The Effects of Visual and Auditory Deprivation on Lower Extremity Neuromuscular Facilitation

Elizabeth Luginbill, Kira Potach, Grant Kaper and Seth Paradis, PhD.

Department of Human Kinetics and Applied Health Science
The Biokinetics Program

Abstract

Purpose: Sensory input is vital to performance, yet some feedback systems may be a greater determinant of neuromuscular activation. Previous studies focused on proprioception using closed kinetics chain movements while under sensory deprivation. The aim of this study was to analyze the neuromuscular function of the lower extremity during auditory and visual deprivation of an open kinetic chain activity. Neuromuscular function was measured through mean power, speed, and eccentric force given by two jump tests utilizing a 3D accelerometer device (Myotest, Switzerland).
Methods: Twenty-five college students (8 male and 17 female, age=20.736±0.97 years) who are physically active participated in this study. Subjects completed a familiarization period consisting of the countermovement jump (CMJ) and squat jump (SJ) before data was collected. Following familiarization, lower extremity neuromuscular function data was collected on subjects during normal and sensory deprivation jump protocols. Blindfold eyewear and white noise were utilized to eliminate visual and auditory stimuli and feedback during the sensory deprivation jumps.
Results: Paired sample t-tests were conducted with $p \leq .05$. The results showed no significant difference in squat jump power (p=.179) or countermovement jump eccentric force (p=.669). However, there was a significant decrease in countermovement power (p=.005), countermovement speed (p=.002), and squat jump speed (p=.030) for sensory deprivation jumps.
Conclusion: The present study does not demonstrate that there are immediate proprioceptive adaptations in open chain activities (jumping) during sensory deprivation. For therapeutic applications, open loop exercises would not be beneficial in producing the needed neuromuscular adaptations initially in the rehabilitation of neurological dysfunction. Closed kinetic chain movements would be better suited for developing the optimal therapeutic response in the early stages of rehabilitation.

Methods

A total of twenty-five college students (8 male, 17 female mean age=20.736±0.97 years) who abide by the American College of Sports Medicine standards for physically activity (at least 150 min/week of moderate-intense activity) participated in this study. Subjects completed protocol training using Myotest resources consisting of video tutorials and instruction for the countermovement jump (CMJ) and squat jump (SJ).[4] Following training, a familiarization period consisting of the CMJ and SJ trials were completed before data was collected. Lower extremity neuromuscular function data was then collected on subjects during normal conditions and then sensory deprivation jump protocols. Sensory deprivation was achieved using blindfold eyewear and white noise. Utilizing a digital media device, white noise was played through headphones to eliminate auditory stimuli during the sensory deprivation jumps. A one minute acclimatization period was given to the subjects while they were wearing the blindfold and white noise prior to collecting data. After the one minute marker, jump protocols were initiated using sensory deprivation. Intermediately, a three-minute recovery period was given to subjects between the end and beginning of each jump sequence completed.
The dependent variables of neuromuscular function were measured through average power (Watts), speed (cm/sec), and eccentric force (N) given by the CMJ and SJ tests during normal and sensory deprivation conditions.

Introduction

Sensory information is processed in specific areas of the cerebral cortex, a system consisting of receptors and neural pathways throughout the body. Sensory impulses provide the information necessary for the bodily systems to maintain homeostasis within a stable or unstable environment. If vision or hearing is lost, other senses and neural pathways are recruited in order to compensate for the missing stimuli, thus maintaining proprioceptive function and quality movement.

Exercise therapy is dependent on neural adaptations and the input of sensory information. When we perform a movement, proprioceptive impulses from receptors within the joint, muscle, and skin create feedback for the higher processing centers, allowing for a motor response or modification to the movement. There has always been a considerable amount of debate in regards to closed kinetic chain (CKC) and open kinetic chain (OKC) exercises in regards to proprioceptive rehabilitation. Though both types of movements are used in the rehabilitative setting, current research tends to support that CKC produces greater neuromuscular adaptations and improved functional strength.[5,6]

Proprioception is a vital component in the rehabilitative process. When visual and auditory stimuli are inhibited, the kinesthetic pathways are recruited in order to compensate for the lack of sensory stimuli, thus attempting to maintain proprioceptive control.[2] Joint and skin receptors provide sensory information to the CNS, communicating muscle length, tension, and position. These peripheral receptors send impulses to the central nervous system where movements can be processed and then performed.

