POSTURAL AND NEUROMUSCULAR CONTROL WITH CHRONIC ANKLE INSTABILITY

by

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ABSTRACT

Chronic ankle instability (CAI) is a prevalent condition that affects an individual's balance, coordination, and stability as a result of one or more acute ankle sprains. CAI results in proprioceptive deficits, altered and rigid movement strategies, reduced adaptability, delayed neuromuscular responses, and an increased risk of re-injury. The purpose of this study was to determine the effects of increasing task difficulty and visual feedback on existing postural control deficits exhibited by individuals with CAI. This study focused on a collegiate sample of adults, including a total of 21 participants to achieve this purpose. 13 participants were considered healthy participants while 8 were considered to be participants with chronic ankle instability, in accordance with guidelines by the International Ankle Consortium and the Cumberland Ankle Instability Tool. Four separate tasks were assessed, with each task performed separately for each leg, both with and without visual feedback. The tasks included two balance tests: static balance and dynamic balance, followed by two landing tasks: lateral hop and drop landing. A statistically significant effect for feedback was found on medial-lateral variation for the CAI group ($P=0.047$), in addition to a significant interaction effect of task and feedback found on anterior-posterior variability in the CAI group ($p=0.035$). No significant interactions or effects were observed for the landing tasks. These findings suggest that visual feedback may decrease postural control deficits in individuals with CAI.

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INTRODUCTION

Chronic Ankle Instability

Lateral ankle sprains are among one of the most common musculoskeletal injuries, especially amongst young, healthy populations. While many individuals fully recover and are able to return to normal activities, up to 40% will experience residual symptoms including the development of chronic ankle instability (Herzog et al., 2019). While there’s no medical test to confirm the condition, current diagnosis criteria for chronic ankle instability (CAI) is defined by the International Ankle Consortium, a global group that maintains a goal of establishing standardized criteria for identifying and classifying individuals with CAI in order to best reduce variability across studies (International Ankle Consortium, 2024). The currently endorsed inclusion criteria for CAI by this group is as follows: (a) a history of at least one significant ankle sprain, with significant being defined that the individual experienced inflammatory symptoms and experienced at minimum a one-day interruption of physical activity. (b) a history of the injured ankle joint “giving way,” defined as uncontrollable or unpredictable foot inversion when the foot makes initial contact with the ground. (c) a CAI classifying score on an ankle instability-specific questionnaire. The currently accepted questionnaires are the ankle instability instrument (AII), the Cumberland ankle instability tool (CAIT), and the identification of functional ankle instability (IdFAI) (Gribble et al., 2014).

When an individual experiences a lateral ankle sprain, damage to the muscles, ligaments, and mechanoreceptors are common implications (Kim et al., 2024). This is most commonly observed in a lab setting through electromyography where key muscles such as the tibialis anterior, peroneus longus, and medial gastrocnemius, exhibit a reduction in activation and therefore altered motor unit firing (Son et al., 2017). Due to this damage, impairments in proprioception, muscular strength, joint function, and stability are typically observed and are the key characterizations of CAI (Kim et al., 2024).

Postural Control

Postural control is defined as the ability of an individual to maintain balance and stability by utilizing both sensory inputs and motor responses regardless of posture or task. This is done via somatosensory integration of sensory input to produce motor outputs that maintain an upright posture. Deficits in postural control are one of the key indicators of CAI; the structural damage seen in CAI individuals results in somatosensory integration impairments, which therefore results in proprioceptive deficits. In an effort to adapt, many CAI individuals rely more heavily on visual feedback than healthy individuals, though significant deficits are still observed (Kim et al., 2024).

Postural control is an important tool in understanding sensorimotor function and motor coordination across a multitude of population. Postural control relies on the integration of multiple sensory systems such as visual, proprioceptive, and vestibular, which means that an understanding of one's postural control can reveal deficits in one or more of these systems. Using laboratory equipment such as a force plate allows researchers to identify deficits that are nearly invisible when utilizing pure visual observation. When these deficits can be measured and quantified, clinicians and researchers can better identify compensatory mechanics, and the effectiveness of applied rehabilitation protocols (Mohamadi et al., 2020; Simpson et al., 2019). This demonstrates the postural control is not only a critical tool for injured populations such as the CAI population, but can also be beneficial for groups such as adults who experience declines in proprioceptive acuity and vision. Due to these changes, the aging population is linked to a greater fall risk, and by evaluating their postural control, clinicians can uncover underlying sensorimotor deficits and best tailor rehabilitation protocols.

