Differences in Lateral Drop Jumps From an Unknown Height Among Individuals With Functional Ankle Instability

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Context: Functional ankle instability (FAI) is a debilitating condition that has been reported to occur after 20% to 50% of all ankle sprains. Landing from a jump is one common mechanism of ankle injury, yet few researchers have explored the role of visual cues and anticipatory muscle contractions, which may influence ankle stability, in lateral jumping maneuvers.

Objective: To examine muscle-activation strategies between FAI and stable ankles under a lateral load and to evaluate the differences in muscle activation in participants with FAI and participants with stable ankles when they were unable to anticipate the onset of lateral loads during eyes-open versus eyes-closed conditions.

- Design: Case-control study.
- Setting: Controlled laboratory setting.

Patients or Other Participants: A total of 40 people participated: 20 with FAI and 20 healthy, uninjured, sex- and age-matched persons (control group).

Intervention(s): Participants performed a 2-legged lateral jump off a platform onto a force plate set to heights of 35 cm or 50 cm and then immediately jumped for maximal height. They

performed jumps in 2 conditions (eyes open, eyes closed) and were unaware of the jump height when their eyes were closed.

Main Outcome Measure(s): Amplitude normalized electromyographic (EMG) area (%), peak (%), and time to peak in the tibialis anterior (TA), peroneus longus (PL), and lateral gastrocnemius (LG) muscles were measured.

Results: Regardless of the eyes-open or eyes-closed condition, participants with FAI had less preparatory TA ($t_{158} = 2.22$, P = .03) and PL ($t_{158} = 2.09$, P = .04) EMG area and TA ($t_{158} = 2.45$, P = .02) and PL ($t_{158} = 2.17$, P = .03) peak EMG than control-group participants.

Conclusions: By removing visual cues, unanticipated lateral joint loads occurred simultaneously with decreased muscle activity, which may reduce dynamic restraint capabilities in persons with FAI. Regardless of visual impairment and jump height, participants with FAI exhibited PL and TA inhibition, which may limit talonavicular stability and intensify lateral joint surface compression and pain.

Key Words: electromyography, peroneus longus, tibialis anterior, neuromuscular control

Key Points

- Participants with functional ankle instability (FAI) had less preparatory electromyographic (EMG) area and less peak EMG amplitude in the peroneus longus and tibialis anterior compared to control participants.
- When landing from a lateral jump, participants with FAI exhibited muscle-activation strategies that were different from those of participants with stable ankles.
- Participants with FAI did not appropriately increase dynamic stability relative to the functional demands.
- Decreased activation in the peroneus longus and tibialis anterior before landing from unknown heights has important clinical applications because it may place persons with FAI at risk for further injury during athletic activities.

A nkle injuries are one of the most common injuries in athletes, and evidence suggests that the cause of injury may not always involve mechanical laxity but rather complex abnormalities within the sensorimotor system.¹⁻³Approximately 50% of the population with lateral sprains experiences functional ankle instability (FAI), which is a frequent and serious pathologic sequela.^{4,5} These persons often present with sensations of the ankle "giving way" and sudden "rollover" events, which are characteristic of FAI.^{1,3} Several factors contributing to FAI have been proposed to result from the failure of the

dynamic restraint mechanism, such as deficits in kinesthetic awareness and balance, weakness of the musculature, mechanical laxity, and many other influences.^{1,3,6–10} However, limited data are available to establish whether persons with FAI attempt to negotiate sensory conflicts with different dynamic restraint strategies when confronted with sudden lateral ankle loading during functional activities.¹¹

Sudden bouts of instability to the ankle can occur during many functional tasks, including walking, running, cutting, and jumping.¹² During athletic competition, the combina-

tion of high-speed, ballistic-like movements and rapid joint loading requires people to use feed-forward motor control to execute preprogrammed movement strategies.¹³ Based on past experiences, the central nervous system develops and executes the preactivation strategies to anticipate the expected joint loads associated with specific maneuvers.^{14,15} Preactivation of muscles is an important contributor to joint stability because properly tensioned muscles optimize joint stiffness for dynamic restraint and functional performance capabilities.^{16–19} If somatosensory information is misinterpreted or incompatible with physical events, optimal stiffness may not be achieved, and both functional performance and joint stability may be compromised.