Sensory information is important to proprioceptive function, and the body may adapt and compensate for, if any of senses are lost.[3] This principle has led these researchers to question if sensory deprivation occurs and proprioception is heightened, will neuromuscular communication increase for open kinetic chain movements, heightening motor recruitment and increase function?

Figure 1

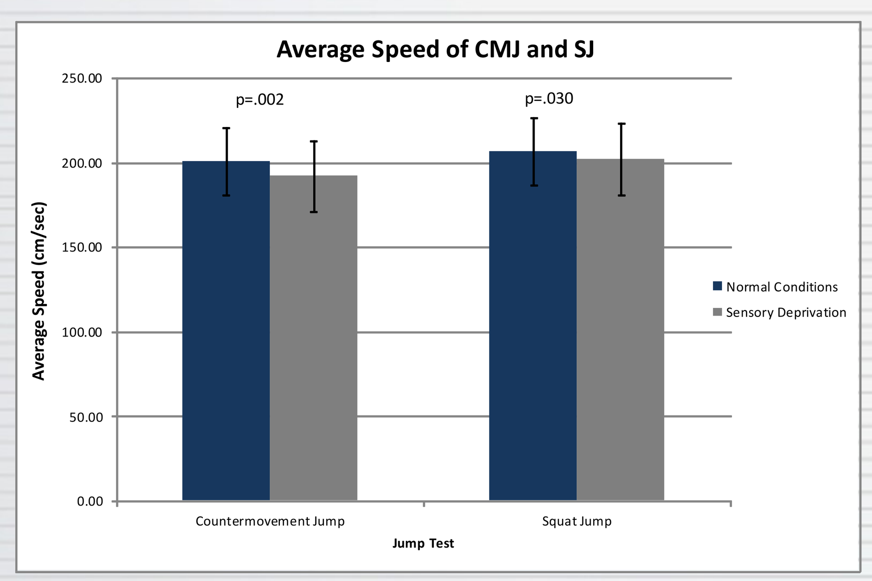


Figure 2

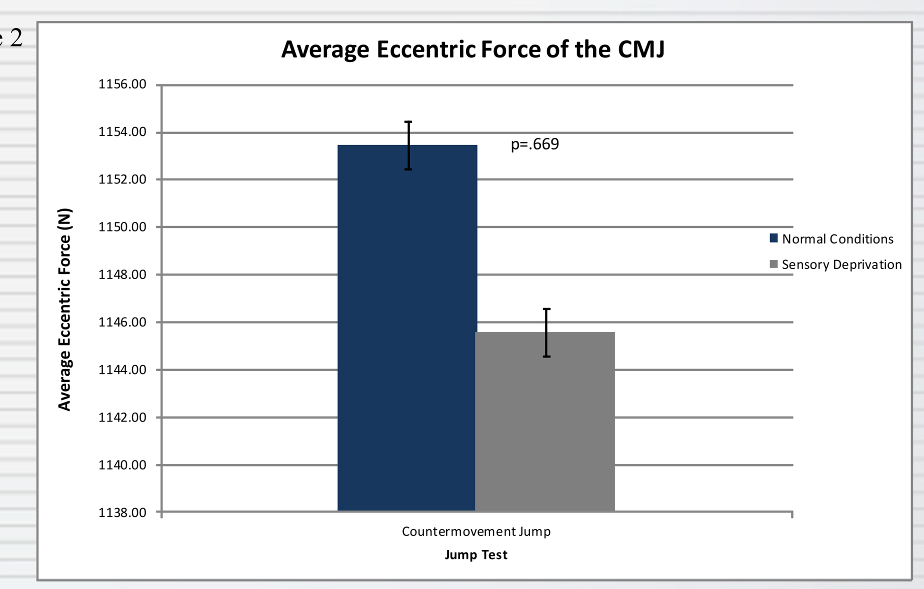
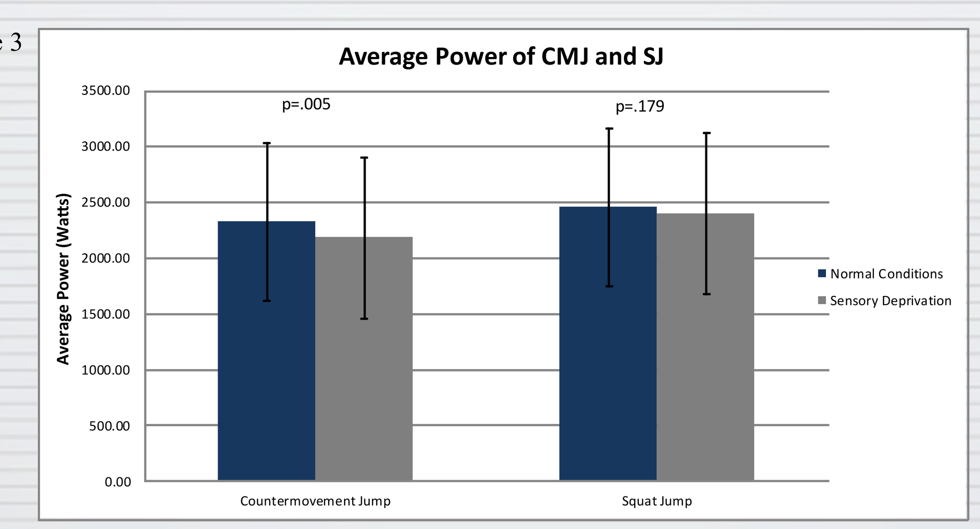


