Clinical Examination Results in Individuals With Functional Ankle Instability and Ankle-Sprain Copers

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Context: Why some individuals with ankle sprains develop functional ankle instability and others do not (ie, copers) is unknown. Current understanding of the clinical profile of copers is limited.

Objective: To contrast individuals with functional ankle instability (FAI), copers, and uninjured individuals on both self-reported variables and clinical examination findings.

Design: Cross-sectional study.

Setting: Sports medicine research laboratory.

Patients or Other Participants: Participants consisted of 23 individuals with a history of 1 or more ankle sprains and at least 2 episodes of giving way in the past year (FAI: Cumberland Ankle Instability Tool [CAIT] score = 20.52 ± 2.94 , episodes of giving way = 5.8 ± 8.4 per month), 23 individuals with a history of a single ankle sprain and no subsequent episodes of instability (copers: CAIT score = 27.74 ± 1.69), and 23 individuals with no history of ankle sprain and no instability (uninjured: CAIT score = 28.78 ± 1.78).

Intervention(s): Self-reported disability was recorded using the CAIT and Foot and Ankle Ability Measure for Activities of Daily Living and for Sports. On clinical examination, ligamentous

laxity and tenderness, range of motion (ROM), and pain at end ROM were recorded.

Main Outcome Measure(s): Questionnaire scores for the CAIT, Foot and Ankle Ability Measure for Activities of Daily Living and for Sports, ankle inversion and anterior drawer laxity scores, pain with palpation of the lateral ligaments, ankle ROM, and pain at end ROM.

Results: Individuals with FAI had greater self-reported disability for all measures ($P < .05$). On clinical examination, individuals with FAI were more likely to have greater talar tilt laxity, pain with inversion, and limited sagittal-plane ROM than copers ($P < .05$).

Conclusions: Differences in both self-reported disability and clinical examination variables distinguished individuals with FAI from copers at least 1 year after injury. Whether the deficits could be detected immediately postinjury to prospectively identify potential copers is unknown.

Key Words: laxity, chronic ankle instability, giving way, range of motion

Key Points

- Compared with copers, participants with functional ankle instability had greater self-reported disability, talar tilt laxity, and pain with inversion and limited sagittal-plane range of motion.
- Identifying dynamic coping mechanisms may help to improve ankle-sprain prevention and treatment strategies.

Functional ankle instability (FAI) is a common sequela of ankle sprain, affecting approximately 32% to 47% of patients with symptoms including sensations of giving way, subsequent sprains, and instability.^{1–3} Because these symptoms can limit physical activity and activities of daily living for years after injury^{2,3} and decrease quality of life,¹ significant resources have been dedicated to elucidating the mechanisms behind this condition. However, despite extensive research in this area, the factors that contribute to the development and continuation of FAI are still not clear.^{4–6}

In the search to clarify current understanding, recent reports^{7,8} have focused on ankle instability definitions and patient inclusion criteria. Delahunt et al⁷ highlighted the varied inclusion criteria in studies of chronic ankle instability and FAI. They emphasized that variability in

the pathologic group may partially account for inconsistent findings in the research literature. In contrast to the highly variable FAI groups, the comparison groups in studies of ankle instability are very consistent. Comparison groups are generally individuals who have never sprained either ankle (the uninjured or control group).⁹ Some authors^{10,11} have studied copers as an alternative comparison group: individuals with a history of lateral ankle sprain but no recurrent instability for at least 1 year postinjury. Rather than compare individuals with FAI with individuals who have never sprained an ankle, it may be more appropriate to compare them with individuals who have been exposed to the initial risk factor (lateral ankle sprain) but have not gone on to develop FAI.¹⁰ Although the precise mechanism of coping is still unknown,^{11–14} insight into coping mechanisms may help explain why individuals with FAI are

