Influence of Visual Feedback on 3-Dimensional Forces in a Drop Jump Landing
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ABSTRACT

Objective: To compare the mediolateral, anteroposterior and vertical ground reaction forces (GRF) of a drop jump landing (DJL) with eyes open and eyes closed conditions to analyze the effect of visual input on the body’s ability to modulate motion.

Methods: An experimental crossover research design was used for this study. Twenty-four subjects were recruited to participate containing male and female subjects. All subjects performed a DJL from a height of 24-inches onto a force plate below for a total of 6 alternating attempts of 3 eyes closed and 3 eyes open. Maximal GRF were analyzed for each condition in the anteroposterior, vertical and mediolateral directions and averaged for each participant.

Results: There was a statistical significance of the GRF analyzed when comparing the eyes closed with the eyes open drop jump landing in the vertical and mediolateral direction. The GRF in these directions were shown to decrease during a DJL with the eyes open condition. There was no statistical significance found in the GRF within the anteroposterior direction.

Conclusion: The results indicate that the absence of visual input had a significant effect on the GRF in the vertical and mediolateral directions indicating greater visual input is necessary to decrease the GRF imposed on the human body during a DJL. Although the anteroposterior direction GRF tended to increase during the eyes closed attempts of the DJL, the difference was determined to lack statistical significance. Future research is encouraged to study the effects on static or dynamic neuromuscular training with eyes closed to see if improvements will decrease VGRF.

Keywords: Drop jump landing; Mediolateral forces; Anteroposterior forces; Vertical forces; Eyes open; Eyes closed; Ground reaction forces

ABBREVIATIONS: Drop Jump Landing (DJL); Ground Reaction Forces (GRF); Vertical Ground Reaction Forces (VGRF); Advanced Medical Technologies Inc. (AMTI); Statistical Package for the Social Science 23 (SPSS23); Anterior Cruciate Ligament (ACL); Electromyography (EMG)

INTRODUCTION

The Drop Jump Landing (DJL) is a common strength and conditioning exercise tool that can be utilized for analyzing anteroposterior (x), mediolateral (y) and vertical (z) plane movements for a specific individual. Dynamic standing requires the attention of three sensory inputs from the body: vestibular input, somatosensory input and visual input. Information about body posture and movement from the visual system is given higher priority over information over the other two sensory modalities and information about the environment is used primarily in feedforward sampled control [1]. There are currently limited and inconclusive results with studies on visual feedback with regards to DJL coupled with ground reaction forces (GRF). Santello et al. [2] found decreased knee flexion and increased vertical ground reaction forces (VGRF) without vision, whereas Liebermann and Goodman found unchanged or decreased VGRF when blindfolded [3]. A study by Chu et al. [4] examined 139 air assault soldiers and determined that without vision there was increased hip abduction, decreased knee flexion and increased VGRF without vision. The purpose of the study is to identify how visual feedback affects the GRF in a DJL analysis. Visual input may be a significant contributor for maintaining dynamic stability through modulating muscle activity and joint motion during a functional task [3]. Full visualization of the entire landing surface may be difficult to achieve in many sports that require visual attention to be focused on other things such as with a ball, basket, or another person.

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This can also apply to our aging population who can be visually impaired while also losing power at a rate of approximately 7.5 to 8.5 percent per decade due to normal age-related physiological changes. The simple task of walking demonstrates the fundamental form of dynamic balance that can be compromised because of an inability to preview the environment. The ability to walk without falling depends on the successful shift of body weight and absorbing forces between single- and double-limb support phases as the body moves forward. Individuals with visual deficits negotiate obstacles during walking as they are encountered without the benefit of prior visual anticipatory information which can lead to falls [5]. Visual feedback is crucial in the control of human movement. When vision is obstructed, alterations in landing neuromuscular control may increase movements that place individuals at risk for falls or even injury. Therefore, the purpose of this study is to compare the mediolateral, anteroposterior and VGRF of a DJL with eyes open and eyes closed conditions to analyze the effect of visual input on the body’s ability to modulate motion. Our research hypothesizes that the open eyes DJL will significantly reduce the GRFs on the lower extremity and that participants who can utilize vision tend to absorb GRFs more in all planes of movements.