Neuromuscular Control

Neuromuscular control is defined as an individual's ability to coordinate organized movements to perform specific tasks. This is an unconscious process that is a direct result of the central nervous system's control. Damage to mechanoreceptors results in deficits in somatosensory integration, which consequently results in neuromuscular control alteration. Additionally, deficits in neuromuscular control are linked to heighted re-injury rates (Micrograte, 2025). When an individual with CAI experiences an inversion perturbation, as seen with lateral ankle sprains, damage to supporting muscles such as the peroneus longus and the peroneus brevis inhibit effective responses and are one of the leading causes of re-injury. Additionally, it's been observed that individuals with CAI rely more on feedback rather than feedforward information, meaning their corrective responses are delayed. Additionally, this means that individuals with CAI exhibit decreased levels of preparatory neuromuscular control, resulting in maladaptive joint positions when the foot makes contact with the ground and increased levels of instability (Simpson et al., 2019). These preparatory deficits were demonstrated in Han et al. (2022), it was demonstrated that CAI individuals exhibit altered pre-landing joint mechanics, including reduced ankle dorsiflexion and an increased reliance on proximal joint strategies.

A commonly seen compensatory response for individuals with CAI is to adopt rigid motor strategies that rely on larger joints such as the hip and the knee, even for smaller tasks that could be completed relying majorly on ankle strategies. This proximal shift of control is an attempt to stabilize the self by utilizing less impaired regions of the body, but results in limiting degrees of freedom as the movement efficiency is overall reduced in the long run. Not only does this adaptation result in force production not appropriated to the task at hand, but also decreases functional responsiveness and therefore increases the risk of re-injury (Han et al., 2022; Son et al., 2017).

Dual Task

Dual-task activities are situations in which the cognitive and motor systems are sharing attentional resources. (Mohamadi et al. 2020). Due to the fact that many CAI individuals exhibit reduced degrees of freedom in their lower limbs, recent research has explored the possibility of dual-task implementations on increasing adaptability and variability, exploring how cognitive load may affect balance performance. Studies focused on dynamic tasks have suggested that dual-task conditions result in increased gait variability in individuals with CAI. While increased gait variability is seen as a heightened risk of re-injury, it does suggest that the rigid and non-adaptable motor strategies of CAI individuals can be broken, which means that the individual may be breaking free from their adopted, inflexible motor strategies (Springer & Gottlieb, 2017). Dual-task research regarding static balance has suggested that the increased cognitive load also has the ability to improve balance and postural control due to the observed decrease in postural sway. With these findings, it’s been suggested that dual-task interventions are able to target sensorimotor deficits seen in the CAI population (Wang et al., 2023; Mohamadi et al., 2020). With those demonstrated results, it’s been suggested that task difficulty may be the determining factor (Spring & Gottlieb, 2017). Despite these findings, the effect of task difficulty and visual feedback on balance and stability for the CAI population remains widely unexplored.

Methods of Measurement and Influence

Measures of postural and neuromuscular control are typically obtained in a laboratory setting. Electromyography is used to record muscle activity while three-dimensional motion capture systems are used to obtain kinematic data, including joint angles, angular velocities, and segment coordination (Simpson et al., 2019). The usage of these tools has allowed the advancement of our current understandings regarding CAI adaptive motor strategies. Force plates are commonly used to evaluate postural control through measures of center of pressure area, sway velocity, and range of COP displacement during static and dynamic tasks, and these methods of measure have revealed impaired postural control in individuals with CAI. Specifically, individuals with CAI experience a greater center of pressure area during static stance, as well as a higher sway velocity (Mohamadi et al., 2020). Outside of the lab, self-reported surveys and questionnaires are used to screen for or confirm a CAI diagnosis, as recommended by the International Ankle Consortium (Gribble et al., 2014).

Project Significance

Despite these previous findings, the effect of task difficulty and visual feedback on balance and stability for the CAI population remains widely unexplored. It's been shown that individuals tend to rely more heavily on visual cues due to their proprioceptive deficits, but the extent to which visual feedback can compensate for these deficits also remains unknown, which is what our study plans to measure (Kim et al., 2024). Individuals with CAI rely on compensatory and rigid movement strategies in situations they encounter in everyday life, which tend to be of higher predictability and lower demand (Son et al., 2017). When faced with unfamiliar task demands, healthy individuals tend to make minor adjustments in the movement strategies to adapt to the task, while individuals with CAI may maintain their compensatory movement strategy without adaptability, until a change is necessitated (Springer & Gottlieb, 2017). This inflexibility may lead to more substantial performance declines when the task difficulty is outside the normal, predictable range. The focus on task difficulty and visual feedback interactions in this study is an important concept that focuses on the reasoning behind these well-known deficits. Current literature has a focus of quantifying the extent of the balance deficits and determining the effects of implemented training and protocols but lacks depth in the exploration of the conditions that worsen or improve existing deficits. By looking at the interaction of task difficulty and visual feedback, we can gain insight on the extent to which people with CAI exhibit adaptability, and the driving force behind their adaptations.

