UNLOADING REACTIONS DURING SUDDEN ANKLE INVERSION IN INDIVIDUALS WITH FUNCTIONAL ANKLE INSTABILITY

Tarang Jain, Wen Liu, and Clayton Wauneka

Department of Physical Therapy and Athletic Training, Northern Arizona University, Flagstaff, AZ, USA
Department of Physical Therapy and Rehabilitation Science, University of Kansas Medical Center, Kansas City, KS, USA
Bioengineering Program, University of Kansas, Lawrence, KS, USA
Email: Tarang.Jain@nau.edu, web: http://www.ptrs.kumc.edu/research/neuromuscular-research-lab/index.html

INTRODUCTION

Functional ankle instability (FAI) is defined as a condition whereby an individual reports feelings of ankle joint instability and/or frequent episodes of ankle “giving way” [1]. The neurophysiological mechanisms causing FAI are unknown, but FAI is considered to be a heterogeneous clinical issue that involves multiple factors such as impaired proprioception, neuromuscular control, postural control, and strength deficits [1]. Recently, Santos et al. [2] demonstrated that during a potential injury event, individuals may utilize flexion reflexes, also known as “unloading reactions”, to reduce the vertical load on the supinated foot and thus reduce the risk of ankle sprain injuries. These unloading reactions were characterized by simultaneous movement of the body downwards and a shift of body weight towards the non-stimulated foot. Santos et al. [3] further compared a group of individuals with FAI to a healthy control group and found a hyper-reactivity to unloading reaction in FAI ankles under a normal static ankle stretch. The findings suggested that a static stretched ankle position led to significantly greater unloading reaction in healthy ankles, and ankles with FAI showed greater unloading reaction compared to the healthy ankles. However, the amount of unloading reaction observed was far less than a drastic reaction that usually occurs during ankle giving way. Therefore, the purpose of the present study was to test the sensitivity of unloading reactions in individuals with FAI under a combined sensation of dynamic stretch and nociceptive stimuli. We hypothesized that individuals with FAI would show increased magnitude of unloading reactions on the involved ankle under a combined sensation of dynamic stretch and nociceptive stimuli when compared to uninvolved ankle.

METHODS

We conducted our experiments on twenty-four subjects with FAI (8 males, 16 females; age: 43.3 ± 7.5 years, height: 171 ± 9.24 cm; weight: 75.5 ± 13.4 kg). Participants were at least four weeks but not beyond one year after an unilateral ankle sprain (>grade II), with ongoing ankle giving way incidence during functional activities, and active in exercise. The individuals were excluded if they had severe ankle pain and swelling, ankle surgery, gross limitation in ankle inversion (<15º), lower extremity injuries other than ankle sprain in past 12 weeks, current enrollment in formal rehabilitation program, any severe joint disease, or any previous experience of intolerance to electrical stimulation.

Two force plates were used to record ground reaction forces of both limbs. Two surface electrodes (3x3 cm) were placed at the lateral aspect of the tested ankle, below and anterior to the lateral malleolus, to deliver nociceptive stimulation. A newly developed trapdoor had a tilt platform held at a level position by a remote-controlled deadbolt which, when released, allowed the platform to rotate 30º before hitting a mechanical stop (Figure 1). The subjects distributed equal weight on both feet while keeping one foot on a level wooden box and the tested foot on the tilt platform centered over the pivot joint.

Figure 1: Illustration of the experimental setup.
During unloading reaction test, the trapdoor was released without a warning. The subject went through the first five trials of the trapdoor drop test without nociceptive stimulation (“no stim”), followed by five trials of the combined trapdoor drop and nociceptive stimulation (“with stim”). The nociceptive stimuli were delivered to the tested ankle at a level of 20% above the tolerable pain threshold when the trapdoor rotated for about 20-25 degrees. The vertical force variation (VFV) defined as the magnitude of decrease in the combined vertical ground reaction forces was measured for both the involved and uninvolved limb. Paired t-test was used in statistical analysis.

RESULTS

The magnitude of the unloading reactions increased progressively in the following order: (1) Uninvolved ‘no stim’ (54.48 N), (2) Involved ‘no stim’ (57.57 N) (3) Uninvolved ‘with stim’ (61.93 N), and (4) Involved ‘with stim’ (120.63 N) (Figure 2). The time to peak VFV on the stimulated foot demonstrated similar values under the four testing conditions. With the number of subjects available (n = 24), the VFV magnitude and time to peak VFV were not significantly different between the four conditions (p > 0.05).

Figure 2: The mean ± S.E. of the vertical force variations (VFV) during the four conditions.

Based on the video recordings during the testing, seven subjects (age, 38.3 ± 6.6 years; 2 males; weight, 82.0 ± 15.1 kg; height, 171.3 ± 7.5 cm) were identified to have drastic response (hyper-reactivity) to the unloading reaction test. During the trapdoor drop test, these seven subjects were unable to maintain an upright standing position and unloaded their body weight onto the safety harness. The mean magnitude of the unloading reactions in these seven subjects was greatest during the involved ‘with stim’ condition (325.05 N) when compared to involved ‘no stim’ (111.47 N), uninvolved ‘with stim’ (117.19 N), and uninvolved ‘no stim’ (94.59 N) conditions. The time to peak VFV was similar during the four testing conditions.

DISCUSSION

The magnitude of unloading reactions in the four testing conditions were found to be significantly stronger than the unloading reactions reported by Santos et al. [3]. Although the VFV magnitude did not differ significantly between the four testing conditions, some subjects demonstrated drastic reaction (hyper-reactivity) to the unloading reaction when a combination of dynamic ankle stretching and nociceptive stimuli was applied on their affected ankles (involved ‘with stim’ condition). The video recording during the testing revealed that these subjects were unable to maintain control of upright standing position and unloaded their body weight to the safety harness. Previous studies have indicated that in healthy individuals, hierarchy of postural control is prioritized [4]. During a potential injury event, the flexor reflex is suggested to be modulated in such a way that the primary importance is given to preservation of balance while ensuring an appropriate withdrawal. It appears that in individuals with FAI, modulation of the flexion reflex is affected resulting in impaired descending inhibitory control and/or increased sensitivity to the spinal reflex loop and thus, lack of appropriate use of the unloading reaction.

The drastic reaction (hyper-reactivity) in some subjects may not have occurred because the intensity of ankle stretching or nociceptive stimuli did not reach individual threshold for triggering a drastic reaction. It is also possible that some individuals with FAI might not have hyper-reactivity to unloading reaction. Nevertheless, the drastic reactions showed in involved “with stim” trials indicated a unique reaction pattern in some individuals with FAI.

REFERENCES