METHODS

Twenty-four university members with a mean age of 25.4 years (13 females and 11 males) without a lower extremity injury within the last 6 months and activity level greater than 4 on the Tegner activity scale were recruited for this experiment. Informed consent was obtained from the subjects prior to participation in the study in accordance with the policy statement of the University of Saint Mary research department. Participants were randomly allocated using simple randomization to two groups: one starting with eyes open and another with eyes closed, prior to participation. Each subject was given a practice trial drop jump landing with their eyes closed prior to participating in the study. No subjects were given verbal instruction on proper landing techniques. The subjects began by standing on a 24-inch step and were instructed to perform the DJL onto a force plate with their eyes open for three trials and subsequently with their eyes closed for three trials. Trials in which subjects failed to regain balance or touched the ground off the force plates were rejected and replaced. Proper landing forces generated by the participants landing were analyzed using AMTI Netforce and BioAnalysis in the University of Saint Mary department’s research lab to compare the differences in forces between the eyes open and eyes closed conditions. AMTI’s Netforce software is a flexible data acquisition system designed to facilitate the use of AMTI’s multi-axis force platforms for biomechanics and industrial force measurements. An Advanced Medical Technologies, Inc. (AMTI) forceplate system was used to record anteroposterior, mediolateral and vertical GRF data. A forceplate was mounted on an aluminum base, which was firmly secured to the concrete foundation within the building floor. The forceplate was positioned to record concurrent foot contact from an individual during the data collection process. The forceplate data acquisition was initiated by the investigator, which was followed by instruction to perform the DJL. Data acquisition of anteroposterior, mediolateral and vertical force components were recorded with a maximum threshold set at 10,000 N. The sampling period ended when the investigator determined the individual was standing in a static position after performing their DJL [6]. Since, maximum values were the focus of our study, the end of data acquisition was a subjective determinant. Subjects were required to practice one DJL to demonstrate proper understanding of the task (Tables 1 and 2).

RESULTS

A paired-samples t-test was conducted on 24 participants to determine whether there was a statistically significant difference between ground reaction forces (X, Y, Z) with eyes open versus eyes closed during a DJL. Statistical Package for the Social Science 23 (SPSS23) was utilized for data analysis. There was no significant difference in the anteroposterior (X) forces for eyes closed (M=200.1250, SD=50.10437) and eyes open (M=197.4583, SD=61.811113); t (23) = 3.04, p=.764, (CI .95). Further, Cohen’s effect size value (d=.720) for anteroposterior forces suggested a moderate to high practical significance. There was a significant difference in the mediolateral (Y) forces for eyes closed (M=200.2083, SD=14.65540) and eyes open (M=33.9167, SD=11.0411); t (23)=4.224, p=.000, (CI .95). Further, Cohen’s effect size value (d=.755) for mediolateral forces suggested a moderate to high practical significance. There was a significant difference in the vertical (Z) plane forces for eyes closed (M=985.564, SD=33.9167) and eyes open (M=985.19499, SD=43.025); t (23)=5.907, p=.000, (CI .95). Further, Cohen’s effect size value (d=.946) for vertical plane forces suggested high practical significance (Figures 1,2 and 3).

DISCUSSION

We can conclude that participants utilizing vision during a DJL tend to absorb more ground reaction forces in the mediolateral (Y) and vertical (Z) planes than when they were not allowed to utilize vision. Although subjects on average showed increased forces to the anteroposterior direction with eyes closed, there was no significant difference in force absorption with eyes open and eyes closed in the anteroposterior plane. Currently, there is limited research on anteroposterior force absorption in healthy individuals with vision deficits. In a study by Grooms et al. [7] they studied the effects of visual-feedback disruption on vertical-jump landing
In a study by Santello et al. [2] they demonstrated that vertical forces lower extremity injuries within the last six months. All our participants were healthy individuals who had no prior there was no significant difference in sagittal plane forces because on participants with ACL reconstruction may induce alterations in sagittal-plane visual motor control of the knee. We hypothesize that the soldiers likely demonstrated increased hip abduction angles as a strategy to expand the base of support in the mediolateral direction because if the center of mass falls outside of such area, the posture becomes unstable and the risk of fall increases. It may be possible that soldiers were attempting to drop and land more cautiously, resulting in unconscious increased abduction by widening the base of support.

