SUBTHRESHOLD VIBRATION INFLUENCES THE POSTURE AND GAIT OF TRANSTIBIAL AMPUTEES

Ian Sloan [1], Jenny A. Kent[1], Aaron Likens[1], Kota Z. Takahashi[1], Nicholas Stergiou[1, 2]
[1]Department of Biomechanics, University of Nebraska at Omaha, Omaha, NE USA
[2]College of Public Health, University of Nebraska Medical Center, Omaha, NE USA
Email: csloan@unomaha.edu

SUMMARY

Unilateral transtibial amputees lose the afferent pathways of the limb when amputation occurs. The addition of vibration has shown to increase sensation on the applied limb. This study looks into how the addition of subthreshold vibration affects amputee gait and posture. Vibration applied to the residual limb was shown to have worked in posture, but not in gait.

INTRODUCTION

Amputation below the knee causes a person to lose important pathways to the central nervous system used in sensation and balance [1]. A lack of sensation in the residual limb [2] has been shown to be a factor in poor balance [3]. The 'stochastic resonance' phenomenon, where the addition of subthreshold noise enhances detection of a weak stimulus, has been shown to improve sensation and subsequently balance [4]. White noise has been typically used in previous stochastic resonance studies; a random signal with equal intensity throughout its frequency spectrum. We also investigated a pink noise (1/f) vibration structure based on the fact that it is more often seen in natural processes [5]. We hypothesized that stimulation would improve control of the prosthesis, which would decrease step variability during walking and increase postural control. Further, we expected the change to be greater with the pink noise stimulation when compared with the white noise.

METHODS

Fourteen participants with a unilateral transtibial amputation (height 1.79m±0.07, weight 100.3kg±15.6, age 59.7±15.0) completed a balance test, overground walking, and treadmill walking trials, under three different vibration conditions: None, pink noise, and white noise. Vibration was provided by a vibrating device set on the thigh of the residual limb. The three conditions were randomized and kept from the subject. The vibration thresholds were set at the beginning of the session and then set to 60-90% of this threshold to ensure that the participant could not feel the vibration. Kinematic data for all walking trials was collected at 100Hz, and balance testing was collected at 60 Hz, with a twelve-camera motion capture system (Motion Analysis Corporation, Santa Rosa, CA). Averages and standard deviations for all kinematic variables were computed using Visual 3D (C-Motion, Germantown, MD) for all three conditions. A series of linear mixed effects models was conducted in order to understand the effects of vibration condition on various kinematic variables obtained from walking (treadmill and over ground) and quiet standing. Baseline models were 'intercept-only' models. Final models contained fixed main effects and interactions of noise type and diabetic threshold (above and below) and random intercepts. Overground and treadmill walking trials were analyzed separately, as distinguishing between those conditions was not of central interest.

RESULTS AND DISCUSSION

Walking. Analysis of the sound leg step length variability during over ground walking trials revealed that the white noise condition produced lower step length variability than the none condition (Fig. 1; *Estimate*=-.003, *SE*=.001, *p*=.034). Also, above threshold participants produced greater sound leg step length variability than those participants classified as below threshold (Fig. 1; *Estimate* = -.004, *SE* = .002, *p* = .008).

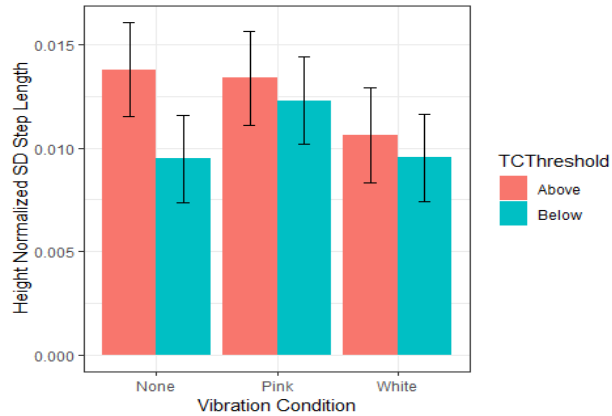

Figure 1. Bar chart of sound leg step length variability during over ground walking as a function of vibration condition and diabetic threshold. Error bars reflect 95% confidence intervals. Step length variability was height normalized.

Quiet standing. The analysis revealed that the pink noise condition reduced mediolateral COP range when compared with the none condition (Fig. 2; *Estimate* = -.004, *SE* = .002, *p* = .013. Similarly, mediolateral RMS COP displacement was also lower in the pink noise condition than the none condition (*Estimate* = -.001, *SE* = .0002, *p* = .008.

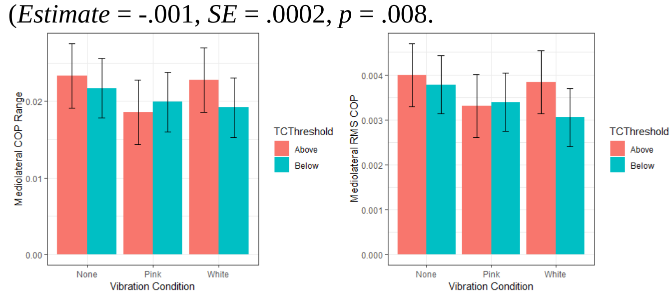

Figure 2. Bar charts of mediolateral COP range (left) and RMS displacement (right) during quiet standing as a function of noise and diabetic threshold. Error bars reflect 95% confidence intervals. Range and RMS were height normalized.

CONCLUSIONS

In conclusion, the addition of subthreshold vibration has shown to have an effect in amputee gait and posture. During quiet standing, results show that pink noise subthreshold vibration has the ability to decrease sway in the mediolateral direction for all amputees. The weaker results during walking indicate that an alternative option should be explored for use during gait.

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ACKNOWLEDGEMENTS

This work was supported by NIH P20GM109090 and NIH R15HD0868.