Much of the previous research on muscle activation has focused on various types of forward or sagittal-plane movements (ie, forward gait, forward hopping, running).^{7–11,13} In a study on gait, Caulfield and Garrett⁷ reported increased electromyographic (EMG) amplitude in the peroneus longus (PL) after heel strike among persons with FAI. In addition, decreased PL EMG amplitude has been observed before landing from a jump.^{7,8} These differences in EMG activation of the PL may reflect compensatory strategies to dynamically protect the ankle joint from excessive inversion. In walking and forward-landing research, investigators^{8,9,11,13} have provided some evidence of neuromuscular disparities in persons with FAI during activity. However, lateral maneuvers are also important functional tasks involved in the pathomechanics of injury and have not been measured adequately.

Given that most athletic maneuvers are executed in multiplanar directions and that a combination of inversion and plantar flexion is a common contributor to ankle injury, researchers need to examine movements within other functional planes, such as lateral jumping.^{3,20} Docherty et al²⁰ suggested that measurable functional performance deficits are present during lateral hopping in participants with instability, but no deficits are present when they are executing sagittal-plane functional movements. In earlier research, Delahunt et al¹¹ also demonstrated that participants with FAI have less eversion from 45 milliseconds before contact to 95 milliseconds after contact and have increased EMG activity in the tibialis anterior (TA) and soleus muscles during a lateral hop. These data show the differences of anticipatory muscle activation and joint positioning in preparation for joint loading and illustrate that participants with FAI may present with incorrect neuromuscular control strategies that could predispose them to future episodes of instability.

In addition, increased EMG activity in the surrounding musculature has been seen with an increase in jump height.^{15,21} Consequently, when a person knows there is a large drop-jump height, the amount of muscle stiffness increases to account for the increase in anticipated forces that will be placed on the ankle.^{15,21} However, during physical activity, sensory conflict may occur and disrupt preparatory motor planning. If visual clues are lacking or conflicting, other input, such as proprioceptive and vestibular information, is necessary to modulate preactivation of muscles and navigate safe landings.¹⁵

Muscle-activation strategies may be altered in patients with FAI and may influence dynamic restraint capabilities. It is not known whether persons with FAI execute normal

Table 1. Summary of Demographics for Uninjured Control and Functional Ankle Instability Groups (Mean \pm SD)

	· /		
	Group		
Characteristic	Uninjured Control	Functional Ankle Instability	
Men, n	10	10	
Women, n	10	10	
Age, y	20.6 ± 2.4	20.9 ± 2.3	
Height, cm	173.9 ± 9.9	173.1 ± 8.1	
Mass, kg	75.6 ± 18.5	76.23 ± 16.2	
Cumberland Ankle Instability Tool score	29.8 ± 0.5	20.4 ± 4.2	
Previous sprains, n	0 ± 0	4.45 ± 3.2	

preactivation strategies during lateral drop jumps or how they respond to conditions where they cannot anticipate the jump height. Potential differences in the preactivation of muscles in persons with FAI versus persons with stable ankles may provide insight about compensatory movement strategies underlying chronic sensations of the ankle giving way and instability. To our knowledge, no researchers have observed drop jumps with lateral loading of the ankle or have examined the effects of anticipatory muscle preactivation in FAI participants under unknown landing conditions. Therefore, the purpose of our research was 2-fold: (1) to examine muscle-activation strategies between persons with FAI and those with stable ankles under a lateral load and (2) to evaluate the differences in muscle activation in participants with FAI and participants with stable ankles when they were unable to anticipate the onset of lateral loads during eyes-open versus eyes-closed conditions.

