# Development of a low-cost clinical gait analysis system

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## INTRODUCTION

In the P&O clinic, it can be useful to measure gait kinematics and kinetics to determine the outcome measures and effectiveness of treatment. A low-cost gait analysis system would allow higher reliability of quantitative assessment (Rathinam et al, 2012).

The objective of this study was to validate a Wii Balance Board (WBB) with an instrumented walkway, Kinovea free motion-tracking software, and video camera. We hypothesized this low-cost system would perform within a 5° angle and 5% force of a popular laboratory grade gold standard system.

## METHOD

*Subjects/Apparatus*: One female, age 22, 55.9kg, 158cm tall; WBB, Kinovea software, GearPro camera, multi-camera Vicon motion analysis system, AMTI force plate

*Procedures*: Validation trials used a known angle and weights to compare the two systems. Ground reaction force (GRF), center of pressure (COP) and segment angles were collected on a test subject walking across the walkway multiple times (n=10).

*Data Analysis*: GRF, COP, and segment angle data from the laboratory grade system were analyzed using custom MATLAB software. Data from our low-cost system were analyzed using standard spreadsheet software (Excel). The percent error and absolute error metrics of the two systems were compared

## RESULTS

During static validation trials, the WBB measured weights 2-3.7% heavier than the force plate. For all COP static tests, the maximum absolute position error was 0.48cm. The medial-lateral (ML) and anterior-posterior (AP) directions had average errors of 0.28cm. Kinematic trajectory data between the Kinovea and Vicon systems tracked closely (errors of 0.18cm AP and 0.28cm vertically). The human subject gait data showed similar trends between the force plate and WBB data (Figure 1). The COP data followed a similar trend, with an average $COP_{AP}$ error of 0.95cm. The $COP_{ML}$ position did not vary more than 5cm as is typical in gait. The average absolute errors for segment angles were 3.3°, 0.6°, 1.2° and 2.8° for the pelvis, thigh, shank, and foot, respectively. The pelvis and foot had the highest maximum error

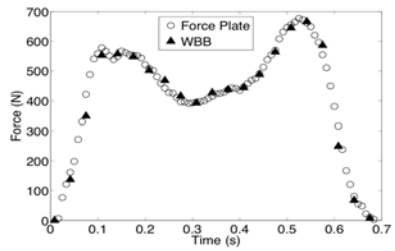


Figure 1. GRF of a representative step on the WBB and force plate

(11.8° and 7.4°, respectively).

## DISCUSSION

The WBB measured peak GRF during gait within 5% of a laboratory grade force plate. The greatest errors in GRF data occurred where GRF values changed rapidly. The COP data were less accurate during dynamic tests but were consistent with previous studies (Bartlett et al, 2014) during static testing. The larger errors in GRF and COP suggest an inconsistent sampling rate of the WBB rather than inaccurate force measurements. The Kinovea/GearPro system measured segment angles within 5° of the Vicon system for the shank and femur only. The higher pelvis and foot segment angle errors were likely due to placement of the ASIS and toe markers; contrast may have been the main issue Future directions are to ensure higher contrast between markers and surroundings, and perform trials on P&O patients.

## CONCLUSION

Our system has potential to provide accurate quantitative gait analysis for under $300. It is possible for this system to be used with smart phone camera video. Low cost enhancements include a longer walkway and multiple WBB and cameras to capture more steps.

## CLINICAL APPLICATIONS

This portable system can ~~be used to~~ aid in outcome measures and determining effectiveness of P&O devices without the need for a costly laboratory grade motion analysis system.

## REFERENCES

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Rathinam C, et al. Gait Posture 2012; 40: 279-285.
Bartlett et al. Gait and Posture 2014; 39(1): 224-228.