PILOT STUDY ON THE EFFECTS OF UPPER LIMB LOSS AND PROSTHESIS USE ON LOCOMOTOR STABILITY

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INTRODUCTION

During steady-state walking, natural arm dynamics facilitate locomotor stability by minimizing body angular momentum through counterbalancing leg motion [1] and reducing trunk motion to constrain body center-of-mass (BCoM) excursion [2]. Consequently, persons with upper limb loss may experience reduced locomotor stability that may be dependent on prosthesis use. This pilot study investigated the effects of prosthesis use and matching inertial properties of the prosthetic limb to the sound limb on stability during walking.

METHOD

Subjects: Two subjects with unilateral transradial (TR; 61yrs, 186cm, 90kg) and transhumeral (TH; 62yrs, 179cm, 111kg) limb loss participated in the study.

Apparatus: Kinematics were measured using an optical motion capture system (Motion Analysis Corp. (MAC), CA) and a modified Helen Hayes marker set [3] with additional trunk and arm markers. BCoM was estimated from an individual body segment model. A custom 'mock prosthesis' was designed to match the mass and inertial properties of the prosthetic limb to the sound limb (Figure 1). The mock prosthesis length, mass, and location of the center-of-mass were estimated using an algorithm based on established able-bodied anthropometric regression equations [4].

Procedures: Subjects walked over-ground on a level walkway at three self-selected speeds (slow, normal, and fast) under three prosthesis conditions: 1) without wearing a prosthesis, 2) wearing their customary prosthesis, and 3) wearing the mock prosthesis. At least five walking trials were collected and analyzed for each speed by prosthesis condition iteration.

Data Analysis: 3-D trunk rotations (relative to the global axes) were estimated using Orthotrak software (MAC). Margin of stability (MoS) was estimated as the minimum distance between the lateral foot border and extrapolated BCoM (a velocity-weighted BCoM) positions [4]. Step width and variability of step width, length, and time were also calculated.

RESULTS

Trunk rotations at a single walking speed are displayed in Figure 2 (speed-matched to data of 13 healthy subjects (51±6yrs, 172±9m, 74±15 kg)). MoS was greater on the prosthetic and sound side for the TR and TH subjects, respectively, but displayed little difference between prosthesis conditions. Minimal changes were seen in step width across conditions, but variability in step width, length, and time generally increased with use of a prosthesis (both customary and mock with less clear individual trends).

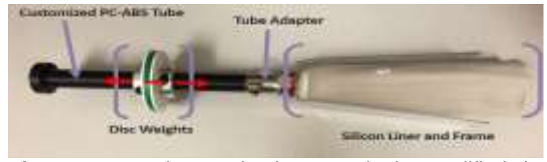

Figure 1. Mock prosthesis. Length is modified by replacing the plastic tube. Mass is modified through adding disc weights, secured in location by cuffs.

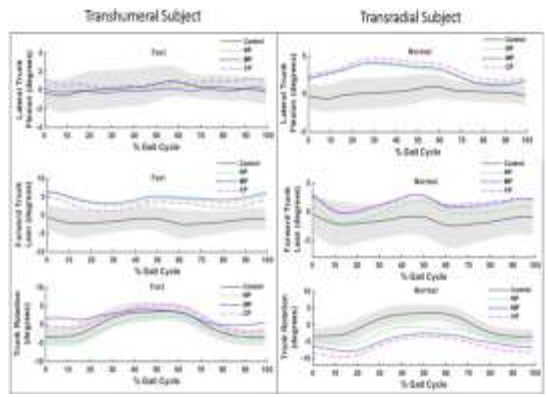

Figure 2. Frontal (top), sagittal (middle), and transverse trunk rotations (bottom) for both subjects. NP=no prosth, MP=mock prosth, CP=customary prosth.

DISCUSSION

These subjects with unilateral TR and TH limb loss displayed asymmetric trunk rotations with temporal profiles similar to controls. Trunk motion was minimally effected by prosthesis use and trends were not clear. Subjects displayed asymmetric MoS which aligned with the direction of asymmetry in lateral trunk lean, but was also not affected by the prosthesis. The side with greater MoS would suggest decreased opportunity for the BCoM to exceed the base of support. Surprisingly, use of a prosthesis increased gait variability, suggesting reduced locomotor stability.

CONCLUSION

Individuals with unilateral upper limb loss walk with asymmetric trunk motion that is not impacted by prosthesis use. However, prosthesis use may result in reduced stability and this should be further explored.

CLINICAL APPLICATIONS

Use of a unilateral upper limb prosthesis may not influence trunk movement but could affect risk of falls.

REFERENCES

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