METHODS

Participants

Forty persons (20 with FAI and 20 healthy, sex- and agematched control participants) volunteered for this study. They were assigned to the FAI group if they had a history of ankle sprains and Cumberland Ankle Instability Tool (CAIT) score ≤ 24 ; in those with bilateral FAI, the ankle with the lower CAIT score was considered the test limb.²² The 20 matched control participants had no history of ankle sprains and CAIT scores ≥ 29 . Participants in both groups who had sustained ankle injuries within 1 year of the study period were excluded. All participants provided written informed consent, and the study was approved by the University of Delaware Human Subjects Review Board (HS 08–105). Summary data on participants assigned to both groups are provided in Table 1.

Procedures

Rectangular 0.875-in (2.22 cm) \times 1.25-in (3.175 cm) Ag/AgCl disposable electrodes (Phillips Medical Systems, Andover, MA) were placed over the TA, PL, and lateral gastrocnemius (LG) muscles. The interelectrode distance was 2 cm, and electrodes were arranged on the skin to ensure that they were aligned parallel with the muscle fibers.²³ To reduce impedance at the skin-electrode interface, the skin of each electrode site was shaved, abraded, and cleaned with isopropyl alcohol. A single



Figure 1. Testing setup for the right ankle. A, Participants were instructed to stand on an adjustable platform (Central Hydrolics, Camarillo, CA) next to an AMTI (Watertown, MA) force plate set to 35 cm or 50 cm (50 cm is shown). B, Next, they performed a lateral 2-legged drop jump followed by a jump for maximal height.

reference electrode was placed on the ipsilateral patella. An 8-channel telemetered EMG transmitter (Konigsberg Instruments Inc, Pasadena, CA) was used for data collection.

Participants were instructed to stand on a hydraulic platform (Central Hydraulics, Camarillo, CA) sideways with the testing ankle closest to the edge (Figure 1). We instructed them to perform a 2-legged lateral jump off the platform onto the center of a force plate (AMTI, Watertown, MA) followed by an immediate jump for maximal height. For safety concerns, participants were permitted to open their eyes after they contacted the ground and to visualize the vertical target. Vertical jump height was measured with a jump trainer (Vertec; Sports Imports, Columbus, OH). They performed 10 jumps (5 jumps at 50 cm and 5 jumps at 35 cm) with their eyes open. Next, they performed 10 jumps (5 jumps at 50 cm and 5 jumps at 35 cm) with their eyes closed. During each eyes-closed jumping trial, the height was randomized and unknown to the participants. The platform with the participant standing on it was capable of lowering at imperceptibly slow velocities to 1 of 2 heights (35 cm or 50 cm) so the estimation of final jump height position was not detectable. If participants opened their eyes before landing or missed the force plate, the trial was discarded. Although unsuccessful trials were recorded, they were not used in the statistical analysis. Participants were given as many practice trials in the eyes-open condition as they wanted, but no practice trials in the eyes-closed condition were given. They had approximately 30 seconds between trials.

Data Analysis

All EMG and force-plate data were sampled at 960 Hz (version EVaRT 5.1.1; Motion Analysis Corp, Santa Rosa, CA). A single-ended amplifier with an impedance greater than 10 $M\Omega$ and a gain of 1000 was used with a fourthorder Butterworth filter (20 to 500 Hz) and a commonmode rejection ratio of 130 dB at DC (minimum 85 dB across the entire frequency of 10 to 500 Hz). A receiver with a sixth-order filter and a total gain of 2000 further amplified the signal. The signal was then converted from analog to digital with an analog-to-digital card (model Metrabyte DAS-1000; Keithley Instruments Inc, Tauton, MA). The EMG data were band-pass filtered with a secondorder, zero-lag, Butterworth filter that had cutoff frequencies of 10 Hz and 500 Hz and were rectified. We used the force plate to denote when ground contact was achieved. We analyzed all EMG data with a custom-written Lab-VIEW (version 8.21; National Instruments, Austin, TX) program. The EMG data were normalized to the ensemble peak of the 50-cm eyes-open trial. The EMG area was calculated as the integral of the normalized EMG data. The data were marked using the vertical ground reaction force as an indicator of initial ground contact. Data were then extracted between 2 periods of interest: 150 milliseconds before ground contact and 250 milliseconds after ground contact. We averaged the EMG data over 3 trials across the 4 jumping conditions (eyes open at 35 cm and 50 cm and eyes closed at 35 cm and 50 cm). The dependent variables of interest were EMG activity area before and after contact, peak EMG activity before and after contact, and time to peak EMG activity. Based on the preliminary analysis of

