Effectiveness of Augmented Reality Biofeedback in Balance and Gait Applications: A Pilot Study

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INTRODUCTION

Rehabilitation following surgery or musculoskeletal injury is crucial for recovery from surgery and successful ambulation (Salzman, 2010). An emerging technology for balance and gait rehabilitation is real-time biofeedback (RTBF). RTBF allows instantaneous feedback on the performance during tasks. Visual feedback allows patients to alter their walking patterns to obtain a more symmetric gait (Dingwell, 1996). A recent technological advance is the development of smart glasses. Smart glasses are similar to normal glasses that overlay a small translucent screen in the field of view. Smart glasses allow users to constantly view data and their environmental surroundings, as opposed to virtual reality where the real environment is removed. The goal of this project was to evaluate an augmented reality biofeedback system using smart glasses and inertial-based sensors. This system may enable patients to receive real-time biofeedback at home that is similar to the feedback received in a clinic.

METHOD

Subjects: Ten healthy participants (7 male, 3 female age: 22.1 ± 0.5 years, height: 175.1 ± 8.8 cm, mass: 77.5 ± 11.2 kg) with no balance or gait disorders participated in this IRB approved study.

Apparatus: Epson BT-200 smart glasses were worn by the participants and the control unit was placed in a waist belt. The waist belt was secured to the lumbar spine (L5) with an elastic strap. A compliant foam pad, locking knee brace, and shoe platform (2 cm) were used to alter balance and gait.

Procedures: Balance and gait tests were completed under three visual conditions (1) no smart glasses (NSG), (2) smart glasses with display off (DO), and (3) smart glasses with visual RTBF (BF). Balance tests consisted of 30 second trials of single leg, double leg, and tandem stances conducted on the ground and foam pad. Gait tests consisted of 2 minute walk tests around a 20 meter rectangular track. Three walking conditions were tested: normal gait, walking with locked knee brace on the dominant leg, and shoe platform on the dominant leg. Trunk flexion and lateral flexion were measured using the accelerometer embedded within the smart glasses control unit (14 Hz). RTBF was displayed on the smart glasses using an android application. As the participant's lumbar moved from vertical, an on-screen graphic moved to show magnitude, and direction of the angle (Figure 1).

Figure 1: Augmented Reality RTBF Interface

Data Analysis: Root mean square (RMS) values were calculated from trunk angles in each direction and averaged to determine trunk angle magnitude from vertical. Wilcox and Freidman tests used to determine differences between NSG/DO groups and DO/BF groups (α = .05).

RESULTS

Wearing smart glasses did not alter balance or gait performance (Figure 2). RTBF had no effect on balance conditions. RTBF significantly reduced trunk angles in sagittal and frontal planes (Figure 2).

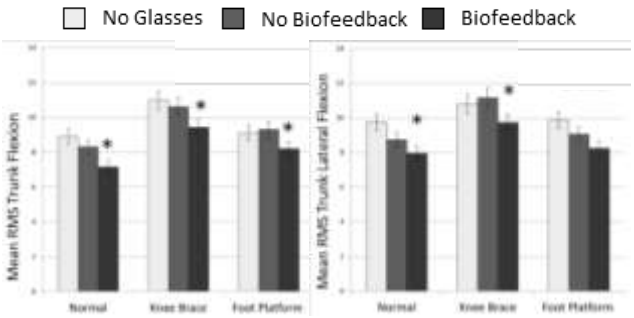

Figure 2: Mean RMS trunk flexion and lateral flexion for different conditions. * Significant difference due to biofeedback.

DISCUSSION

No significant difference between NSG and ND suggests that wearing smart glasses with no display does not affect balance or gait performance. Several variables may have prevented biofeedback from being effective in balance trials. Participants may have been distracted by visual feedback, causing balance errors. Future research will include a larger sample size of lower-limb prosthesis users.

CONCLUSION

Wearing smart glasses with the display off did not alter balance and gait. Augmented reality biofeedback may be an effective tool to reduce trunk movement during gait.

CLINICAL APPLICATIONS

Augmented reality biofeedback may be a technology to provide telerehabilitation services to patients that do not have access to traditional rehabilitation clinics.

REFERENCES

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