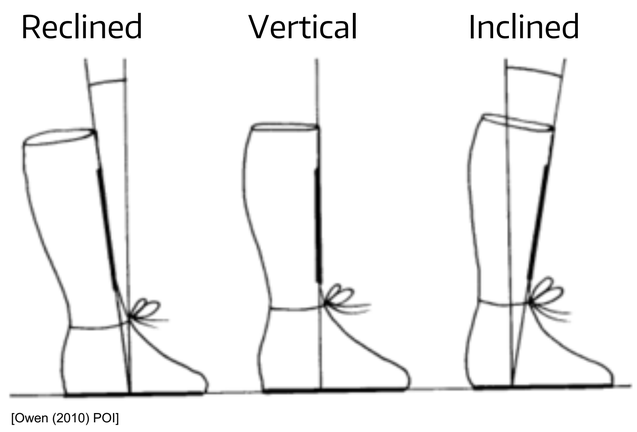
The Challenge

Measuring human movement is clinically important for prescribing devices or guiding treatment decisions

- One measure of clinical interest is **shank-to-vertical angle (SVA)**, the orientation of the lower leg with respect to the vertical in the global sagittal plane [1]
- Current techniques (*e.g.,* motion capture, video, goniometer) to measure SVA largely require **expensive** equipment, are **time intensive**, or are **isolated to static** measurements with **poor reliability** [2-4]
- **Need:** An affordable and widely-available rehabilitation method that dynamically tracks shank orientation in real time



[Owen (2010) POI]

Shank-to-Vertical Angle (SVA)

The application of smartphone sensing has created opportunities to enhance clinical gait analysis [4]

Before integrating smartphone sensing of SVA into clinical practice, research must evaluate:

- (1) **Accuracy** of smartphone sensing compared to gold-standard motion capture
- (2) **Inter- and intra-rater repeatability** for measuring SVA with a smartphone

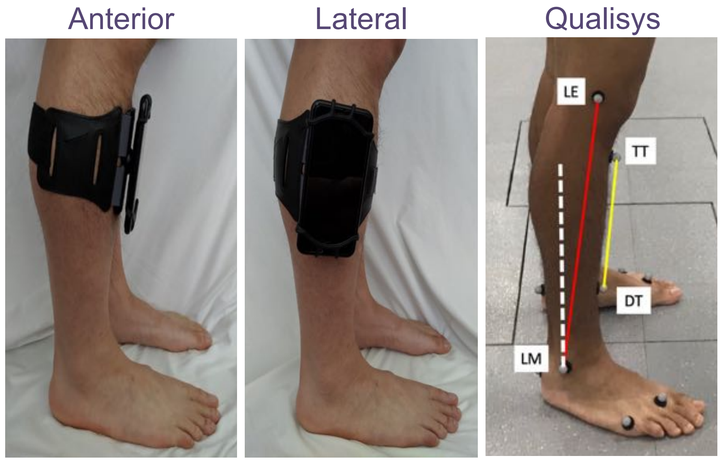
Methods

Participants: Four licensed rehabilitation clinicians (2 physical therapists and 2 orthotists) recruited to use smartphone to measure SVA on two unimpaired, healthy participants during gait analysis.

Smartphone Sensing: A custom mobile application was used to measure SVA using phone's accelerometer. Two different smartphone positions were evaluated, corresponding to anterior and lateral methods for measuring SVA.

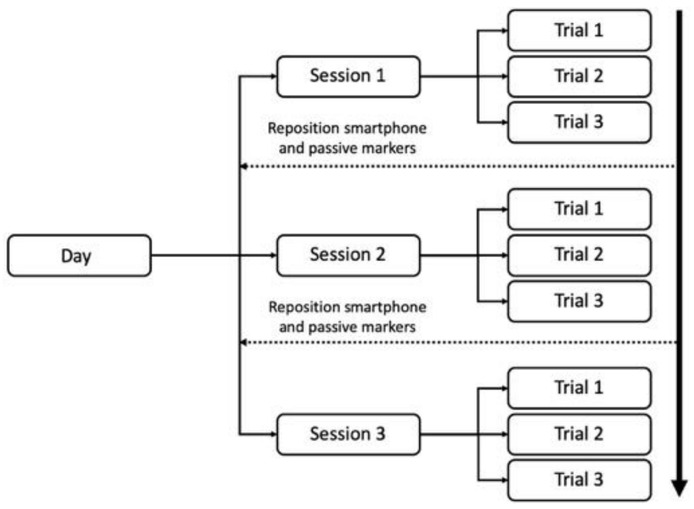
Accuracy

- Smartphone and Qualisys motion capture concurrently gathered data
- Anterior SVA was calculated from Qualisys using tibial tuberosity (TT) and distal tibia (DT) markers. Lateral SVA used lateral epicondyle (LE) and lateral malleolus (LM) markers.
- Clinicians were blinded to the passive markers upon phone placement

