Validation of a Pressure Sensing Walkway to Assess Approach and Landing Distance During Obstacle Crossing

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Summary

Approach and landing distances are often used to assess obstacle crossing strategy although 3D motion capture is not feasible for most clinical settings and pressure sensing walkways are more common. We examined the validity of quantifying approach and landing distance during obstacle crossing with a pressure sensing walkway. The walkway demonstrated excellent reliability and accuracy for approach distance, in good agreement to 3D motion capture. While the walkway showed excellent reliability and good accuracy for landing distance, we found poor agreement between systems.

Introduction

Falls are a leading cause of unintentional injury; ~25% of unintentional falls among young adults occur as a result of a trip [1]. Incorrect foot placement before (approach) or after crossing an obstacle (landing) can increase risk of obstacle contact and ensuing falls [2]. Usually, approach and landing distances are computed from 3D motion data but motion capture systems are expensive and inaccessible for clinical settings. Pressure sensing walkways are gaining popularity in clinics for their high portability and ease of use [3], however, it is unclear if these pressure sensing walkways are accurate and reliable for determining approach and landing distance during obstacle crossing. The purpose of this study was to examine the validity of approach and landing distance during obstacle crossing collected with a pressure sensing walkway.

Methods

Forty-eight adults (17 male, 24±6 yrs, 1.72±0.10 m, 75.3±20.5 kg) completed obstructed walking trials while wearing their typical walking shoes and fitted with 5 reflective markers on each foot, including the most anterior (toe) and posterior (heel) aspects of the shoe. Participants completed 10 obstacle crossing trials on a 6m pressure sensing walkway (Zeno Walkway), while 3D motion was simultaneously recorded (Vicon Motion Systems). The dowel obstacle (height: 120mm; depth: 22mm) was identified with reflective markers and on the pressure sensing walkway.

For 3D motion capture, approach and landing distance were calculated using markers on the dowel and the toe and heel, respectively. Likewise, approach and landing distance for the walkway was calculated by multiplying the number of sensors between the obstacle and the toe of the trailing foot and the heel of the leading foot, respectively, by the sensor width (127mm) to calculate total distance. Finally, 9 mm was subtracted from the walkway calculated approach and landing distances to approximate the position of the reflective markers on the shoe. We assessed reliability via intraclass correlations with 95% confidence interval (95% CI) of absolute agreement in a 2-way mixed-effects model. We examined validity with Bland-Altman limits of agreement (95% agreement interval) and assessed accuracy with absolute percent error (<5% considered "excellent" and 5-10% considered "good" [4].

Results and Discussion

The Zeno Walkway had excellent reliability for both approach distance (r= .994; 95% CI: .99 – 1.00 and landing distance (r= .989; 95% CI: .97 - 1.00) [5]. For approach distance, Bland-Altman analysis revealed a mean bias of 3 mm with a 95% CI of -0.81 to 6.5 and limits of agreement of -21.7 to 27.3 (Fig. 1). The Bland-Altman plot showed no significant difference from zero ($t(47)$ 1.56, p= .125) and an even distribution across mean values (R^2= .06, $F(1,47)$2.74, p= .105) indicating good agreement between systems. For landing distance, Bland-Altman analysis revealed a mean bias of 9 mm with a 95% CI of 4.2 to 13.3 and limits of agreement of -22.1 to 39.5 (Fig. 1). The Bland-Alman plot showed a significant difference from zero ($t(47)$ 3.85, p< .001) indicating poor agreement between systems. Absolute percent error was considered excellent to good for approach and landing distances (Table 1).

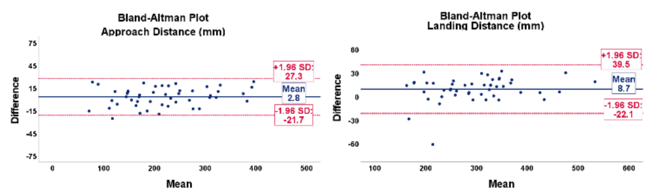

Figure 1: Bland-Altman plots for approach and landing distance comparing the mean and differences between measure methods.

Table 1: Mean approach and landing (mm) and percent error (%).

	Vicon Motion Systems	Zeno Walkway	Absolute % Error
Approach Distance	220 ± 87	217 ± 84	0.7 ± 8.7
Landing Distance	303 ± 86	294 ± 82	2.5 ± 7.2

Conclusions

Although the Zeno Walkway performed well for approach distance, poor agreement between systems for landing distance should be further investigated. We conclude that the Zeno Walkway can be used to accurately and reliably collect approach distance during obstacle crossing, however, shoe shape and sole characteristics may affect landing agreement.

References

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