Purpose

By exploring how postural and neuromuscular control deficits change with task difficulty and the presence of visual feedback, healthcare professionals could potentially implement more effective intervention strategies to address the issue before it becomes detrimental to one's daily function. Our study will include the analysis of a static balance test, lateral jump test, and drop landing test. Each leg will be individually tested, in both the presence and absence of visual feedback, allowing for more standardized results and the ability to isolate the specific conditions of each variable. The study will therefore answer the questions: (a) How does postural and neuromuscular control change with task difficulty? (b) How do postural and neuromuscular control change with the implementation of visual feedback? (c) How do the postural and neuromuscular control differences between healthy individuals and those with CAI change with task difficulty? (d) How do the postural and neuromuscular control differences between healthy individuals and those with CAI change with the implementation of visual feedback.

METHODS

Participants

Prior to data collection, the study received approval from the Institutional Review Board at Texas Christian University. Upon arrival to the lab, participants were given a consent form and given the opportunity to ask questions before signing. It was conveyed that participation was completely voluntary and that they were free to withdraw at any time. If the participant completed the study in its entirety, they were given compensation in the form of a $20 gift card.

A sample population of participants (n=21) was used for this study with 13 participants being classified as healthy and 9 participants being classified as having chronic ankle instability. The sample was recruited through the use of a flyer and word of mouth. All participants were between the ages of 18-35 which is the range covering the typical young adult population for studies related to postural and neuromuscular control; this also provided us with a participant recruitment window beyond college-age students, which improved recruitment efforts. All prospective participants were emailed a blank copy of the Cumberland Ankle Instability Tool (CAIT),and were asked if they had a history of lateral ankle sprains. To be included in the healthy testing group, participants needed to have scored a minimum of 25 on the CAIT for both ankles and have no history of lateral ankle sprains. To be included in the CAI testing group, participants needed to have a maximum score of 24 on the CAIT for one ankle and a history of at least one lateral ankle sprain on that same ankle. Additionally, they needed a minimum of 25 on the Cumberland Instability Survey for the unaffected ankle. Exclusion criteria for any participant were as follows: (a) Participants experiencing acute symptoms of a lower extremity injury such as pain or swelling since any acute symptoms may impair performance or place the participant at risk of worsening the injury. (b) Participants have had a history of lower extremity surgery in the past year since recent lower extremity surgery could interfere with the interpretation of study results due to it being a confounding factor. (c) Participants have experienced a concussion or head injury in the past 3 months since a head injury could impair balance beyond normal abilities which would interfere with the interpretation of the study results. (d) Participants have any current condition that is known to impair balance, including but not limited to Parkinson's, ear infections, vision problems, vestibular disorder, and multiple sclerosis. (e) Participants have experienced a lower extremity injury in the past 6 months. (f) Participants are experiencing bilateral chronic ankle instability.

Demographic Information Collection/Familiarization

Prior to the familiarization period, participants completed a de-identified demographic survey. This survey recorded the participant’s height, body mass, age, and dominant foot through the question of, “what foot do you kick a soccer ball with?” Results of the demographic survey are displayed in table one. After completion of the demographic survey, the participants participated in a familiarization session in which they were introduced to the force plate and the visual feedback component of the testing. Additionally, the research team demonstrated the proper starting position for each of the tasks. The participants practiced using the visual feedback system until comfort and understanding were achieved.

Instruments/Procedure

This study was conducted in one visit, with a total time commitment of one hour. Each participant completed four tests of increasing difficulty, two balance tasks and two landing tasks. The two balance tasks were completed first and included a static balance task and a dynamic balance task. After a short break, the landing tasks were completed which included a lateral hop test and a drop landing task. The balance tasks were performed barefoot to limit the effects of any shoe cushioning, though not the landing tasks in order to limit the risk of injury. Additionally, each test was performed with the presence of visual feedback and with the condition of absence of visual feedback. The visual feedback was in the form of real-time visual tracking on a screen at eye level with the participant that either displayed center-of-pressure, or the vertical force applied to the force plate. The order of the tasks was randomized within the balance task time frame, as well as the landing task time frame.

The beginning position for every test was the same, with the participant being instructed to stand on one leg, with the other leg bent and off the ground, eyes open, and both hands on their hips. The participant was also instructed to "keep their vision up" in the direction of the screen for all conditions in order to limit the effects of looking down at their feet during the tests.

Static Balance

The static balance test was performed as a single-leg stance test. The test began once the starting position was attained, and the research investigators began the data recording. The stance was held for 30 seconds, or unless the testing conditions were terminated. The time stopped if testing conditions became unsafe, if the foot in the air touched the back of their leg or the floor, or if their hands came off their hips. The visual feedback condition of this test was performed identically, with the addition that the participant had the screen in front of them displaying their center of pressure. Prior to this condition, the investigator explained to the participant that the goal of the test was to maintain balance, and keep the line that shows their center of pressure, even with the centerline on the screen. Each condition was repeated twice, for a total of 4 trials on each foot and 8 in all.