Table 1. Participants' Demographics and Injury History

Descriptor	Group, Mean $\pm$ SD			Statistic	P Value
	Functional Ankle Instability (n = 23)	Coper (n = 23)	Uninjured (n = 23)		
Age, y	23.30 $\pm$ 3.84	23.52 $\pm$ 3.68	23.17 $\pm$ 4.01	$F_{2,66} = 0.048$	.953
Height, m	1.71 $\pm$ 0.11	1.72 $\pm$ 0.07	1.72 $\pm$ 0.08	$F_{2,66} = 0.186$	.830
Weight, kg	68.66 $\pm$ 14.60	69.57 $\pm$ 13.94	68.78 $\pm$ 13.26	$F_{2,66} = 0.029$	.972
Cumberland Ankle Instability Tool score ^a	20.52 $\pm$ 2.94 ^c	27.74 $\pm$ 1.69	28.78 $\pm$ 1.78	$F_{2,66} = 95.38$	<.001
Foot and Ankle Ability Measure Activities of Daily Living subscale, % ^b	96.36 $\pm$ 3.39 ^c	99.54 $\pm$ 1.25	99.79 $\pm$ 0.57	$F_{2,66} = 18.92$	<.001
Foot and Ankle Ability Measure Sports, % ^b	89.76 $\pm$ 6.19 ^c	98.70 $\pm$ 3.68	97.83 $\pm$ 8.86	$F_{2,66} = 12.85$	<.001
Initial ankle sprain evaluated by a medical professional?	19 yes 4 no	16 yes 7 no	NA	$\chi^2_1 = 1.08$	.300
Severity of initial ankle sprain	2 mild 6 moderate 4 severe 11 unknown	3 mild 4 moderate 2 severe 14 unknown	NA	NA	
Limited weight bearing, d	11.74 $\pm$ 14.06	5.86 $\pm$ 6.58	NA	$F_{1,41} = 3.17$	.084

Abbreviation: NA, not applicable.

^a Maximum score = 30, with lower scores indicating decreased stability.

^b Maximum score = 100, with lower scores indicating decreased function.

^c Functional ankle instability group scored lower than the coper and uninjured groups.

unable to cope after ankle sprain. Additionally, once identified, successful coping mechanisms may be useful in treating FAI.

In recent years, a number of authors have included comparison groups of ankle-sprain copers.^{11–14} Differences in functional performance,¹¹ self-assessed disability,^{11–14} ligamentous laxity,¹² injury history,^{11–13} lower extremity kinematics,¹⁴ ankle-joint stiffness,¹³ fibular position,¹³ and postural control^{13,15} have been investigated. However, more information about the clinical profiles of these individuals is needed because it may help us to prospectively differentiate potential copers and noncopers (postsprain but before development of FAI). Clinicians could then target individuals who are likely to have recurrent injury, leading to more efficient use of resources and enhanced injury-prevention efforts. Such a prospective clinical screening evaluation already exists for patients with anterior cruciate ligament injuries.¹⁶ However, the ankle-instability literature is still several steps away from this type of measure.

We believe one of the next steps to better understand ankle-sprain copers is to compile a profile of a typical coper, consisting of injury history, self-reported disability, and clinical examination and to compare that profile with the profiles of both individuals with FAI and uninjured individuals. Thus, the primary purpose of our study was to explore potential group (FAI, coper, and uninjured) differences in both self-reported variables (injury history and disability) and clinical examination variables (laxity, pain, and range of motion).

METHODS

Participants

We studied 23 individuals with FAI, 23 individuals with a history of an ankle sprain but no instability (copers), and 23 individuals with no history of ankle sprain (uninjured). Participants were recruited from a large metropolitan area,

including a university campus. Each group contained 12 men and 11 women (Table 1). This study was approved by the university's institutional review board.

Volunteers reported for a single visit to the sports medicine research laboratory. After informed consent was provided, participants completed an injury-history questionnaire and the Cumberland Ankle Instability Tool (CAIT). A customized computer program (version 2003; Access, Microsoft Corporation, Redmond, WA) recorded and scored CAIT responses. The CAIT has excellent test-retest reliability (intraclass correlation coefficient [ICC]_{2,1} = 0.96), and is scored on a 30-point scale, with lower scores indicating decreased stability.¹⁷ The injury-history form collected information about the initial ankle sprain, symptoms of giving way and resprains, history of lower extremity fractures or surgeries, and limb dominance. If the initial ankle sprain was evaluated and graded by a medical professional, we asked the participant to report the diagnosed severity of injury. However, because this was a retrospective study, we did not have control over the exact grading criteria used by each professional. This is a limitation of the study, but we believed that limited data on the severity of the initial injury were better than no data. Choices were mild (grade 1), moderate (grade 2), severe (grade 3), or unknown (could not remember). All sprains that were not evaluated by a medical professional were labeled as unknown severity. Limb dominance was assessed by asking which limb the individual preferred for activities such as kicking a soccer ball.

