Quantifying Static and Dynamic Stability Using Mobile Sensors

Mason Schleu[1], Brian A. Knarr[2]

1. Computer Engineering, University of Nebraska-Lincoln, Lincoln, NE 68588
2. Department of Biomechanics, University of Nebraska at Omaha, Omaha, NE 68182

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 smart phone application will be programmed to create a friendly user interface while mobile sensors collect and analyze data during the duration of the tests. It will keep track of time and prompt the user to proceed to the next segment. (Prototype, Figure 1)

Fig. 1 Displays a screenshot of the prototype mobile app.

The BESS Balance test (Figure 2) will be used with the smart phone accelerometer and gyroscope to detect and analyze if any balance problems are present.

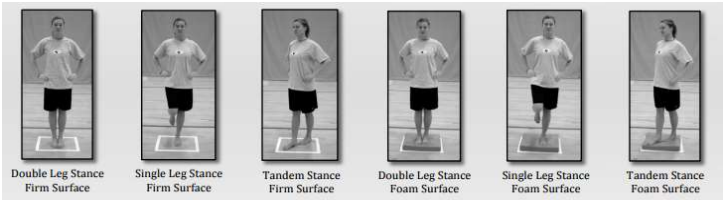

Fig. 2 The six conditions of the BESS Balance Test Protocol.

- Standing balance will be analyzed through linear and non-linear methods. Path length will be used to calculate distance traveled by using the NIH standard equation for static balance testing.

$$Normalized\ Path\ Length = \frac{1}{t}\sum_{j=1}^{N-1} |P_{j+1} - P_j|$$

- Sample Entropy, a non-linear method of quantifying static stability, will be used to observe the variability of the subjects' postural sway.

$$SampEn = -\log\left(\frac{A}{b}\right)$$
$$A = d[X_{m+1}(i), X_{m+1}(j)] < r$$
$$\mathrm{B} = d[X_m(i), X_m(j)] < r$$

- Maximum Lyapunov exponent will be calculated during a 3 minute walking trial to quantify balance during dynamic movement.

$$\lambda \approx \frac{log_2\left(\left(\frac{Z(t)}{Z_0}\right)\right)}{\mathrm{k}}$$

SAMPLE RESULTS

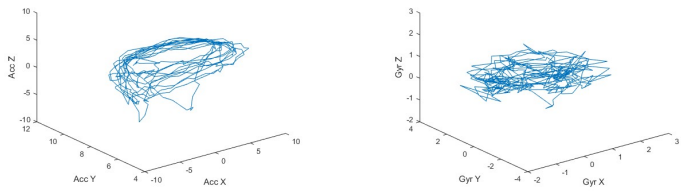

Figure 3 displays raw accelerometer and gyroscope data collected from the mobile application.

DISCUSSION

- 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.
- This experiment will expand current systems to assess dynamic walking balance, which may have increased relevance to risk of falls.
- 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.

REFERENCES

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