Dynamic Balance

For the dynamic balance test, the participant was instructed to begin the same starting position, and instructed to lean as far forward as possible without falling, then lean as far back as possible without falling. They repeated this back-and-forth motion for a total of 30 seconds. The time stopped if testing conditions became unsafe, if the foot in the air touched the back of their leg or the floor, or if their hands came off their hips. The visual feedback condition of this test was performed identically, with the addition that the participant had the screen in front of them displaying their center of pressure. Each condition was repeated twice for a total of 4 trials on each leg and 8 trials in all. After the completion of all sixteen trials, the participant was instructed to put their shoes back to prepare for the landing tests.

Lateral Hop

For the lateral jump test, a piece of tape was placed in the center of the force plate, as well as a piece of tape on both the left and right sides of the force plate, 40cm from the center tape. This test began with the participant attaining the previously mentioned starting position on the piece of tape beside the force plate, opposite of the leg they're standing on (when jumping with the left leg, the participant will begin on the right side of the force plate so that they can jump to the left). The participant was instructed to jump inwards towards the force plate so they landed on the piece of tape on the center of the force plate. The participant was instructed to maintain the single leg stance with their hands on their hips for 15 seconds, to ensure adequate postural stabilization. If balance was unable to be maintained for the entire 15 seconds or if termination criteria was met, the test was terminated. The visual feedback condition of this test was performed identically, with the addition that the participant had the screen in front of them displaying their force applied into the plate for the time they are balancing on the force plate. Each condition was repeated 3 times, for a total of 6 trials on each leg and 12 trials in all.

Drop Landing

The drop landing test began with the participant in the same starting position on the edge of a box, without their toes going over the edge. The box was 31 centimeters in height, positioned 12.5 centimeters behind the back edge of the force plate. The participant was told not to jump off the box, but to instead “step off” onto the force plate. Once on the force plate, the participant once again maintained balance for 15 seconds or until test termination conditions were met. The visual feedback condition of this test were performed identically, with the addition that the participant will have the screen in front of them displaying their force applied into the plate for the time they are balancing on the force plate. Each condition was repeated 3 times, for a total of 6 trials on each leg and 12 trials in all. For all testing conditions, the screen displaying the visual feedback was placed one meter away from the front edge of the force plate, and adjusted to the eye level of the participant. For analysis, $\alpha = 0.05$ and a repeated-measure ANOVA was utilized.

Data Processing and Statistical Analysis

Data was collected using Qualisys Track Manager program in conjunction with the in ground AMTI force plate. During the balance tasks, postural control measures of medial-lateral sway, anterior-posterior sway, and sway velocity were recorded. During the landing tasks, force applied into the force plate was recorded and later used to establish time-to-stabilization.

After the initial data collection using Qualisys Track Manager, the raw force plate data was exported to MATLAB for further processing and analysis. Custom scripts were used to extract the center-of-pressure data for the balance tasks. This was done for the average sway in both the medial-lateral and anterior-posterior directions. An additional script was used to extract information about the average velocity during the balance tasks. All averages were derived from COP time-series data. For the landing tasks, a custom script was used to calculate time-to-stabilization. This script was designed based on previous data methods that stability as the point in which the vertical ground reaction force maintained a value with five percent of the participant's body weight for a subsequent second (Bryne et al., 2021).

Using JASP, an open-source statistics program, statistical analyses were run. Inter-class correlation coefficients and standard errors of measurement were conducted on the separate dependent variables, and repeated measures (3x2x2) ANOVA tests were used to assess the data with independent variables being task type (static balance test, dynamic balance test, lateral hop test, and drop landing test), feedback (presence or no presence), and leg (dominant/injured and non-dominant/non-injured).The dependent variables included the previously states metrics of medial-lateral sway, anterior-posterior sway, sway velocity, and time-to-stabilization. An alpha of 0.05 was used to determine statistical significance for all tests.

RESULTS

Balance Tasks

The results of the balance tasks were expressed in terms of medial-lateral sway variation (figure 1), anterior-posterior sway variation (figure 2), and velocity of sway (figure 3). For each figure, the x-axis portrays the presence of visual feedback in which the screen displays anterior-posterior center-of-pressure, where "0" represents conditions in the absence of visual feedback, and "2" represents conditions with the presence of visual feedback. The y-axis portrays task in which task "1" is representative of the static balance task, while task "2" is representative of the dynamic balance task. A statistically significant effect was found for task on all three postural control measures for both the CAI and healthy groups ($p<0.05$), indicating that the structure of increasing task difficulty was successful. A statistically significant effect for feedback was found on medial-lateral variation for the CAI group ($P=0.047$). Additionally, a statistically significant interaction effect of task and feedback was found on anterior-posterior variability in the CAI group ($p=0.035$). No statistically significant effects were observed in terms of sway velocity.

Landing Tasks

The results of the landing tasks were expressed in terms of time-to-stabilization. The lateral hop test is displayed in figure 4 while the drop landing test is displayed in figure 5. No significant interaction effect of task and feedback was observed in the landing tasks. Additionally, there was no significant effect of feedback on the landing tasks.

