Chronic Ankle Instability Subjects Demonstrate Lower Rate of Torque Development in Ankle Eversion, Hip Abduction Muscles Compared to Healthy, Coper Groups

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ABSTRACT

Chronic ankle instability (CAI) is a pathological condition characterized by repeated lateral ankle sprains. Many ankle sprains are not a singular occurrence and can lead to perpetual disability, with some patients reporting repeated episodes of the ankle “giving way” during activity. CAI is multifactorial in nature, with contributors such as ligamentous laxity, strength deficit, and proprioceptive impairment (1). Each of these contributors negatively affects the muscles of the ankle complex.

Rate of torque development (RTD) is a metric demonstrating explosive muscle capability, and is related to measurement of maximal voluntary isometric contraction (MVIC). RTD is a more accurate reflection of functional strength than MVIC because peak torque generally occurs 300ms or more after the onset of torque generation (2) while the time available for torque production in a functional daily movement context is generally between 50-250ms (3). RTD is generally measured within the first 200ms of the trial and therefore better captures the muscle’s ability to generate strength for daily activities.

Understanding the relationship between RTD of the ankle evertor/invertor muscles and hip abductor muscles in individuals with CAI against healthy controls will better inform rehabilitation strategies and provide a benchmark of improvement for individuals recovering from CAI. **PURPOSE**: The purpose of this study was to better understand how CAI affects the force production capabilities of the ankle evertors/invertors, as well as the hip abductors. We hypothesized that individuals with CAI would

demonstrate lower RTD in all three muscle groups in comparison to healthy and coper controls.

METHODS: A total of 58 males and females participated in this study, and participants were divided into three cohorts. The first was a CAI patient group, a "coper" group, defined as individuals who can return to pre-injury levels of performance after LAS, and a healthy control group. CAI individuals and LAS copers were identified using the guidelines provided by the International Ankle Consortium (4). Subject exclusion criteria included previous history of lower extremity surgery, fracture, neurological disease affecting the lower extremity, or any injury to the lower extremity in the 3 months leading up to the study. Before data was obtained participants were familiarized with experimental procedures and protocols. Signed consent was obtained from each subject prior to data collection. The study was approved by the university institutional review board (Approval number: F2019-338). The study design required two visits from the subjects. The first visit was to familiarize subjects with the ankle eversion, inversion, and hip abduction movements they would be required to perform. On this day patients were also made familiar with the Biodex dynamometer (System Pro 4, Biodex Medical Systems, Inc., Shirley, NY; sampling rate: 100 Hz). On the second day subjects were seated on the dynamometer and performed 3 maximal voluntary isometric contractions (MVIC) of each movement. Patients were instructed to perform the movements as quickly as possible and to hold each trial for 5 seconds. Three trials were collected for each movement, with a minute separating each trial. Subjects were encouraged to give maximal effort through verbal cues. RTD and MVIC were calculated from each torque-time curve using custom code written in MatLab (MathWorks 2021a, Natick, MA). RTD was defined as the rate of change of the first 200ms of each trial; MVIC was defined as the peak value of each trial. RTD and MVIC values were averaged for each subject.

RESULTS: No statistically significant differences in sex, age, height, or mass were detected among subjects (Table 1). Table 2 shows mean RTD for each group for the ankle eversion, inversion, and hip abduction movements. Notable results from Table 2 include the finding that CAI patients demonstrated significantly lower RTD than healthy controls ($p = .02$) and lower RTD than LAS copers ($p = .03$). Furthermore, CAI patients showed lower hip abductor RTD than healthy controls ($p = .04$). Table 3 shows MVIC data for each group for each movement and demonstrates that CAI patients showed significantly lower MVIC of the ankle eversion muscles than healthy controls ($p = .02$). No statistically significant differences in any strength metrics were detected between LAS copers and healthy controls, nor were there differences detected between groups in the ankle inversion movement**. DISCUSSION**: The primary finding from this study was that CAI ankle eversion RTD was significantly lower than RTD in healthy controls. This is significant because it provides insight on the adverse effects of repeated LAS on the muscles of the ankle complex. One of the factors determining RTD is the force transmission capabilities of the tendinous structures (10), and it is possible that the stretching of the ankle ligaments during LAS negatively affects its ability to efficiently transmit force generated from the muscle.

Given the correlation between CAI patients and decreased RTD of ankle eversion muscles, it is possible that focusing on improvement in RTD of this muscle group could improve CAI symptoms. Numerous studies have focused on modalities targeted at improving RTD of the leg extensors muscle groups with generally positive results (5, 9), the majority of which include protocols that would be easily modifiable to the ankle eversion muscle group.

Another notable finding from this study was that RTD of the hip abductors in the CAI group was significantly less than that of the healthy group. Although studies exist that have measured maximal hip abduction isometric strength in CAI groups, to our knowledge this is the first study analyzing the RTD of hip abduction. Our findings of deficits in hip abduction strength coincide with those of previous studies (6-8). Whether deficits in hip abduction strength increase potential for LAS or arise as a result of CAI is unclear, but it is becoming evident that the two factors are related. This is a promising area of CAI research and further study is required to fully elucidate the relationship between CAI and hip abductor strength. **CONCLUSION**: RTD of the ankle evertors in individuals with CAI is significantly lower than in LAS copers and healthy controls. Additionally, CAI patients demonstrated significantly lower RTD in hip abduction than healthy controls. While the need for exploring muscle force production capabilities in individuals with CAI persists, we suggest exploring modalities targeted at improving ankle eversion and hip abduction strength in patients with CAI. It is possible that improving strength in these areas will help return CAI patients to pre-injury levels of function and further our understanding of CAI.

Table 1. Subject demographics

Characteristic	Group, Mean (SD)		
	CAI (n = 20)	Coper (n = 20)	Healthy (n = 20)
Sex, male/female	10/10	10/10	10/10
Age, y	23.6 (3.9)	22.2 (1.4)	22.6 (2.7)
Height, cm	174.5 (11.8)	176.4 (10.2)	174.4 (7.2)
Mass, kg	76.3 (17.5)	69.3 (10.9)	80.0 (24.4)
FAAM ADL, %	77 (7.3)	100 (0.0)	100 (0.0)
FAAM Sports, %	69 (4.6)	100 (0.0)	100 (0.0)
AII, No. of yes	6.4 (1.1)	0 (0.0)	0 (0.0)
Previous ankle sprains, No.	5 (1.7)	1 (1.1)	0 (0.0)

Abbreviations: y, years; No., number; CAI, chronic ankle instability; SD, standard deviation.

Table 2. Mean RTD

	RTD (mean±SD)			One-way ANOVA P value
	CAI	Copers	Healthy Controls	
Eversion*,**	0.30±0.17	0.45±0.28	0.46±0.16	0.04
Inversion	0.37±0.24	0.37±0.22	0.40±0.23	0.87
Hip Abductors†	1.30±0.80	1.82±1.02	1.92±0.93	0.10

*CAI patients showed lower RTD than Healthy controls (p=0.02)

**CAI patients showed lower RTD than Copers (p=0.03)

†CAI patients showed lower RTD than Healthy controls (p=0.04)

Table 3. Mean MVIC

	MVIC, N/kg (mean±SD)			One-way ANOVA P value
	CAI	Copers	Healthy Controls	
Eversion*	0.24±0.10	0.28±0.07	0.34±0.11	0.01
Inversion	0.34±0.11	0.32±0.08	0.35±0.09	0.68
Hip Abductors	1.12±0.40	1.09±0.42	1.32±0.35	0.17

*CAI patients showed lower MVIC than Healthy controls (p=0.02)

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