Amputee gait identification from biological motion: Effect of Experience Level and Kinematics Cues

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I. Introduction

Observe gait is clinically important to allow physical therapists (PT) and clinicians to assess motor deficits in patients. However, the inconsistent results in the skill of visual assessment lead to a question about whether clinicians are accurate and reliable on gait judgment[1, 2]. Also, little is known about which gait features would base accurate judgments. The purpose of this study is to investigate (1) the differences in observational gait analysis skill between those with different level of clinical experience and (2) the kinematics features informative for perceiving amputee gait.

We introduced a new method that combines biological motion and principal component analysis (PCA) to gradually mesh amputee and typical walking patterns for raters to rank. The synthesized patterns preserved the kinematics features that allow physical therapists (PT), PT students (PTS), and novice raters to discriminate different levels of gait impairment. This method can be used to train and evaluate observational gait analysis of PTs, physicians, and prosthetists. In addition, the identified gait features that PTs attended to might inform the future design of automated, clinically relevant gait evaluation and automatic prosthesis tuning algorithm in the future.

II. Methods

We recruited three males with unilateral transfemoral amputation. All of them were active and able to walk independently without assistance (K3-K4 level). We also recruited 10 certificated PT, PTs and Novice in each rater group.

Joint motion of three amputee walkers (Walker A, B and C) and health control walkers were utilized to build three biological motion models through PCA. Each model was based on one amputee walker. We then build 6 videos from each model displaying a synthesized point-light walker varying in weighing from 0, 20, 40, 60, 80 to 100% between healthy walking and the given amputee walking features. These videos were used to test the accuracy in differentiating a range of scaled gait abnormalities for all raters. For each trial, participants were presented with one set of videos randomly ordered for 23s (Figure 1). The goal was to rank the videos from 1 to 6 based on the weighing. Participants performed a total of 30 trials (3 set*10 repetitions).

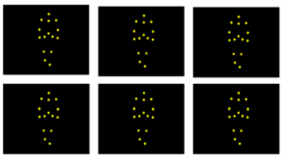

Figure 1. An example of a testing video set for one trial.

Some measurements were performed on the first four principle components. These measurements were used to quantify the amputee gait features that were deviated from normal walking. In addition, the accuracy rate in judging biological videos were used to test the observational gait skill on each rater group.

III. Results and Discussion

We quantified the major dissimilar features between amputee and control walkers that allow individuals to perceive and differentiate walker patterns. The quantified features represent the magnitude of medial-lateral body sway, degree of gait asymmetry, and percentage of gait deviation. We found that the largest spatial deviation is on the medial-lateral body sway for all amputee walkers. A higher degree of spatial asymmetry in gait was presented especially on Walker A and Walker C (Figure1). Also, the percentage of gait similarity to health walker (Walker A: 38.3 %; Walker B: 75.47% and Walker C: 89.88%) was associated with accuracy rate (negative relationship).

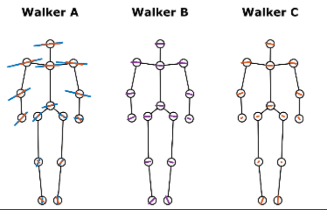

Figure 2. The stick figures of walkers are facing to the viewers. The blue, purple, and red lines indicate the reconstructed joint trajectories of the dissimilar PCs in respected to amputee walker's PC1, PC2, and PC3, respectively.

For the comparison between rater groups, we found that PT and PTS were not significantly different from each other and the both were more accurate in judging biological motion videos than the Novice group. In addition, the minor differences between PT and PTS was found on PT showing equal ability of accuracy for the whole spectrum from normal to abnormal walking patterns in judging Walker C' videos. Considering, Walker C's gait is 89.88% similar to normal walkers but with a relatively larger gait asymmetry, we postulated that PT likely have learned to promptly attend to and sensitive to gait asymmetry.

References

[1] F. Ferrarello *et al.*, "Tools for Observational Gait Analysis in Patients With Stroke: A Systematic Review," *Physical Therapy*, vol. 93, no. 12, pp. 1673-1685, 2013.

[2] M. E. Eastlack, J. Arvidson, L. Snyder-Mackler, J. V. Danoff, and C. L. McGarvey, "Interrater reliability of videotaped observational gait-analysis assessments," *Physical therapy*, vol. 71, no. 6, pp. 465-472, 1991.