Figures and Tables

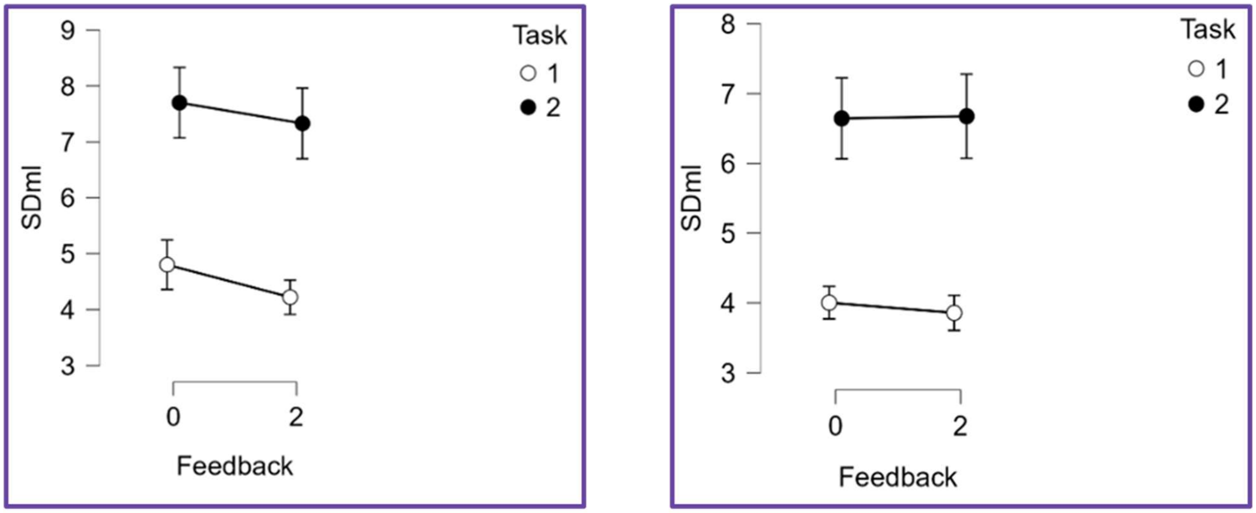
Table 1. participant demographics

Group	**CAIT Score**	**Age (yrs)**	**Sex**	**Height (cm)**	**Weight (kgs)**
Healthy (13)	Dominant: 28.8 ± 1.3	21.2 ± 1.2	6 F	170.8 ± 11.0	69.8 ±14.1
	Non-Dominant: 28.8 ± 1.0		7 M		
CAI (8)	Injured: 20.3 ± 2.2	20.8 ± 0.7	3 F	177.2 ± 7.9	83.9 ± 18.7
	Non-Injured: 27.1 ± 1.6		5 M		

Table 2. definitions of terms

Term	**Definition**
CAI	Chronic Ankle Instability
CAIT	Cumberland Ankle Instability Tool
AP	Anterior-Posterior
ML	Medial-Lateral
COP	Center-of-Pressure

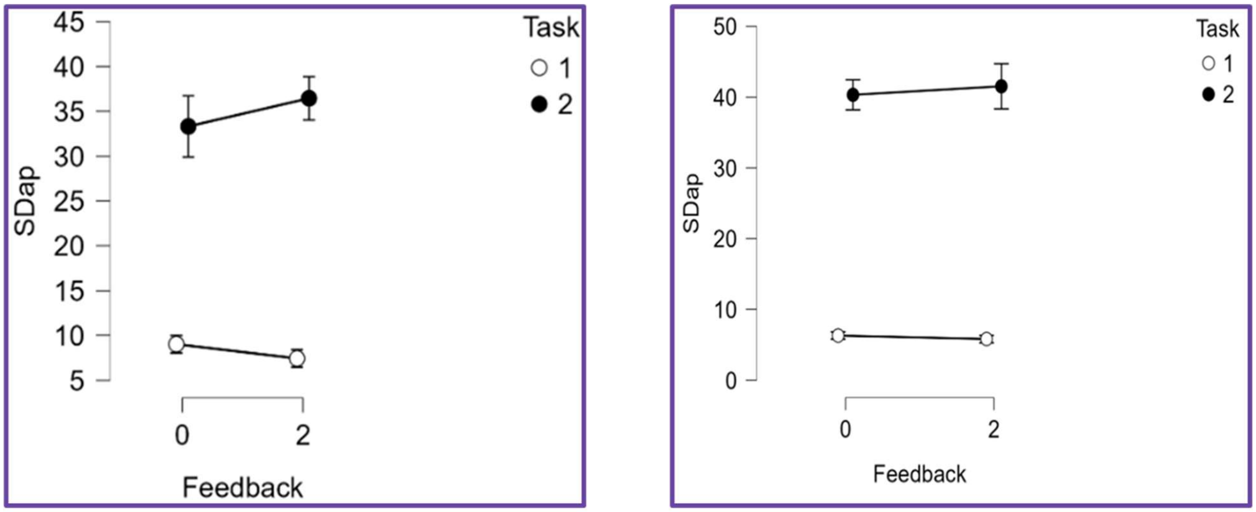
Figure 1. Mean medial-lateral sway variation for condition of no visual feedback (0), and visual feedback (2), for the static balance task (1), and the dynamic balance task (2)