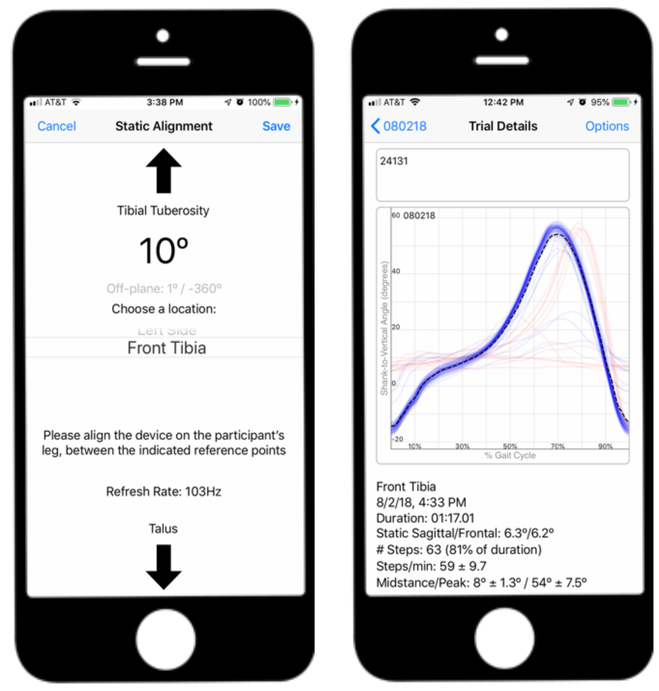


Repeatability

- Inter-rater repeatability compared SVA measures between clinicians
- Intra-rater repeatability assessed the clinician's ability to reposition the smartphone within and between days

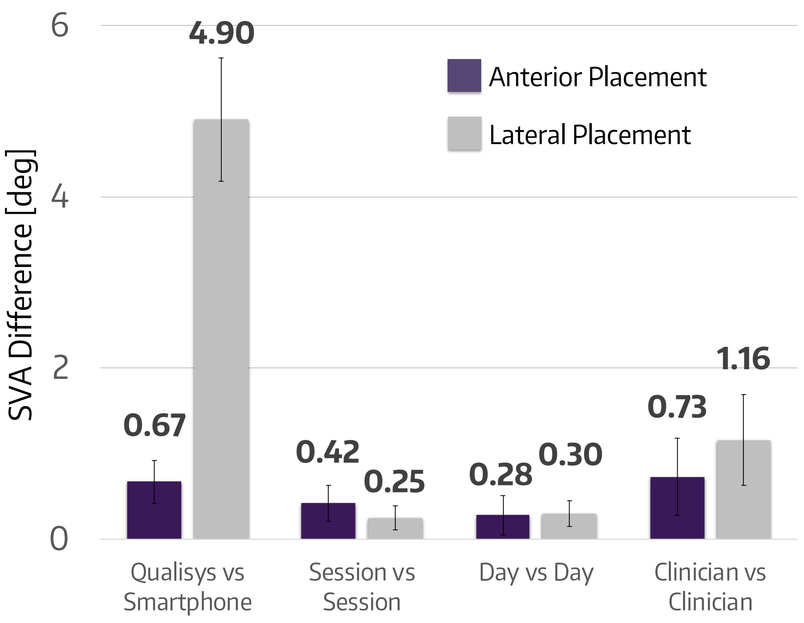


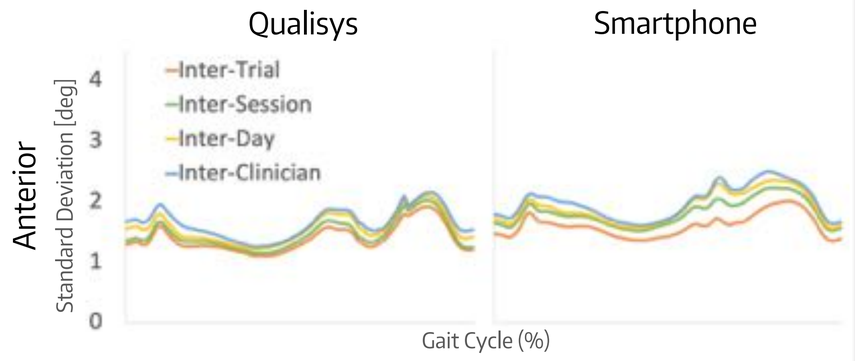
Repeated-measures experimental design adapted from Schwartz et al. [5] Each participant underwent 24 total sessions; **six sessions** conducted by each of the **four clinicians** across **two days**; and **three trials** were acquired during each session. **Five gait cycles** from each trial used in analysis. This process was repeated for each participant.



Results

Anterior placement is accurate and repeatable with deviations less than 2°





Clinician Feedback

- Smartphone sensing would enhance clinical practice
- SVA is not easy to measure with current tools available in clinic
- The custom mobile application is intuitive, but requires some practice to use

Discussion

- **Front placement is generally more accurate and repeatable** in measuring SVA compared to side placement
- Smartphone sensing can be a viable option for measuring SVA in dynamic conditions (i.e. gait analysis), which is a potential advantage over traditional tools used in clinical practice
- Quick, real-time smartphone sensing of SVA and other gait metrics may facilitate orthotic tuning and gait training using affordable and widely-available technology

Next Steps

- Evaluate whether the size and type of smartphone impact accuracy and repeatability
- Assess accuracy and repeatability of SVA mobile sensing in individuals with clinical populations
- Further development of custom mobile application

Acknowledgements

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References

[1] Owen E, (2010) *Prosthet Orthot Int.* 34 (3): 254-269
[2] Milanese S, et al., (2014) *Man. Ther.* 19 (6): 569-574
[3] Milani P, et al., (2014) *PM R.* 6 (11): 1038-1043
[4] Nishiguchi S, et al., (2012) *Telemed J E Health.* 18 (4): 292-296
[5] Schwartz MH, et al., (2004) *Gait Posture.* 20 (2): 196-203

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