Open and Eyes-Closed Conditions (Mean \pm SD)				
Muscle	Group	Condition	Electromyographic Activity Area, % Maximal Voluntary Isometric Contraction	
			Preparatory	Reactive
Tibialis anterior	Control	Eyes open	1.54 ± 2.18	5.13 ± 5.58
		Eyes closed	0.91 ± 0.83	6.12 ± 8.40
		Total	1.23 ± 1.67	5.63 ± 7.10
	Functional ankle instability	Eyes open	1.05 ± 0.89	3.19 ± 2.85
	-	Eyes closed	0.74 ± 1.06	2.31 ± 2.86
		Total	0.90 ± 0.98	2.75 ± 2.87
	Total	Eyes open	1.30 ± 1.67	4.16 ± 4.51
		Eyes closed	0.82 ± 0.95	4.22 ± 6.52
Peroneus longus	Control	Eyes open	2.78 ± 4.70	10.43 ± 18.59
-		Eyes closed	1.05 ± 1.34	8.44 ± 19.47
		Total	1.91 ± 3.54	9.43 ± 18.94
	Functional ankle instability	Eyes open	0.99 ± 0.79	3.89 ± 5.93
		Eyes closed	1.01 ± 1.82	2.93 ± 5.01
		Total	1.00 ± 1.39	3.41 ± 5.48
	Total	Eyes open	1.88 ± 3.47	7.16 ± 14.10
		Eyes closed	1.03 ± 1.59	5.68 ±14.40
_ateral gastrocnemius	Control	Eyes open	1.67 ± 3.22	7.32 ± 11.53
		Eyes closed	0.69 ± 0.67	11.61 ± 48.89
		Total	1.18 ± 2.36	9.46 ± 35.36
	Functional ankle instability	Eyes open	0.80 ± 0.90	3.98 ± 9.06
		Eyes closed	0.83 ± 1.72	2.52 ± 4.27
		Total	0.82 ± 1.36	3.25 ± 7.07
	Total	Eyes open	1.24 ± 2.39	5.65 ± 10.44
		Eves closed	0.76 ± 1.30	7.07 ± 34.78

Table 2. Preparatory (150 ms Before Contact) and Reactive (250 ms After Contact) Electromyographic Activity Area of the Tibialis Anterior, Peroneus Longus, and Lateral Gastrocnemius Muscles in the Control and Functional Ankle Instability Groups Within the Eyes-Open and Eyes-Closed Conditions (Mean \pm SD)

the data, we found no differences in EMG activity between the heights, so the heights were pooled for the final statistical analysis.

The data were analyzed using a 2 (eyes open, eyes closed) $\times 2$ (control, FAI) multivariate analysis of variance (MANOVA). We used a 2 \times 2 MANOVA rather than a series of 2 \times 2 univariate analyses of variance (ANOVAs) for 3 reasons. First, single dependent variables rarely capture a phenomenon completely. Multiple measures provide researchers with a certain amount of useful redundancy through the correlation of the multiple measures and the ability to broaden or enhance the conceptual domain under study.^{24,25} Second, MANOVA reduces the experiment-wise error rate relative to AN-OVA.^{26,27} Third, MANOVA is more realistic because it captures the full network of intercorrelations among the dependent variables.^{28,29}

Two independent variables with 2 levels each were included in the MANOVA: control group versus FAI group and eyes-open condition versus eyes-closed condition (averaged over both heights). The 15 total dependent variables included in the MANOVA were preparatory and reactive TA area and peak, preparatory and reactive PL area and peak, preparatory and reactive LG area and peak, TA time to peak, PL time to peak, and LG time to peak. When the Box M test value was different, it indicated unequal variance-covariance matrices of the dependent variables across the 2 independent variables and, therefore, necessitated use of the Pillai trace to assess the multivariate effects.^{29,30}

We conducted post hoc comparisons when needed for each dependent variable and used independent-samples t tests with the Bonferroni adjustment to control the experiment-wise α error rate.³¹ All statistical analyses were conducted using IBM SPSS software (version 19.0, IBM Corporation, Armonk, NY). The α level was set at equal to or less than .05.