CAI

Healthy

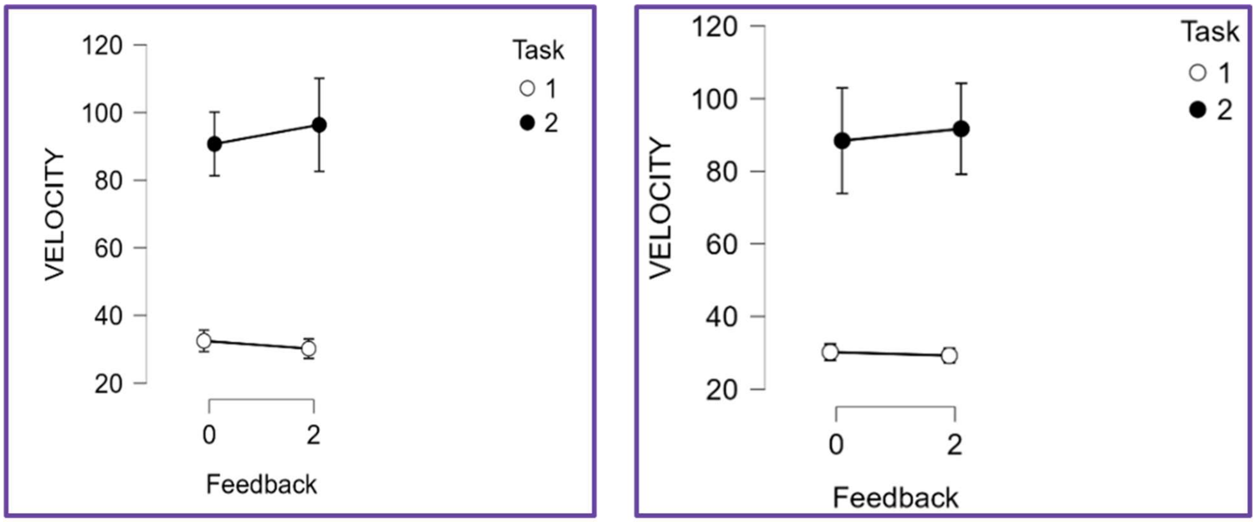
Figure 2. Mean anterior-posterior sway variation for condition of no visual feedback (0), and visual feedback (2), for the static balance task (1), and the dynamic balance task (2)



CAI

Healthy

Figure 3. Mean sway velocity variation for condition of no visual feedback (0), and visual feedback (2), for the static balance task (1), and the dynamic balance task (2)



CAI

Healthy

Figure 4. Mean time-to-stabilization for condition of no visual feedback, and visual feedback for the lateral hop task