All participants were required to be involved in 1.5 or more hours of moderate to vigorous physical activity per week.^{11,14} They self-reported their weekly activity level and intensity using simple recall. Additional inclusion criteria for the FAI and coper groups were a history of an inversion ankle sprain that required protected weight bearing, immobilization, or limited activity for at least 24 hours. The FAI participants also had to report multiple episodes of giving way (at least 2 in the past year),¹⁴ be at least 1 year

since initial injury, and score 27 or less on the CAIT.¹⁷ Copers had no complaints of ankle instability or repeated episodes of giving way and had resumed all preinjury activities without limitation for at least 12 months before testing.^{11,14} In our coper group, CAIT score was recorded but not used as an inclusion or exclusion criterion because research has yet to determine an optimal CAIT cutoff score for identifying copers. If all other inclusion criteria were met, we followed the leads of previous researchers^{13,15} and allowed copers to have had a single episode of giving way or resprain as long as it occurred at least 12 months before the study; 2 of 23 participants reported a single episode of giving way, and none reported resprain. Uninjured individuals had no history of ankle sprain or instability in their lifetime. Volunteers were excluded if they had a history of surgery or ankle fracture on the side of testing, any acute symptoms of lower extremity injury on the day of testing, or known systemic disease or condition affecting the musculoskeletal system.¹⁸

Copers and uninjured participants were matched with FAI participants by sex, age (± 10 years), height (± 10 cm), and weight (± 15 kg). Height was obtained using a mechanical column scale (model 700; Seca, Hanover, MD). Weight was obtained by having individuals stand quietly on a force plate (Bertec Corporation, Columbus, OH) to calculate the vertical component of the ground reaction forces. Each group had equal numbers of left- and right-limb-dominant individuals (2 left, 21 right). Testing was performed on the involved limb (side of ankle sprain) of the FAI and coper groups and the matched side of the uninjured group. Individuals with bilateral FAI were asked to subjectively identify the most unstable ankle, which was designated as the involved limb.

Descriptive Questionnaires

In addition to the CAIT, participants completed the Foot and Ankle Ability Measure (FAAM) to quantify functional limitations. The FAAM has 2 parts: the Activities of Daily Living (ADL) subscale and the Sports subscale. Reliability for both subscales is good (FAAM ADL ICC_{2,1} = 0.89, FAAM Sports ICC_{2,1} = 0.87).¹⁹ Scores are reported as a percentage out of 100, with lower scores indicating decreased function.¹⁹ The FAAM's predecessor, the Foot and Ankle Disability Instrument, has been used in similar ankle-instability research on copers, noncopers, and uninjured individuals.^{11,12,14} We chose the FAAM because of improved clinimetric qualities.²⁰ Responses to the FAAM were recorded and scored using the same customized computer program as for the CAIT.

Clinical Examination

A single investigator, a certified athletic trainer with 6 years of experience, performed a clinical examination on the involved limb of each participant. The purpose of this examination was to assess ankle-joint laxity, pain with palpation of the lateral ligaments, and pain with passive end range of motion (ROM). Because the same investigator was involved in recruitment and screening of participants, blinding to group was not possible.

The investigator palpated the anterior talofibular, calcaneofibular, and posterior talofibular ligaments and

assessed pain by asking the question, "Is this painful?" and recording *yes* or *no*. Next, the investigator passively moved the ankle joint through full ROM in plantar flexion, dorsiflexion, and inversion and eversion and applied firm pressure at end ROM in each direction. Pain at end ROM in each direction was assessed similarly to pain on palpation. The investigator also evaluated ankle-joint laxity using the anterior drawer and talar tilt tests, performed according to Ryan.²¹ The talar tilt test was performed with the ankle starting in slight plantar flexion, applying an inversion force to the calcaneus, and observing gapping caused by excessive movement between the lateral malleolus and the talus. The anterior drawer test was performed with the knee flexed and ankle in neutral position, applying an anterior force to the calcaneus, and palpating anterior displacement. Grading for both tests was on a scale of 1 to 5, with 1 = *very hypomobile*, 2 = *slightly to moderately hypomobile*, 3 = *normal*, 4 = *slightly to moderately hypermobile*, and 5 = *very hypermobile*.²¹ Good reliability for these tests has been reported using these methods (ICC_{2,1} > 0.80, standard error of the measure < 0.25).¹⁴

