TURNING BIOMECHANICS OF LOWER-LIMB PROSTHESIS USERS WITH A HISTORY OF FALLS

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INTRODUCTION

Turning and curved-path walking are challenging for prosthesis users. The Figure-of-8 Walk Test (F8WT) combines straight and curved-path walking, can be conducted in small spaces, and requires participants to turn towards the prosthesis and sound limbs (Hess, 2010). Turn biomechanics can be measured with small, wearable sensors and the data obtained may help to differentiate between fallers and non-fallers. The purposes of this study were to (1) establish test-retest reliability of the instrumented F8WT and (2) investigate turn biomechanics of unilateral lower-limb prosthesis users with and without a history of falls.

METHOD

Subjects: Sixty-eight unilateral transtibial (TT) and transfemoral (TF) prosthesis users were enrolled in this IRB approved study. The TF group included one knee and one hip disarticulation. Nine participants repeated the experimental protocol to obtain test-retest reliability.

Apparatus: Fall history over the past year was self-reported by participants. Four wireless triaxial inertial measurement units (Opal, APDM, Inc., Portland, OR) were secured to the sternum, lumbar spine, and feet using elastic straps. Each sensor recorded at 128 Hz.

Procedures: Participants walked as quickly and smoothly as possible around a pair of cones (spaced 1.525 m apart) in a figure-of-8. Two laps were performed without pausing.

Data Analysis: Angular velocity in the transverse plane at the lumbar spine (L5) was measured with the gyroscope. Outcome measures were peak angular velocity when turning towards the prosthesis (p-turn), peak angular velocity when turning towards the sound limb (s-turn), and turn asymmetry index (turn-ASI) (Herzog, 1989).

Test-retest reliability of the outcome measures were examined using intraclass correlation coefficients (ICC(2,1)). Mann Whitney U tests were used to compare TT fallers and non-fallers and TF fallers and non-fallers. Alpha was set to .05 *a priori*.

RESULTS

Outcome measures were reliable: p-turn (ICC = .910), s-turn (ICC = .830), and turn-ASI (ICC = .780). No significant differences were identified between TT fallers and non-fallers. TF non-fallers resulted in significantly greater turn-ASI (30.4% ± 21.9%) (p = .008) as compared to fallers (12.9% ± 20.6%) (Figure 1).

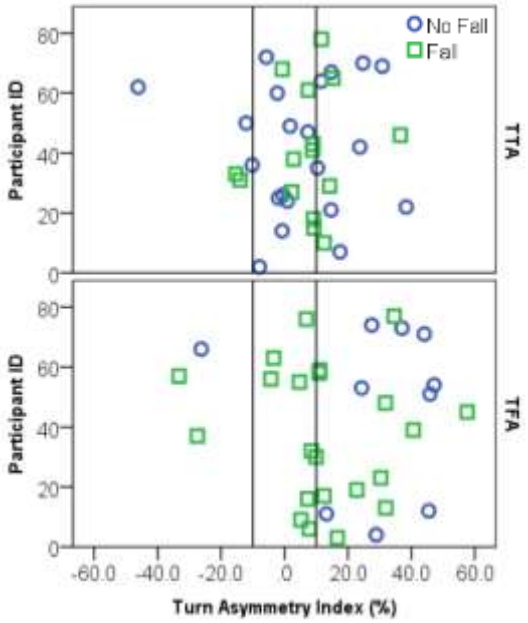

Figure 1. Scatterplot of turn-ASI for TT (n = 35, fallers = 14) and TF (n = 33, fallers = 22) prosthesis users. Vertical lines are ± 10% which is considered symmetric.

DISCUSSION

TF non-fallers had greater asymmetry when turning towards the sound limb. Turns and curved-path walking towards the sound limb require decreased stride length of the sound limb and increased stride length of the prosthetic limb, while simultaneously shifting the body's center of mass to the sound limb (Hess, 2010). This asymmetry may be a successful protective mechanism in TF prosthesis users to prevent falling.

CONCLUSION

The instrumented F8WT is a reliable test for unilateral lower-limb prosthesis users. TF non-fallers have significantly greater turn asymmetry when turning towards their sound limb as compared to TF fallers.

CLINICAL APPLICATIONS

The instrumented F8WT allows quantification of turn and curved-path walking performance and may provide greater resolution to identify fall risk when combined with traditional clinical outcome measures.

REFERENCES

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