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Short communication

Cognitive loading-induced sway alterations are similar in those with chronic ankle instability and uninjured controls

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ABSTRACT

Performing a cognitive task while balancing can result in either increased or decreased sway depending on the nature of the cognitive task, and is commonly used in pathologic populations to evaluate postural performance. A total of 39 participants were recruited into two groups: uninjured controls ($n = 20$, age: 21.9 ± 2.1 years, height: 175.0 ± 11.2 cm, mass: 71.3 ± 14.9 kg) and chronic ankle instability ($n = 19$, age: 22.1 ± 5.6 years, height: 169.7 ± 7.7 cm, mass: 72.9 ± 17.3 kg). Participants were asked to perform one of three cognitive tasks while maintaining single limb balance. Cognitive tasks included backwards counting by 3 (BC), the manikin test (MAN), and random number generation (RNG). Time-to-boundary minima, mean, and standard deviations were calculated and compared between groups as pre to post change scores. Effect sizes and 95% confidence intervals were also calculated to test for group differences and the effect of task performance on sway. No significant main effects of Group or Group by Task interactions were identified ($p > 0.05$). However, a significant multivariate main effect of Task was identified in BC ($p = 0.001$, $F(6, 32) = 4.804$) and RNG ($p < 0.001$, $F(6, 32) = 6.233$) but not for MAN ($p = 0.117$). The results suggest that those with chronic ankle instability and uninjured controls have similar postural–suprapostural interactions across multiple cognitive task domains. Both the BC and RNG tasks resulted in less sway for all participants. Our results suggest that dual-task interference in the CAI population may not be present as previous research would suggest.

1. Introduction

Researchers estimate that approximately 25,000 lateral ankle sprains occur daily in the United States [1], with reported recurrence rates and persistent symptoms present in as many as 2 out of every 3 individuals with a history of a lateral ankle sprain [2,3]. Additionally, patients often report instances of the ankle 'giving way', a defining characteristic of chronic ankle instability (CAI) [4]. Patients with CAI have a breadth of structural and sensorimotor alterations relative to uninjured controls [5], including increased postural sway [5,6]. Dual-task research suggests this could be due to an increased demand for attentional resources during postural tasks [7,8].

Sway often decreases in healthy individuals while dual-tasking [9–11], but results are mixed in those with CAI [7,8]. A backwards digit span task increased sway in those with CAI relative to an uninjured control group [8]. However, both uninjured controls and those with CAI demonstrated similar increases in sway while performing an auditory short term memory task [7].

Based on the available evidence, dual-tasking may increase sway in those with CAI but the results appear to be cognitive task dependent [7,8]. If, dual-tasking increases sway in CAI patients in a constrained laboratory environment, the effect may be amplified in real world settings and should be addressed during rehabilitation. However, the effects of different cognitive tasks on postural sway must be characterized prior to incorporating cognitive loading into musculoskeletal rehabilitation for CAI patients.

Our aim is to evaluate the effect of different cognitive tasks on postural sway in CAI participants relative to uninjured controls. We hypothesize that the CAI group would have greater sway when dual-tasking relative to controls and that a backwards counting task would cause the greatest increase in postural sway based on previous research [8].

2. Methods

A single session, repeated-measures between group design was used for this investigation. Participant demographics can be seen

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Table 1
Group demographics. 'Roll' is defined as a self-reported event of instability at the ankle, typically with a reported sensation of the ankle giving way.

	Uninjured controls $n = 20$ (SD)	CAI $n = 19$ (SD)
Age (years)	21.95 (2.01)	22.05 (5.58)
Height (cm)	175.04 (11.24)	169.66 (7.74)
Mass (kg)	71.33 (14.92)	72.99 (17.31)
# of "yes" answers on AII	0.70 (0.92)	6.26 (1.99)
Total number of Ankle Sprains	0.00 (0.00)	3.84 (2.48)
# of "rolls" in past 6 months	0.00 (0.00)	2.79 (2.04)
FAAM-ADL (%)	99.94 (0.27)	92.25 (10.12)
FAAM-S (%)	99.22 (1.72)	79.01 (19.68)

in Table 1. Inclusion criteria for the CAI group were consistent with the position statement by the International Ankle Consortium [12]. Controls must have never sustained a lateral ankle sprain. Exclusion criteria for both groups included a history of lower extremity injury or concussions for the past 3 months as well as a history of lower extremity surgeries. Informed consent was obtained from all participants prior to data collection and was approved by the Institutional Review Board.

Participants were provided with an explanation and example of the three cognitive tasks (backwards counting (BC), manikin test (MAN), and random number generation (RNG)), then completed three 10-second practice trials of each task [8,9]. Participants then performed three 10-second baseline balance trials while standing barefoot on a single limb (dominant for control, injured for CAI) with their hands at the hip and the contralateral knee flexed approximately 30°. A total of three, 10-second trials were completed for each of the tasks (BC, MAN, RNG) in an investigator-generated counterbalanced order [9]. Data was collected using a tri-axial force platform (Bertec Corp, Columbus, OH) at 200 Hz and reduced using the Motion Analysis Cortex software (Motion Analysis Corporation, Santa Rosa, CA) [9]. Data were exported to MATLAB (Mathwords Inc., Natik, MA) to calculate time-to-boundary outcomes in the anterior-posterior (AP) and medial-lateral (ML) planes as previously established [6].