Range of Motion

Active ROM was recorded for the involved limb using 3-dimensional motion capture. The investigator attached 2 rigid plastic plates of markers to the participant's shank using tape prewrap and attached 28 individual 9.5-mm reflective markers (MoCap Solutions, Huntington Beach, CA) using double-sided adhesive tape at specific anatomical landmarks. Marker placement was according to the Oxford foot model^{22,23}: The examiner attached anatomical markers bilaterally on the lateral and medial femoral epicondyles, lateral and medial malleoli, proximal and distal fifth metatarsals, distal second metatarsals, proximal and distal first metatarsals, and lateral, medial and posterior calcanei. The Oxford foot model method is reliable for calculating adult hindfoot motion (ICC = 0.90–0.97, SEM₉₀ = 0.89°–2.21°).²² The participant stood in the capture volume in anatomical position as a static calibration trial was captured. For all data capture, a 12-camera Vicon MX motion-monitoring system using Nexus 1.4 software (Oxford Metrics Group, Oxford, UK) collected the 3-dimensional location of the reflective markers at 100 Hz.

For the ROM trials, the individual sat in a chair with the knee flexed to approximately 30°–45° for plantar flexion and dorsiflexion ROM and the knee flexed to 75°–90° and the ankle in 0°–10° of plantar flexion for inversion and eversion ROM. The investigator verified participant positioning and comprehension of the task, then collected data as he or she actively moved the ankle through its maximal ROM 3 times in each direction (plantar flexion, dorsiflexion, inversion and eversion). Once the participant stated that maximal ROM had been attained, the investigator activated a manual trigger.

Data Processing

All kinematic data were processed using Visual3D Professional (version 4.00.19; C-Motion Inc, Germantown, MD). Kinematic data for the forefoot and hindfoot were calculated using the segment coordinate systems defined by Stebbins et al.²³ Euler angles were calculated for the

hindfoot relative to the tibia using the Grood and Suntay sequence.²⁴ Dynamic hindfoot angle was calculated referenced to standing neutral position (setting all angles equal to zero in standing neutral position), and all kinematic data were filtered at 12 Hz using a digital Butterworth filter.²⁵

For ROM, hindfoot angle at maximum dorsiflexion, plantar flexion, inversion and eversion was extracted. Although each participant recorded 3 trials in each direction, obscured markers rendered only 2 trials useable in many cases. Thus, for each individual, we averaged the first 2 useable trials in each direction to obtain maximal ROM. Intertrial reliability was excellent for all tested directions ($ICC_{2,k} = 0.98-0.99$). Overall ROM in the sagittal and frontal planes was calculated as the difference between average maximum and average minimum ROM in each plane.

Statistical Analysis

All analyses were completed with SAS (version 9.2; SAS Institute Inc, Cary, NC), assuming an overall type I error rate of $\alpha = .05$. We used a 1-way analysis of variance to compare CAIT and FAAM scores and ROM for the 3 groups. Tukey post hoc methods for multiple comparisons were conducted to assess significant pairwise differences. A 1-way analysis of variance was performed to compare 2 groups (FAI and copers) on the number of days of limited weight bearing.

A Pearson χ^2 test was used to test for differences between the FAI and copers groups for the categorical variable of professional medical care sought. For all other categorical clinical examination variables (ie, ligamentous laxity, pain on palpation, pain at end ROM), all possible 2-group comparisons (ie, FAI versus copers, FAI versus uninjured, copers versus uninjured) were assessed using the Fisher exact test. We chose this test over the χ^2 because of the low expected cell counts and because it is more conservative. For analysis, the 5 scored categories of the ligamentous laxity test were collapsed into positive tests (score of 4 or 5) or negative tests (score of 1–3).

RESULTS

Participant Demographics

Descriptive data for demographics, injury history, and questionnaire scores are reported by group in Table 1. Individuals with FAI averaged 5.8 ± 8.4 episodes of giving way per month and reported 2.1 ± 2.5 resprains after the initial injury.

