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# Reliability and Validity of a Portable Inertial Sensor and Pressure Mat System for Measuring Dynamic Balance Parameters during Stepping

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**Abstract :** Introduction: Balance assessments can be used to help evaluate a person's risk of falls, determine causes of balance deficits and inform intervention decisions. It is widely accepted that instrumented quantitative analysis can be more reliable and specific than semi-qualitative ordinal scales or itemised scoring methods. However, the uptake of quantitative methods is hindered by expense, lack of portability, and set-up requirements. During stepping, foot placement is actively coordinated with the body centre of mass (COM) kinematics during pre-initiation. Based on this, the potential to use COM velocity just prior to foot off and foot placement error as an outcome measure of dynamic balance is currently being explored using complex 3D motion capture. Inertial sensors and pressure mats might be more practical technologies for measuring these parameters in clinical settings. Objective: The aim of this study was to test the criterion validity and test-retest reliability of a synchronised inertial sensor and pressure mat-based approach to measure foot placement error and COM velocity while stepping. Methods: Trials were held with 15 healthy participants who each attended for two sessions. The trial task was to step onto one of 4 targets (2 for each foot) multiple times in a random, unpredictable order. The stepping target was cued using an auditory prompt and electroluminescent panel illumination. Data was collected using 3D motion capture and a combined inertial sensor-pressure mat system simultaneously in both sessions. To assess the reliability of each system, ICC estimates and their 95% confident intervals were calculated based on a mean-rating (k = 2), absolute-agreement, 2-way mixed-effects model. To test the criterion validity of the combined inertial sensor-pressure mat system against the motion capture system multi-factorial two-way repeated measures ANOVAs were carried out. Results: It was found that foot placement error was not reliably measured between sessions by either system (ICC 95% CIs; motion capture: 0 to >0.87 and pressure mat: <0.53 to >0.90). This could be due to genuine within-subject variability given the nature of the stepping task and brings into question the suitability of average foot placement error as an outcome measure. Additionally, results suggest the pressure mat is not a valid measure of this parameter since it was statistically significantly different from and much less precise than the motion capture system (p=0.003). The inertial sensor was found to be a moderately reliable (ICC 95% CIs >0.46 to >0.95) but not valid measure for anteroposterior and mediolateral COM velocities (AP velocity: p=0.000, ML velocity target 1 to 4: p=0.734, 0.001, 0.000 & 0.376). However, it is thought that with further development, the COM velocity measure validity could be improved. Possible options which could be investigated include whether there is an effect of inertial sensor placement with respect to pelvic marker placement or implementing more complex methods of data processing to manage inherent accelerometer and gyroscope limitations. Conclusion: The pressure mat is not a suitable alternative for measuring foot placement errors. The inertial sensors have the potential for measuring COM velocity; however, further development work is needed.

**Keywords :** dynamic balance, inertial sensors, portable, pressure mat, reliability, stepping, validity, wearables
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