Reproducibility of Balance Measures Using Motion Sensors in Smartphone Technology to Measure Balance: Preliminary Result

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Abstract. PURPOSE: This pilot study was to determine the reproducibility of the output generated by Smartphone accelerometers when used for balance assessment. METHODS: 61 healthy individuals (28 male, 33 female; mean age = 23.8+6.2yr) performed a static Single Leg Athlete's Test (SLS) and a Tandem Stand with eyes closed (TSEC) for 10 seconds each. A commercially available Smartphone was used to determine Anterior/Posterior stability. 4 trials were completed for each test with 1 minute rest between trials. RESULTS: For each balance assessment, one-way ANOVA was performed and pairwise comparisons determined. For SLS, no significant differences were noted between trials ($p = 0.05$). For TSEC, trial 1 was significantly different from trials 2, 3, and 4 ($p < 0.05$). Additionally, for TSEC, a significant difference was observed between trials 2 and 4 ($p < 0.05$), however neither trial 2 nor 4 was significantly different than trial 3. For SLS, no significant differences were observed between trials 2, 3, or 4. CONCLUSION: No significant differences were found between trials for SLS, the first trial of TSEC was found to be significantly different than subsequent trials. This may indicate a familiarization trial is necessary if Smartphone technology is to be used for conducting balance assessments.

1. Introduction

In recent years, technology advances in telecommunication, electronics, and computer science have opened new perspectives to biomedical devices. The latest Smartphones have built-in motion sensors called a tri-axis accelerometer.

One of the clinical measures that can take advantage of this technology is balance assessment. This was a pilot study to assess the value and validity of using software developed to access the phone accelerometers output and translate that to the measurement of human balance.

2. Experiment, Results, Discussion, and Significance

Experiment: 61 healthy individuals (28 male, 33 female; mean age = 23.8$\pm$6.2yr) performed a static Single Leg Athlete's Test (SLS) and a Tandem Stand with eyes closed (TSEC) for 10 seconds each. A commercially available Smartphone was used to determine Anterior/Posterior stability. 4 trials were completed for each test with 1 minute rest between Trials.

Results: For each assessment, one-way ANOVA was performed and pairwise comparisons determined. For SLS, no significant differences were noted between trials ($p = 0.05$). For TSEC, trial 1 was significantly different from trials 2, 3, and 4 ($p < 0.05$). Additionally, for TSEC, a significant difference was observed between trials 2 and 4 ($p < 0.05$), however neither trial 2 nor 4 was significantly different than trial 3. For SLS, no significant differences were observed between trials 2, 3, and 4.

Discussion and Significance: Balance is a fundamental ability for humans, and its impairment dramatically reduces a person's ability to perform activities essential to daily living. The unique technology used in this study can be useful in several different contexts, with different kinds of users (e.g. fall risk assessment in older adults, populations with balance impairments such as Parkinson's, concussion evaluations) and in different environments such as schools, clinics, and wellness centers.

The information obtained from this study can be of benefit to medical professionals, physical education coaches, parents and the athletic community. There is an unmet need for a convenient, easy to use, cost-effective tool to measure balance. A device meeting those criteria would be an important development in the task of identifying individuals with postural instability.

3. Conclusions

Results from the validation process are promising, however further experiments are necessary, both on a healthy population and on a population with impairment of the motor control system. No significant differences were found between trials for SLS, the first trial of TSCE was found to be significantly different than subsequent trials. This may indicate a familiarization trial is necessary if Smartphone technology is to be used for conducting balance assessments.

4. Acknowledgements

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Table: 1
Reproducibility of balance measures: Average and Standard Deviation

	Age	Height (cm)	Weight (kg)	SLS 1	SLS 2	SLS 3
Average	24	171	70.5	2.236	1.742	2.193
Standard Deviation	6.2	9.54	14.3	2.523	1.174	2.205

Table: 1
Reproducibility of balance measures: Average and Standard Deviation

	SLS 4	TSEC 1	TSEC 2	TSEC 3	TSEC 4
Average	2.108	4.293	2.486	2.289	2.018
Standard Deviation	1.636	4.482	1.768	1.670	1.121