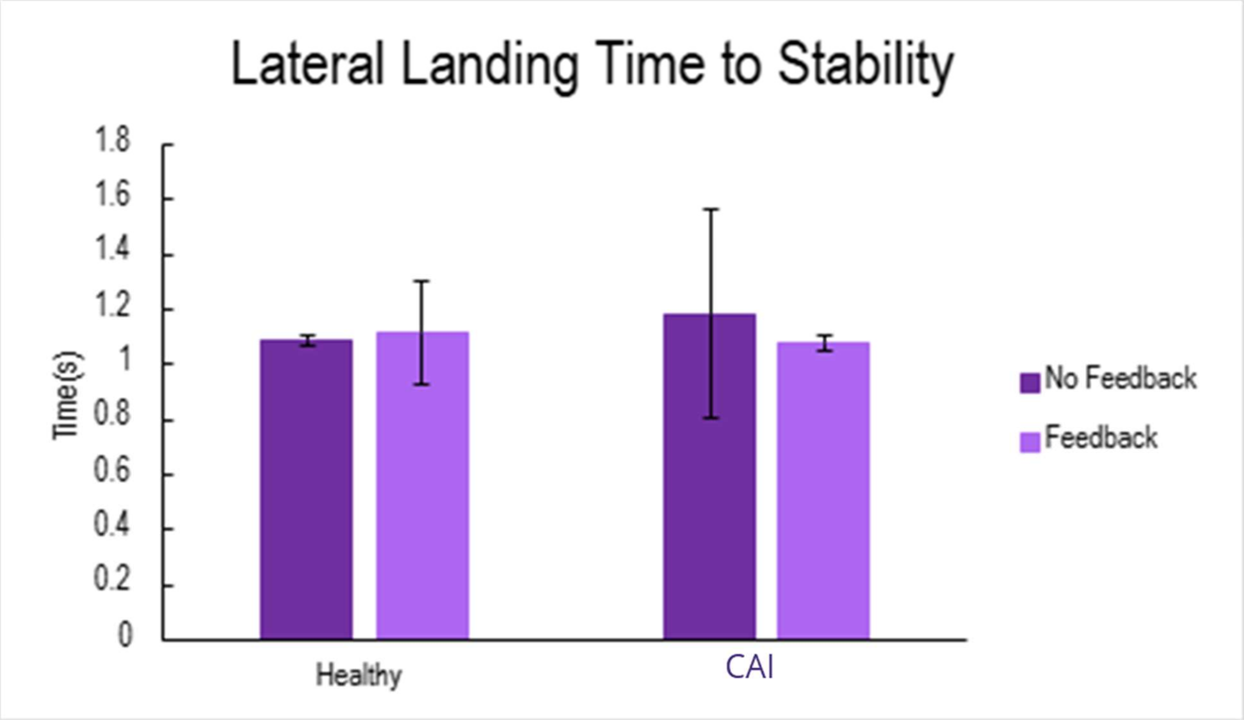
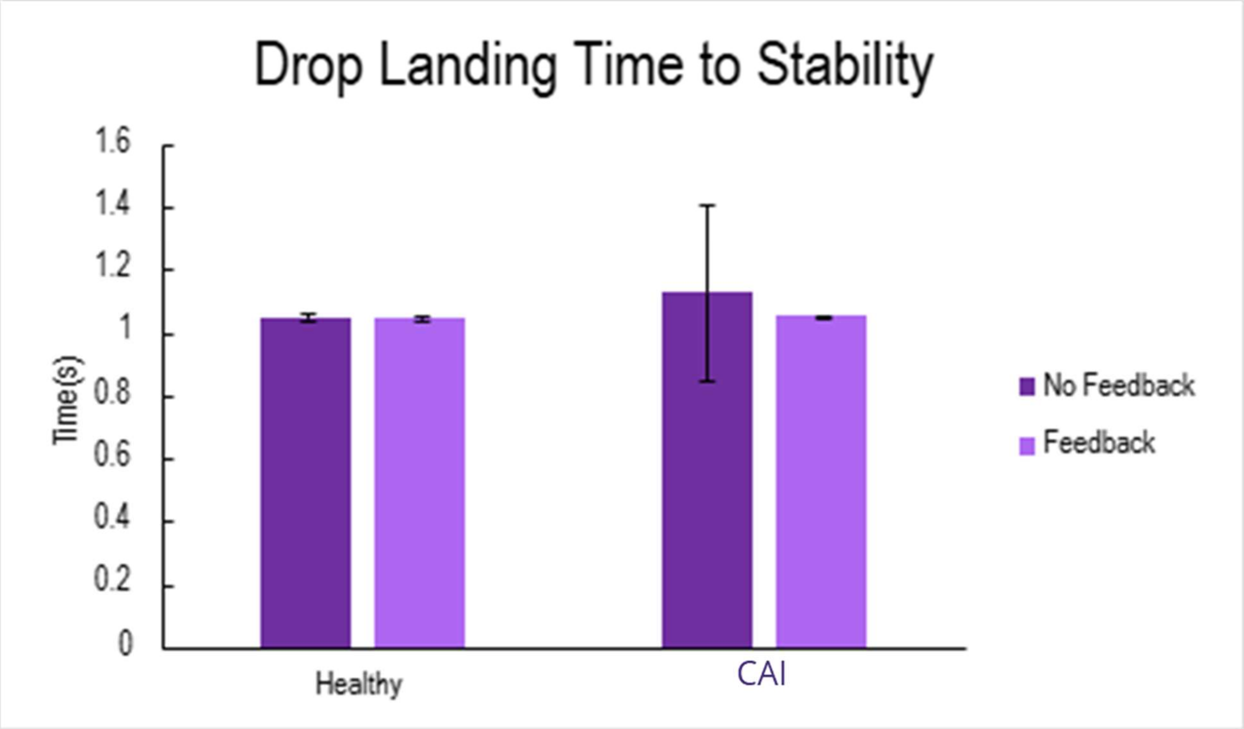


Figure 5. Mean time-to-stabilization for condition of no visual feedback, and visual feedback for the drop landing task