RESULTS

Distributional statistics for the dependent variables are presented for each group in Tables 2 through 4. All assumptions regarding the use of MANOVA were met with the exception of the Box M test, which was different ($F_{408.0, 551396.6} = 6.60, P = .001$). We did not find a multivariate main effect for eye condition (Pillai trace = $0.116, F_{16,142} = 1.16, P = .31$) or an eye condition-byinstability group interaction (Pillai trace = $0.101, F_{16,141} =$ 0.995, P = .47). By contrast, the multivariate main effect for the control versus FAI group showed that the dependent variables as a set were affected by the membership in the 2 groups (Pillai trace = $0.274, F_{16,142} =$ 3.32, P < .001).

Using post hoc tests, we found differences in the following dependent variables where the FAI group had decreased preparatory TA EMG activity area ($t_{158} = 2.22$, P = .03) and peak EMG activity ($t_{158} = 2.45$, P = .02) (Figure 2). The participants with FAI also had decreased preparatory PL EMG activity area ($t_{158} = 2.09$, P = .04) and peak EMG activity ($t_{158} = 2.17$, P = .03) (Figure 3). We found no differences among any of the dependent variables associated with the LG or any time-to-peak variables (P > .05).

Table 3. Preparatory (150 ms Before Contact) and Reactive (250 ms After Contact) Peak Electromyographic Activity of the Tibialis Anterior, Peroneus Longus, and Lateral Gastrocnemius Muscles in the Control and Functional Ankle Instability Groups Within the Eyes-Open and Eyes-Closed Conditions (Mean \pm SD)

			Peak Electromyographic Activity, %	
Muscle	Group	Condition	Preparatory	Reactive
Tibialis anterior	Control	Eyes open	30.78 ± 47.21	68.27 ± 86.25
		Eyes closed	16.75 ± 15.86	91.05 ± 154.89
		Total	23.77 ± 36.70	79.66 ± 125.09
	Functional ankle instability	Eyes open	20.67 ± 20.66	48.66 ± 67.82
		Eyes closed	12.79 ± 15.79	27.21 ± 34.23
		Total	16.73 ± 18.69	37.94 ± 54.46
	Total	Eyes open	25.73 ± 36.56	58.47 ± 77.72
		Eyes closed	14.77 ± 15.85	59.13 ± 115.99
Peroneus longus	Control	Eyes open	54.26 ± 94.62	128.06 ± 203.44
		Eyes closed	20.17 ± 26.25	161.45 ± 538.52
		Total	37.21 ± 71.10	144.75 ± 404.82
	Functional ankle instability	Eyes open	19.21 ± 20.40	72.66 ± 167.20
		Eyes closed	17.37 ± 28.95	36.18 ± 65.38
		Total	18.29 ± 24.90	54.42 ± 127.47
	Total	Eyes open	36.73 ± 70.26	100.36 ± 187.11
		Eyes closed	18.77 ± 27.49	98.81 ± 386.33
Lateral gastrocnemius	Control	Eyes open	28.18 ± 47.89	114.18 ± 229.06
		Eyes closed	12.80 ± 13.48	311.16 ± 116.05
		Total	20.49 ± 35.80	212.67 ± 182.63
	Functional ankle instability	Eyes open	19.85 ± 38.30	60.79 ± 150.25
		Eyes closed	14.98 ± 30.44	30.65 ± 54.08
		Total	17.41 ± 34.46	45.72 ± 113.22
	Total	Eyes open	24.01 ± 43.29	87.48 ± 194.34
		Eyes closed	13.89 ± 23.42	170.91 ±152.81

DISCUSSION

We investigated the differences in EMG activity characteristics between participants with and without FAI