Three separate 2-by-2 (Group by Task) repeated measures MANOVAs were used to evaluate AP and ML TTB Min, TTB Mean, and TTB StDev outcomes between baseline and the dual-task conditions. Hedges' g effect sizes and 95% confidence intervals were calculated to confirm the dual-task effect of each cognitive task (dual-task – baseline) and on change scores to test between group effects. An alpha level of 0.05 was used for all statistical analyses.

3. Results

Group and pooled means and standard deviations for all 6 TTB outcomes can been seen in Table 2. Hedges' g effect sizes and 95% confidence intervals can be seen for the calculated change from baseline (task – baseline) and on the change scores between groups for each cognitive task in Table 3. No significant main effects of Group or Group × Task interactions were identified ($p > 0.050$). However, a significant multivariate main effect of Task was identified in BC ($p = 0.001$) and RNG ($p < 0.001$) but not for the MAN task ($p = 0.117$). Interestingly, the follow-up univariate analyses illustrated that the direction (increased vs decreased sway) was different among TTB outcomes. During both the BC and RNG task, the AP and ML absolute minima reflect decreased sway, while the ML TTB StDev during BC and the TTB Mean and StDev in the AP and ML directions during RNG show increased sway. Effect sizes across all three conditions ranged from small to large for each group with all but one 95% CI (1 of 18; 5.55%) crossed zero, confirming a lack of group differences across different cognitive tasks.

4. Discussion

The goal of this investigation was to determine if CAI participants had different sway responses when dual-tasking in different WM domains relative to uninjured controls. Our most important finding was that both uninjured controls and CAI participants have similar sway responses while completing cognitive tasks that stress different aspects of WM. As a result, the data failed to support our a priori hypotheses.

Rahnama et al. [8] identified significantly greater sway during a backward digit span test using the Biodex Stability System in those with CAI relative to controls. In the CAI literature, increased sway is often interpreted as impaired postural control [6,13,14], however it is possible that increased sway may reflect changes in postural control strategies. For instance, if resources are being shared between the WM task and the sensorimotor system [15], then decreasing the rate of postural adjustments would result in greater excursions of the COP as cognitive resources are being used for the WM task.

Table 2
Means and standard deviation of postural control time-to-boundary data. A larger number represents a more stable posture. Task means are pooled data for both groups. [a]Significantly different from baseline at $p < 0.05$. ML: medial–lateral; AP: anterior–posterior.

		Baseline (SD)	Backwards counting (SD)	Manikin test (SD)	Random number generation (SD)
ML min	Control	0.37 (0.07)	0.41 (0.13)	0.36 (0.07)	0.37 (0.08)
	CAI	0.35 (0.10)	0.37 (0.11)	0.42 (0.09)	0.40 (0.11)
	Task mean	0.36 (0.08)	0.39 (0.12)[a]	0.39 (0.08)[a]	0.39 (0.10)
AP min	Control	0.87 (0.26)	1.09 (0.25)	1.05 (0.37)	1.04 (0.33)
	CAI	0.81 (0.26)	0.97 (0.33)	0.97 (0.24)	0.92 (0.24)
	Task mean	0.84 (0.25)	1.03 (0.29)[a]	1.01 (0.31)[a]	0.98 (0.29)[a]
ML mean	Control	1.77 (0.38)	1.73 (0.43)	1.73 (0.37)	1.66 (0.37)
	CAI	1.85 (0.51)	1.79 (0.46)	1.93 (0.50)	1.74 (0.50)
	Task mean	1.81 (0.45)	1.76 (0.44)	1.82 (0.44)	1.70 (0.44)[a]
AP mean	Control	5.19 (1.06)	5.18 (1.32)	5.13 (1.22)	4.82 (1.20)
	CAI	5.20 (1.77)	4.92 (1.67)	5.18 (1.64)	4.96 (1.81)
	Task mean	5.19 (1.43)	5.05 (1.49)	5.16 (1.42)	4.89 (1.51)[a]
ML StDev	Control	1.43 (0.41)	1.29 (0.39)	1.34 (0.31)	1.26 (0.34)
	CAI	1.51 (0.54)	1.34 (0.35)	1.55 (0.53)	1.43 (0.49)
	Task mean	1.47 (0.48)	1.32 (0.36)[a]	1.44 (0.44)	1.35 (0.42)[a]
AP StDev	Control	3.47 (0.69)	3.25 (0.80)	3.33 (0.86)	3.01 (0.78)
	CAI	3.47 (1.18)	3.40 (1.25)	3.47 (1.11)	3.23 (1.13)
	Task mean	3.47 (0.94)	3.32 (1.03)	3.40 (0.98)	3.11 (0.96)[a]