

# Virtualization of exercise: An innovative ankle exercise paradigm based on virtual reality for improving balance in diabetes

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## Background:

People with diabetes-related peripheral neuropathy (DPN) frequently suffer from concomitant postural instability that can lead to falls, fractures, depression, anxiety, and decreased quality of life. Exercise has been demonstrated to be effective in improving balance. However, high demands of conventional balance programs might overtax DPN patients' ability to perform exercises correctly. This might in turn reduce motivation or increase risk of diabetic foot ulcers. In addition, conventional training regimes do not incorporate visual feedback, which is of key importance for compensating the impaired proprioceptive feedback due to DPN. In this study, we examined the effectiveness of an innovative ankle exercise program based on virtual reality for improving postural control among DPN patients.

## Methods:

A novel ankle reaching exercise program was developed based on virtual reality and body worn sensors. Twenty-nine eligible DPN subjects (Age:  $57 \pm 10$  years; BMI:  $55.9 \pm 11.1$  kg/m<sup>2</sup>) were asked to perform a set of point-to-point ankle reaching tasks while receiving real-time video game style feedback from ankle joint motion. The ankle motion in medial-lateral and anterior-posterior was measured using a set of wearable sensors attached to the subject's shank. To evaluate the benefit of this paradigm for improving postural control, a validated technology based on body worn sensors was used to examine balance at baseline and after training. Postural control was quantified by measuring the area of center of mass sway (COM) and reciprocal compensatory index (RCI).

## Results:

Our findings revealed a significant reduction in COM post-training in average by 16% ( $p = 0.03$ ). A negative correlation ( $r = -0.46$ ;  $p < 0.05$ ) was observed between baseline COM and the magnitude of COM reduction post-training suggesting a larger exercise benefit for those who have higher postural control deficit. A similar association was observed between neuropathy severity and magnitude of exercise benefit. In addition, a significant improvement was observed in RCI in average by 11.3% ( $p < 0.005$ ).

## Conclusions:

The current research has implemented a novel balance training paradigm that provides real-time visual feedback from ankle joint motion in order to incorporate joint proprioception in balance training. Our findings support that motor learning based on real-time feedback from ankle joint motion is effective in improving postural stability among DPN patients.