Development of a clinically usable assessment tool for static standing balance

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Purpose

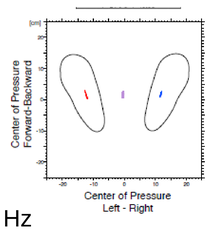
- To find the optimal parameter for identifying balance ability, and to find the optimal location for placement of an Inertial Measurement Unit (IMU) for estimating the body's Centre-of-Mass (COM)
- To develop a cost-effective clinical assessment for standing balance

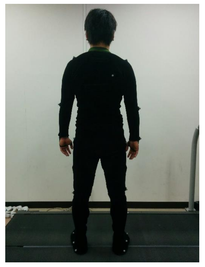
Background

- Falls are a serious issue among individuals with impaired motor abilities such as post-stroke patients and the elderly
- Assessments using force plates and motion capture during quiet standing can be used to identify risk of fall [1,2]
- These methods are not always applicable in a clinical setting due to their setup times and cost

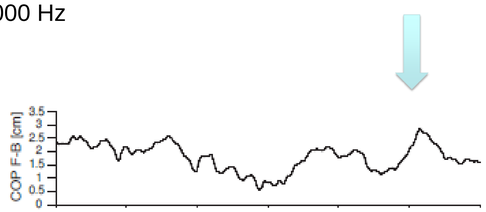
Method

- 14 young, able-bodied participants
- Three standing conditions:
  1. Standing with eyes open
  2. Standing with eyes closed
  3. Standing with Stroop test (mental task)
- Motion capture, 20 markers, bilateral, Fs = 200 Hz
- Force plate, Fs = 1000 Hz





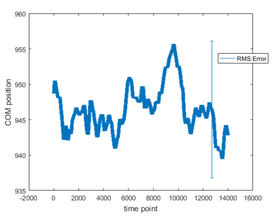
MoCap markers

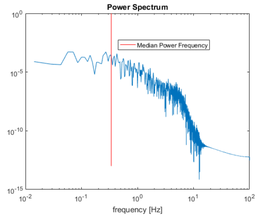


Centre-of-Pressure (COP) fluctuation during quiet standing

Optimal Postural Sway Parameter

- Identifying the parameter quantifying COM or COP data that shows statistically significant differences between conditions
- Time-domain parameters: mean distance, Root-Mean-Square (RMS) distance, mean velocity, total excursions, range, RMS velocity, RMS acceleration, mean amplitude, mean frequency [3]
- Frequency-domain parameters: centroidal frequency, frequency dispersion, power frequency, total power [3]





- A paired t-test showed that COM acceleration in the Anterior-Posterior (AP) direction was the most statistically significant indicator of differences between the three conditions

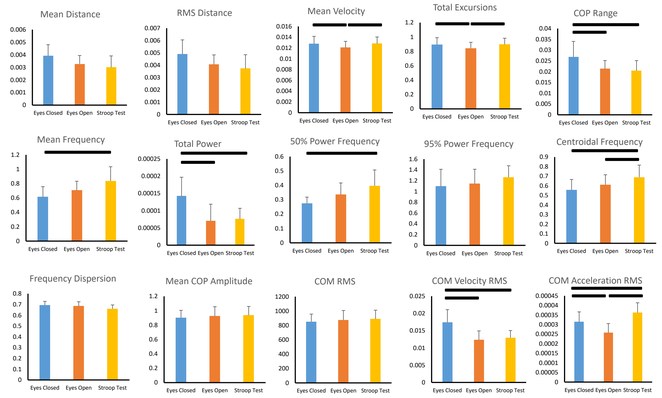
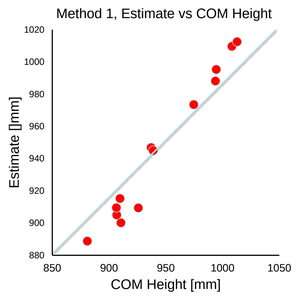
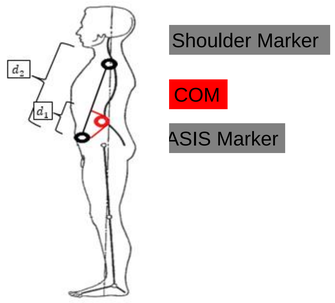


