Quantifying Static and Dynamic Stability Using Mobile Sensors

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INTRODUCTION

- Over 35% of Americans suffer from balance disorders [1].
- Improved quantitative and low cost analysis of these disorders is necessary.
- The goal of this project is to develop a solution to the problems of expensive equipment and lack of quantitative data in balance assessments using smart phone sensors.
- The project aims to improve upon existing standing balance testing and validate a system for dynamic testing.

METHODS

- A mobile application has been developed to walk the user through the six stances of the BESS balance test (Figure 1), as well as a six minute walking trial.
- The smart phone is strapped to the users waist and collects tri-axial acceleration and angular velocity data.

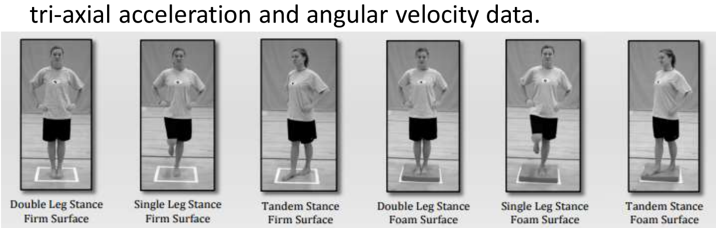

Figure 1 The six conditions of the BESS Balance Test Protocol.

- Sample Entropy (SE), a non-linear method of quantifying static stability, is used to observe variability of the subjects' static postural sway during each of the six BESS stances.
- Maximum Lyapunov exponents (LyE), a non-linear method of quantifying dynamic stability, are calculated to quantify dynamic movement from the six minute walking test.
- Balance data is analyzed external to the application using custom MATLAB code. The middle 30 seconds of walking data is analyzed to facilitate compare with similar studies [2].

RESULTS

- The average greatest LyE, or least stability, was found in the medial-lateral direction (Figure 2).

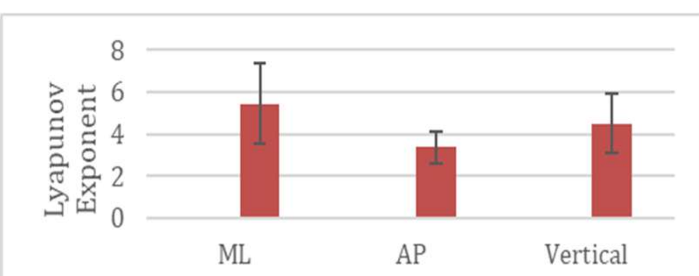

Figure 2: Maximum LyE values for the medial-lateral, anterior-posterior, and vertical directions during overground walking.

- Values calculated from mobile phone data proved to be slightly higher than previous studies using an XSENS system [2]. This is likely due to the amount of noise in the low quality mobile accelerometer sensors.
- Average SE of all 11 subjects is shown for each of the six BESS balance stances (Figure 3).

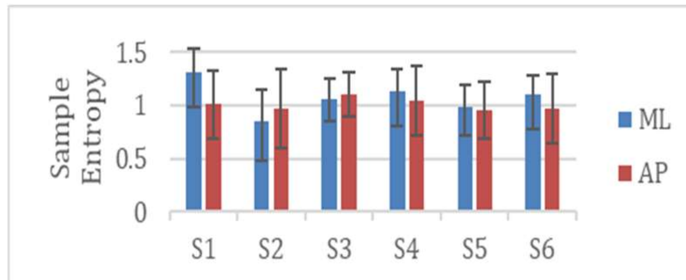

Figure 3: Average SE values show the most variable postures to be stances 2 and 5 in standing tests.

- Both single leg stances (S2 and S5) on different surfaces, display the least regular postures.
- Similar to LyE data, we observed greater values in Stance 1 of the BESS balance test when compared to previous literature using lab grade accelerometers [3].

DISCUSSION

- Smart phone technology has proven to be promising using more sophisticated, nonlinear analysis and in the use of dynamic testing.
- This experiment has expanded current systems to assess dynamic walking balance, which may have increased relevance to risk of falls.
- Previous research has shown the potential for smart phone sensors to collect continuous data to diagnose balance disorders, however, validation and more sophisticated sensor fusion is lacking [4].
- We believe a low cost, accessible, yet sophisticated system can enhance the detection of balance problems and aid in early identification of risk and disorders.
- Future studies will investigate balance performance in unhealthy individuals.
- Future work will collect more subjects to establish healthy baseline data.

REFERENCES

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