Table 4. Time to Peak Electromyographic Activity of the Tibialis Anterior, Peroneus Longus, and Lateral Gastrocnemius Muscles in the Control and Functional Ankle Instability Groups Within the Eyes-Open and Eyes-Closed Conditions (Mean \pm SD)

Muscle	Group	Condition	Time to Peak Electromyographic Activity, ms
Tibialis anterior	Control	Eyes open	0.14 ± 0.04
		Eyes closed	0.14 ± 0.05
		Total	0.14 ± 0.05
	Functional ankle	Eyes open	0.16 ± 0.04
	instability	Eyes closed	0.17 ± 0.04
		Total	0.16 ± 0.04
	Total	Eyes open	0.15 ± 0.04
		Eyes closed	0.16 ± 0.05
Peroneus longus	Control	Eyes open	0.12 ± 0.04
		Eyes closed	0.14 ± 0.04
		Total	0.13 ± 0.04
	Functional ankle	Eyes open	0.13 ± 0.05
	instability	Eyes closed	0.14 ± 0.05
		Total	0.14 ± 0.05
	Total	Eyes open	0.13 ± 0.04
		Eyes closed	0.14 ± 0.05
Lateral	Control	Eyes open	0.14 ± 0.05
gastrocnemius		Eyes closed	0.15 ± 0.05
		Total	0.14 ± 0.05
	Functional ankle	Eyes open	0.14 ± 0.05
	instability	Eyes closed	0.13 ± 0.05
		Total	0.13 ± 0.05
	Total	Eyes open	0.14 ± 0.05
		Eyes closed	0.14 ± 0.05

during eyes-open and eyes-closed lateral drop jumps. We observed that EMG activity was different between groups. The participants with FAI showed decreases in EMG amplitude in both TA and PL muscles, specifically the preparatory TA EMG activity area and peak EMG activity and preparatory PL EMG activity area and peak activity EMG.

The decreases in muscle activation in our study support the premise that participants with FAI exhibit muscleactivation strategies that are different from those of participants with stable ankles when landing from a lateral jump. Although the lateral drop jump has never been studied, similar movements have had somewhat conflicting results. Delahunt et al⁹ studied people who performed single-legged drop jumps and found that only the precontact muscle activity of the PL was less in those with than those without FAI. In another study by Delahunt et al,¹¹ EMG amplitude increased for preground and postground contact in persons with FAI for the TA and soleus muscles during a lateral hop. The results of our study have some congruence with portions of each of the previous studies. In those studies, either the TA or PL differed in muscle activation in persons with FAI. However, in our study, both the TA and PL appeared to play important roles to dynamically protect the ankle with a sudden lateral load in those with FAI. Our procedure involved the use of a 2legged lateral drop jump, whereas other researchers have used a single-legged forward drop jump. Either the 2legged or the lateral jumping aspects of our procedure could have accounted for the differences in EMG activation strategies.

Researchers^{32,33} have emphasized that the peroneal muscles eccentrically control inversion in the ankle. However, the TA, which is an invertor and dorsiflexor of the ankle, also has been



Figure 2. Preparatory and reactive electromyographic area (percentage maximal voluntary isometric contraction) between the control and functional ankle instability groups in the tibialis anterior. ^a Indicates a difference between groups (P < .05).

shown to activate differently during lateral maneuvers in persons with FAI than in persons with stable ankles.¹¹ In terms of strength, several investigators³⁴⁻³⁶ have not reported differences in invertor strength between participants with and without FAI. On the contrary, in 2 separate studies, researchers^{37,38} showed less invertor strength in participants with FAI than in participants with stable ankles. Inhibition of the TA in participants with FAI may expose the lateral ankle structures to greater stress and subsequent pain. Weakness of the invertors may be ineffective in stabilizing the talonavicular joint during activity, which could cause increased foot pronation. This increased pronation is linked to intensified compression of the lateral joint surfaces, and anterolateral compression has been identified as a source of pain in conjunction with FAI.^{13,39} The decrease in preparatory muscle activity of the TA further substantiates the important role of the TA in dynamic stabilization of the ankle during athletic maneuvers.