DISCUSSION AND FUTURE DIRECTION

The current findings suggest that CAI postural strategies are sensitive to the task *x* feedback interaction. The evidence also suggests that visual feedback may play a role in stabilizing lateral postural sway for individuals with impaired sensorimotor control, highlighting its potential in targeted rehabilitation strategies. Similar to other studies was our participant population. The majority of current CAI studies are being conducted within the young and healthy population in order to establish a foundation of baseline measures. Though our number of participants was limited, it’s comparable to previous studies such as Springer and Gottlieb (2017) with sixteen participants and Kim et al., 2024) twenty-eight. Studies such as Son (2017) and Kim et al., (2024) included only “active” participants in their study, though the 2017 study did not specify the parameters of this criteria while the 2024 study noted that they did not gather detailed activity levels from the participants to further assess this component. Springer and Gottlieb (2017) recruited solely from military clinics, implying that their participants were also of active lifestyles, though not specifically classified as such. Our study did not include any activity criteria for participants, nor did we collect any information about the participants lifestyle. These differences in participant populations, particularly in terms of the activity levels, could explain a portion of variety between study results. All of the previously mentioned literature recruited participants in the same age range as our study, with the mean age being similar to ours. This age range is common in current studies in order to best establish a foundation in which to base further research, and reduce the effects of age-related confounding variables such as macular degeneration, sarcopenia, slower postural reactions, decreases in muscle strength, or other proprioceptive issues.

Balance Tasks

Statistically significant results were observed within the balance tasks, demonstrating that the implications of task difficulty and visual feedback on current CAI impairments is a topic in need of further research. Additionally, we observed that in all four tasks, the CAI groups, when visual feedback was implemented, achieved similar postural and neuromuscular control measures to the healthy group's baseline values (absence of visual feedback), indicating that closing the gap between healthy and CAI stability measures is possible under the right conditions. These findings are mirrored in the Hung & Miller (2016) study, whose results suggested that visual cues may improve balance in the CAI population. Our findings are similarly mirrored in the Mohamadi et al. (2020) study whose results suggested that sway is reduced when a cognitive task was introduced, likely due to the higher attentional load.

Landing Tasks

In contrast to the balance tasks, the landing tasks did not results in any statistically significant findings. Significant effects would have also been expected within the landing tasks, as demonstrated by Moisan et al (2022) who reported findings of altered lower limb biomechanics during landing tasks of increased difficulty. An important contrast between this study and our current research is that Moisan et al. focused on kinematic analysis including joint angles, electromyography, and landing mechanics. While our current study did not utilize dual-task conditions, a study of influence was conducted Springer and Gottlieb (2017) in which it was found that CAI individuals only decreased stride time variability when walking under the combined conditions of a faster-than-normal pace and a dual-task. Their findings suggested that increasing the overall task difficulty could target the deficits seen within the CAI population, which is what our study aimed to address and ultimately supported for our balance tasks.

Limitations

Explanations for the lack of significant findings within the landing tasks could be due to the many limitations within the sample taken, including variety of CAIT scores, small sample size, or even the shoes each participant was wearing during testing. The effects of shoes were mitigated during the balance tasks by removing both socks and shoes for testing, but due to injury concerns, participants wore athletic shoes of their choice for the landing tasks. The amount of cushion or support a shoe provides can largely impact a person's proprioception, balance, stability, and was likely the most influential confounding variable when calculating time-to-stabilization. Future studies could take additional steps to mitigate this confounding. Additionally, our standard deviations within the CAI were significantly larger than the healthy group. While variability is expected, it's likely that such a wide range of CAIT scores impacted the statistical significance of the findings. Further research could explore the possibility of additional CAI subcategories. Lastly, our sample size consisted of only 21 individuals, and while this is consistent with previous research, as larger sample size could potentially mitigate some variability and therefore produce more significant and applicable results.

An additional consideration is in terms of the selected dependent variables. While our selected variables and measures are common, there has been previous literature such as Moisan et al. (2022) and Han et al. (2022) that have examined more joint-specific kinematics and utilized electromyography. While all are recognized measures, these differences may contribute to discrepancies in statistical significance. Utilizing a force plate with COP and force-based measures gives insight into the whole-body postural responses, while electromyography and joint-specific kinematics are more segmental. To reduce these discrepancies, future research may benefit from utilizing both categories of measures, thus resulting in a more comprehensive analysis.

An important factor of this study was the utilization of the Cumberland Ankle Instability Tool. By utilizing this standardized metric for determining CAI individuals, our results are more comparable to studies employing this same metric. Our adherence to these strict guidelines may have contributed to our findings, and it’s important to note that many studies prior to 2014 did not conform to these same guidelines, making the CAI group definitions more subjective, and therefore the comparisons less reliable.

Future Direction

The presence of significant findings in this study suggests that future research should be explored. With modest, significant findings being found when participants were only in the laboratory setting for an hour, future research could begin by focusing on the longitudinal effects of task and visual feedback training for individuals with CAI. Rehabilitation protocols are often long-term plans that extend beyond the length of a one-hour session, so the exploration of long-term effects would provide practical results for the clinical setting.

Due to our large standard deviations within the CAI group, further research could benefit by further CAI groups specification. While the CAIT is a strongly supported assessment tool for identifying individuals with CAI, it’s clear that there’s a substantial amount of variability within the category. By creating additional specification within the group in terms of CAI severity, additional significance of these interventions may be found.

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