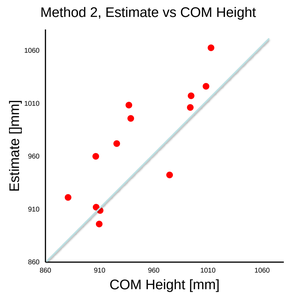
Fig 1-12. COP AP parameters. Fig 13-15. COM AP parameters. ━ p-value < 0.0167

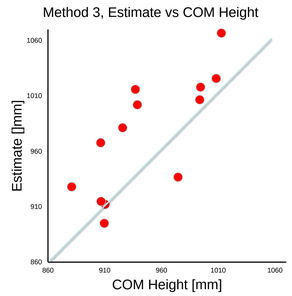
Optimal Placement for IMU

- Identifying the optimal location to place a single IMU such that it can estimate COM motion, using shoulder and ASIS marker data
- Three methods were compared:
  1. Multiple regression analysis using shoulder and ASIS markers to approximate the body COM location
  2. Estimating COM location using the ratio of COM to ASIS difference to trunk length (d_1/d_2)
  3. Estimating COM location as the vertical distance from ASIS









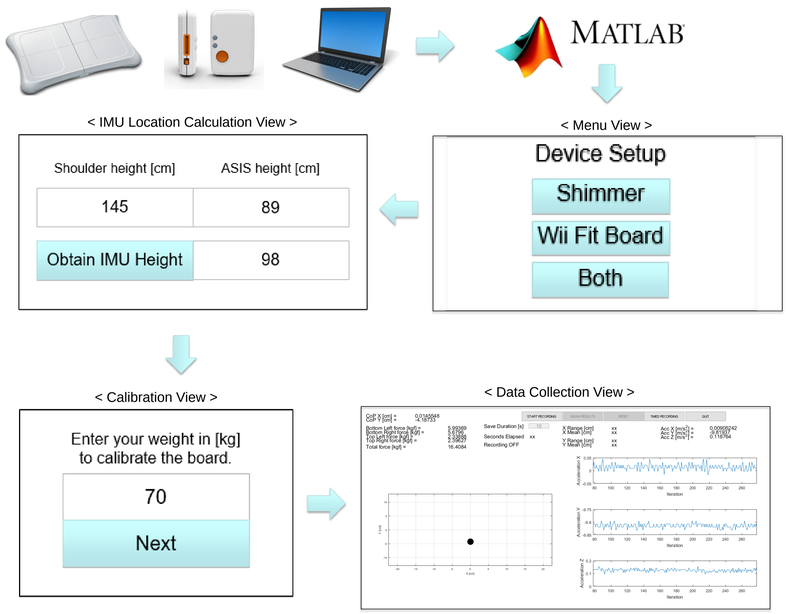
- Method 1 was the most accurate, the multiple regression equation calculating height for IMU location in mm is:

$$COM = 908 - 0.0271 \times Shoulder - 0.954 \times ASIS + 0.000743 \times Shoulder \times ASIS$$

- Where $Shoulder$ is the height of the shoulder marker and $ASIS$ is the height of the ASIS marker in mm
- Method 2 calculated a result 10% of the trunk above the ASIS
- Method 3 calculated a result 5 cm above the ASIS

Clinical Assessment Tool

- The system integrates a commercially available, low-cost force plate (Wii Balance Board, Nintendo Inc.) and an IMU (Shimmer3, Shimmer Inc.) using MATLAB, Shimmer API, WiiLab library [4], and the CU Wii GUI [5]



Conclusion

- Proposed three methods for the IMU optimal location, that can be easily used by clinicians
- An assessment tool has been developed with plans to validate its effectiveness
- The next step would be to test the system and compare the recorded results with those of a conventional static standing assessment

Made in Canada

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References

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