Figure 3



Results

Paired sample t-tests were conducted at $p \leq 0.05$. The results showed no significant difference in squat jump power (p=.179, Figure 3) or countermovement jump eccentric force (p=.669, Figure 2). However, there was a significant decrease in countermovement power (p=.005, Figure 3), countermovement speed (p=.002, Figure 1), and squat jump speed (p=.030, Figure 1) for sensory deprivation jumps.

Conclusion

The present study does not demonstrate that there are immediate proprioceptive adaptations in open chain activities (jumping) during sensory deprivation. For therapeutic applications, open loop exercises would not be beneficial in producing the needed neuromuscular adaptations initially in the rehabilitation of a neurological dysfunction. Closed kinetic chain movements would be better suited for developing the optimal therapeutic response in the early stages of rehabilitation. Patients suffering proprioceptive deficits (post-stroke, Parkinson's) will initially benefit more from predictable movements that focus on joint stability and increased compressive/resistive forces. Thus neuromuscular improvements can be better achieved early in rehabilitation through closed kinetic chain activities before progression to more functional movement.

References

[1]Hoffman, H. S. (1980). Reflex Modification in the Domain of Startle: I. Some Empirical Findings and Their Implications for How the Nervous System Processes Sensory Input. *Psychological Review*: 87(2): 175-189.
[2]Konczak, J. (2009). Proprioception and Motor Control in Parkinson's Disease. *Journal of Motor Behavior* 41(6): 543-551.
[3]Merabet, Lotfi B., and Alvaro Pascual-Leone. "Neural reorganization following sensory loss: the opportunity of change." *Nature Reviews Neuroscience* 11.1 (2009): 44-52.
[4]Myotest (2013): http://www.myotest.com/2011_english/2011_pages_pro/index.html
[5]Nagai, Takashi, et al. "Restoration of sagittal and transverse plane proprioception following anatomic double-bundle ACL reconstruction." *Knee Surgery, Sports Traumatology, Arthroscopy* (2012): 1-9.
[6]Stensdotter, A. K. (2003). Quadriceps Activation in Closed and in Open Kinetic Chain Exercise. *Medicine & Science in Sports & Exercise*, 35(12): 2043-2047.

Elizabeth Luginbill: e-luginbill@bethel.edu Kira Potach: kpn44529@bethel.edu Grant Kaper: gmk77665@bethel.edu ▪ Seth Paradis: s-paradis@bethel.edu