Without vision, participants may have to utilize and trial and error strategy to learn how to build suitable patterns of muscle activity that would lead to a safe and smooth landing. When vision is available, continuous feedback can be used to modulate preparatory muscle activity and/or kinematic variables such as joint angles or body segment orientation to land safely and minimize fall risk. The current study has its limitations. First, all participants were given a practice trial before participating in the study, which could have potential practice effects. In a previous study by Santello et al. [2], they tested their subjects blind folded with varied testing heights and found no practice effects in VGRF or kinematics. Our subjects were aware of the drop landing height prior to participation and were consistently aware because they could utilize vision to get on top of the box in preparation for their jumps. Also, in a study by Magalhaes and Goroso, they found that the first drop jumping landing with vision induced prelanding Electromyography (EMG) adaptations for the following trials, making muscle activation patterns similar to those observed without vision [8]. In a study by Liebermann and Goodman, they allowed their subjects to view the height before dropping and found unchanged or decreased VGRF and earlier muscle firings in the rectus femoris due to a greater resistance to joint rotations and a higher degree of muscle activation (i.e. muscle stiffness).

A study by Chu et al. [4] also analyzed 139 air assault soldiers to see if they were subjected to increased risk of musculoskeletal injury in night operations due to decreased visual input. Their study found that removing visual input resulted in increased hip abduction at initial contact, decreased maximum knee flexion and increased maximum vertical ground reaction forces. They hypothesized that the soldiers likely demonstrated increased hip abduction angles as a strategy to expand the base of support in the mediolateral direction because if the center of mass falls outside of such area, the posture becomes unstable and the risk of fall increases. It may be possible that soldiers were attempting to drop and land more cautiously, resulting in unconscious increased abduction by widening the base of support.

Mechanics on participants with Anterior Cruciate Ligament (ACL) reconstruction. They determined that visual-feedback disruption on participants with ACL reconstruction may induce alterations in sagittal-plane visual motor control of the knee. We hypothesize there was no significant difference in sagittal plane forces because all our participants were healthy individuals who had no prior lower extremity injuries within the last six months.

In a study by Santello et al. [2] they demonstrated that vertical forces could reach up to twelve times the amount of the participant’s body weight when comparing eyes open verse eyes closed in a drop jump landing. Landings without vision present challenges to the motor system because the exact time of impact cannot be accurately predicted prior to performing the DJL at the established height. Visually impaired landing is likely to have increased vertical forces due to a greater resistance to joint rotations and a higher degree of muscle activation (i.e. muscle stiffness).

CONCLUSION

The results indicate that the absence of visual input had a significant effect on the GRF in the vertical and mediolateral directions indicating greater visual input is necessary to decrease the GRF.
imposed on the human body during a DJL.

RECOMMENDATIONS
There are currently thirty-seven million Americans older than fifty who are affected by vision loss. This is a significant population that can have an increased injury or fall risk rate. Family physicians can play a critical role in identifying persons who are at risk for vision loss, counselling patients and referring patients for disease specific treatment [9]. Physical therapists can be beneficial for developing interventions and programs to help improve neuromuscular control. An intervention program conducted on Air Assault Soldiers demonstrated that posture sway in anteroposterior and mediolateral direction under no-vision conditions can be reduced via balance training with eyes closed [4]. It is unclear whether such improvements are sustainable and whether they would translate to a drop jump landing. Future research is encouraged to study the effects on static or dynamic neuromuscular training with eyes closed to see if improvements will decrease VGRF.

REFERENCES
6. Advanced Mechanical Technology Inc. AMTI netforce user’s manual. Advanced Medical Technology Inc. 3:5-19.