Investigators have reported that EMG muscle activity during landing activities decreased when participants' eyes were closed.^{21,40,41} We found no main effects between the eyes-open and eyes-closed conditions; however, nearly every preparatory EMG activity value had decreased area and peak EMG activity, whereas reactive EMG activity remained similar across conditions. This finding is similar to the findings of previous investigators^{21,40,41} studying landings from unknown heights. Greenwood and Hopkins et al⁴⁰ examined EMG activity in participants wearing blindfolds and without knowledge of landing heights of 15, 30, and 50 cm. They found decreased muscle activity in the soleus before ground contact.40 In a similar study, Freedman et al⁴¹ reported that when participants were blindfolded, they could not anticipate the height of the step down. This resulted in suppressed EMG amplitude before ground contact of the gastrocnemius and soleus compared with stable descent.⁴¹ Our results suggest that the ability to achieve proper muscle-activation levels may be compromised when people cannot anticipate the height from which they are landing. The potential suppression of muscle activity may be detrimental to joint stability and may expose the ankle to injury at or immediately after ground contact. If preactivation is inadequate, muscles are incapable of sufficiently absorbing joint loads, and the ligamentous structures may be exposed to excessive forces.42

Aberrations in the muscle-activation strategies of persons with FAI may suggest their dependence on visual information. During sporting events and many activities



Figure 3. Preparatory and reactive electromyographic area (percentage maximal voluntary isometric contraction) between the control and functional ankle instability groups in the peroneus longus. ^a Indicates a difference between groups (P < .05).

of daily living, visual cues may be misinterpreted, and persons with FAI may be placed at higher risk for injury. A reliance on visual feedback in people reporting functional joint instability has also been observed at the knee joint in persons with anterior cruciate ligament abnormalities.^{43,44} Similarly, persons with FAI may be subject to further injury when they cannot see where they are landing or when they land on another player. Sometimes, people land earlier than expected during athletic competition or activities of daily living. However, persons with and without FAI possibly have alternative visual-motor strategies when landing from unknown heights. People with FAI may not be compensating for impending precarious movements when they land unexpectedly. Therefore, when the foot contacts the floor earlier than anticipated, the person needs more time to achieve proper muscle-activation levels necessary for adequate joint stability.

Our method in a controlled laboratory setting may also be a novel and safe way to clinically expose people to unknown drop-jump landings. Motor-control and sensoryintegration concepts emphasize the importance of peripheral information in the development of new motor sequences based on previous experiences.^{45,46} Ankle sprain rehabilitation involving sensory conflicts may be a gateway into the potential reestablishment of preparatory motorcontrol programs within the neuromuscular control system, which is beneficial to dynamic restraint. The controlled and progressive exposure to somewhat unpredictable lateral joint loads may permit people to create new muscleactivation strategies. An integration of activities, such as those in ankle sprain rehabilitation, may help promote the maintenance of dynamic restraint capabilities to prepare athletes for unconstrained functional settings, such as practice and game situations. Given the growing evidence that a failure of the dynamic restraint mechanism primarily leads to episodes of the ankle giving way, a novel technique such as this may be critical for persons with FAI.^{47–49} Researchers may want to focus on different types of perturbations and incorporate more functional activities in rehabilitation.

Our study had some limitations. We studied only EMG during this protocol, so we cannot draw conclusions about the kinematic effect that an unknown lateral drop jump may have on the ankle. Researchers may want to observe both kinematic and kinetic variables associated with unknown lateral drop jumps to help identify other differences between participants with and without FAI. We also recognize the importance of other muscles in the lower extremity that help dynamically stabilize the ankle. Whereas the TA, PL, and LG are the prominent muscles frequently used to assess EMG activity in FAI studies, they are not the only contributors to ankle-joint stability.

CONCLUSIONS

The ability of the musculature to dynamically stabilize and protect the ankle during functional movements is paramount. Persons with FAI do not appropriately increase dynamic stability relative to the functional demands. The decreased activation in the TA and PL before landing from unknown heights is important for clinical applications because it may place persons with FAI at risk for further injury during athletic activities.

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