Increased common corticospinal input during eyes-closed unilateral stance in people with chronic ankle instability

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Summary

Lateral ankle sprains are common, with 50% leading to recurrent sprains and chronic ankle instability (CAI). CAI is associated with neuromuscular impairments, with reduced spinal reflex excitability, while supraspinal mechanisms remain unclear. This study examined intermuscular coherence in CAI and its modulation by visual input. CAI exhibited greater beta-band coherence in antagonist muscle pairs under eyes-closed conditions than healthy controls, suggesting increased corticospinal drive. Beta-band coherence may serve as a biomarker for neuromuscular deficits, with potential implications for neuromodulation therapies.

Introduction

Lateral ankle sprains are among the most common musculoskeletal injuries with approximately 50% leading to recurrent sprains and chronic ankle instability (CAI) [1]. Neuromuscular control impairments in CAI during functional activities has been observed, with reduced spinal reflex excitability in the PL and soleus muscles, while supraspinal mechanisms remain controversial [2]. The role of ankle muscle coordination and common neural inputs during unipedal stance in CAI remains unexplored. This study aimed to compare intermuscular coherence between individuals with CAI and healthy controls during single-leg stance and examine how visual input influences coherence patterns.

Methods

Sixteen CAI (age: 22.2 ± 1.9, height: 1.73 ± 0.08 m, body mass: 75.9 ± 13.5 kg) and 16 healthy control (HC) (age: 23.3 ± 2.9, height: 1.72 ± 0.07 m, body mass: 68.4 ± 8.7 kg) participants performed single-leg balance tasks under eyes-open and eyes-closed conditions. Surface EMG was recorded from TA, PL, GM, and SOL using wireless electrodes (Trigno, DELSYS, 1925.925 Hz). Wavelet coherence coefficients were computed for each muscle pair, and coherence histograms (0–1, bin = 0.01) were generated. Mean coherence in the delta (0.5–5 Hz) and beta (15–35 Hz) bands was calculated using a weighted sum of histogram counts. A 2 × 2 repeated measures ANOVA (group × condition) was conducted, followed by Bonferroni post hoc tests.

Results and Discussion

Figure 1 demonstrates a clear strengthening of significant coherence share in both groups under EC compared to EO, within the 0.5-5 Hz for SOL-TA and 0.5-35 Hz for SOL-GM pair. Additionally, the CAI group exhibited greater significant coherence share compared to the HC group across the beta-band. Table 1 shows the mean coherence in five muscle pairs. Post hoc analysis demonstrated that during EC, the CAI group had significantly greater beta-band coherence in PL-SOL, PL-GM and SOL-TA compared to the HC group, suggesting the CAI may adopt a corticospinal adaptation strategy when visual information was removed. Strengthened beta-band coherence may indicate an adaptive response to increased postural demands, as suggested in older adults compared to young adults [3][4]. Combined with previous findings that suggest decreased corticospinal activation and increased intracortical inhibition, the current findings might indicate reduced corticospinal connectivity and activation in CAI [5]. The reduced corticospinal connectivity may enhance the transmission efficiency of common inputs from the central nervous system to motoneurons [6], resulting in higher beta-band coherence in CAI.

Table 1. Mean coherence (Mean±SD) for the CAI and HC during one-leg static standing during eyes open (EO) eyes closed (EC) condition

Muscle Pair	Frequency Band	Group: CAI Eyes Open	Group: CAI Eyes Closed	Group: HC Eyes Open	Group: HC Eyes Closed	P values (Partial Eta Squared): Interaction p	Interaction ηp^2	Group p	Group ηp^2	Condition p	Condition ηp^2
PL - TA	Delta	‡ **0.43 ± 0.15**	0.35 ± 0.14	0.32 ± 0.16	0.36 ± 0.10	**0.013**	**0.19**	0.297	0.04	0.449	0.019
	Beta	0.40 ± 0.11	0.40 ± 0.09	0.36 ± 0.10	0.34 ± 0.11	0.641	0.01	0.167	0.06	0.656	0.007
PL - SOL	Delta	0.36 ± 0.08	0.35 ± 0.07	0.35 ± 0.09	0.39 ± 0.10	0.192	0.06	0.532	0.01	0.409	0.023
	Beta	0.26 ± 0.07	†**0.28 ± 0.07**	0.24 ± 0.03	0.24 ± 0.04	0.158	0.07	0.092	0.09	0.23	0.048
PL - GM	Delta	0.33 ± 0.08	0.34 ± 0.07	0.33 ± 0.11	0.37 ± 0.08	0.528	0.01	0.559	0.01	0.194	0.056
	Beta	0.27 ± 0.05	†**0.29 ± 0.06**	0.25 ± 0.04	0.24 ± 0.05	**0.024**	**0.16**	**0.047**	**0.13**	0.751	0.003
SOL - TA	Delta	‡ **0.44 ± 0.11**	0.51 ± 0.14	‡ **0.44 ± 0.10**	0.51 ± 0.12	0.838	0.00	0.969	0.00	**< .001**	**0.345**
	Beta	0.31 ± 0.07	†**0.33 ± 0.06**	0.28 ± 0.04	0.29 ± 0.04	0.732	0.00	0.07	0.11	0.154	0.067
SOL - GM	Delta	‡ **0.37 ± 0.11**	0.51 ± 0.10	‡ **0.42 ± 0.11**	0.56 ± 0.11	0.687	0.01	0.162	0.06	**< .001**	**0.72**
	Beta	‡ **0.32 ± 0.05**	0.38 ± 0.06	‡ **0.32 ± 0.05**	0.37 ± 0.06	0.924	0.00	0.882	0.00	**< .001**	**0.702**

† Denotes significant difference between CAI the HC (p<0.05). Bonferroni adjusted for multiple comparisons.
‡ Denotes significant difference between EO and the EC conditions (p<0.05). Bonferroni adjusted for multiple comparisons.
Effect Size was estimated by Partial Eta squared (ηp^2).

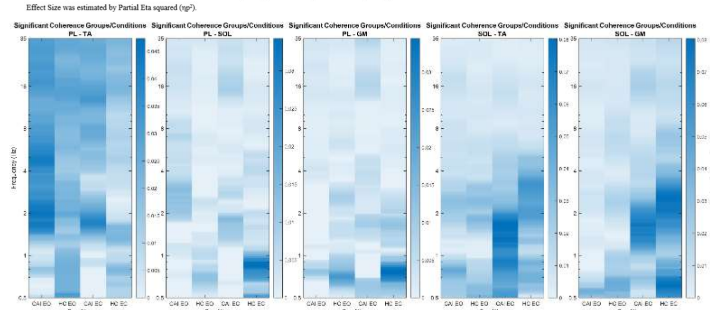

Figure 1. The heatmaps illustrate the five muscle pairs Significant Coherence Share G (%) across different frequency bands (0.5 Hz to 35 Hz) for two groups (CAI and HC) during single leg standing under eyes open (EO) and eyes closed (EC) conditions.

Conclusions

CAI exhibited greater beta-band intermuscular coherence in antagonist pairs during eyes-closed stance, indicating increased corticospinal drive. This coherence may serve as a non-invasive biomarker for neuromuscular deficits in CAI. Further research is needed to confirm its potential and explore transcranial direct current stimulation as a therapeutic option.

Acknowledgments

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