We noted differences between groups on the CAIT, FAAM-ADL, and FAAM-Sport questionnaires (CAIT: $F_{2,66} = 95.377$, $P < .001$; FAAM-ADL: $F_{2,66} = 18.918$, $P < .001$; FAAM-Sport: $F_{2,66} = 12.850$, $P < .001$). Tukey post hoc comparisons revealed that, for all questionnaires, the FAI group scored lower than did the copers and uninjured groups. However, the copers and uninjured groups were not different from each other for any questionnaire results.

The frequency with which the FAI and copers groups sought medical treatment for their initial ankle sprains was not different ($\chi^2_1 = 1.08$, $P = .300$). Additionally, no differences were evident between the number of days of

limited weight bearing after the initial sprain ($F_{1,41} = 3.17$, $P = .084$).

Clinical Examination

Laxity. Frequency data as well as 2-sided Fisher exact test P values for ligamentous laxity are reported in Table 2. In summary, individuals with FAI were more likely than uninjured individuals to test positive for both anterior drawer and talar tilt laxity. Individuals with FAI were also more likely than copers to test positive for talar tilt laxity. No other group differences were observed for either laxity measure.

Pain. Frequency data as well as 2-sided Fisher exact test P values for pain over the lateral ligaments and pain at end ROM are reported in Table 2. No differences were seen among groups for pain on palpation of the lateral ankle ligaments. For end ROM in inversion, the FAI group was more likely to report pain than either the copers or uninjured group. No group differences were demonstrated for pain at end ROM in any other direction.

Range of Motion. Data-collection errors resulted in missing active ROM data for 1 copers participant and 1 uninjured participant. Thus, all ROM analyses were performed on the remaining 67 individuals. No group differences were noted for plantar flexion, dorsiflexion, inversion, eversion, or total frontal-plane ROM (ie, inversion plus eversion; Table 3). A group difference was found for total sagittal-plane ROM (ie, plantar flexion plus dorsiflexion, $F_{2,64} = 4.36$, $P = .017$). Specifically, individuals with FAI had less active ROM than did copers (mean difference = 6.60° , 95% confidence interval = 1.23° , 11.98°). However, the uninjured group was not different from the FAI or copers groups.

DISCUSSION

The inclusion of copers is a relatively recent trend in the ankle-instability literature and may provide insight into coping mechanisms after acute lateral ankle sprain that enhance treatment or injury-prevention efforts (or both).^{11–15,26} Our goal was to further describe ankle-sprain copers and compare them with FAI and uninjured participants. This information might be used to fine tune the inclusion criteria for copers and serve as a springboard to prospectively identify potential copers and noncopers. This type of clinical screening examination would be advantageous to clinicians, who could better use limited resources, and to patients, who would receive treatment targeted to their risk level.

We chose to include 3 groups: FAI (history of at least 1 sprain and recurrent instability), copers (history of 1 sprain, no active instability), and uninjured (no history of ankle sprain) participants. Although our primary comparison was between the FAI and copers groups, we believed it was essential to include an uninjured group to obtain normal values.

Ankle-sprain copers have been defined as individuals with a history of lateral ankle sprain but no recurrent instability.^{10,11} Several authors have used this general definition, adding additional inclusion and exclusion criteria as they thought appropriate. The inclusion criteria used in 5 studies of ankle-sprain copers are presented in Table 4. The number of inclusion and exclusion criteria

Table 2. Clinical Examination Results

Clinical Test	Group, n (%)			Fisher Exact <i>P</i> Value		
	Functional Ankle Instability	Coper	Uninjured	Functional Ankle Instability Versus Coper	Functional Ankle Instability Versus Uninjured	Coper Versus Uninjured
Anterior drawer						
Negative	11 (47.8)	15 (65.2)	20 (87.0)	.373	.011 ^a	.165
Positive	12 (52.2)	8 (34.8)	3 (13.0)			
Talar tilt						
Negative	13 (56.5)	20 (87.0)	22 (95.7)	.047 ^a	.004 ^a	.608
Positive	10 (43.5)	3 (13.0)	1 (4.3)			
Anterior talofibular ligament						
Pain	4 (17.4)	0 (0.0)	0 (0.0)	.109	.109	— ^b
No pain	19 (82.6)	23 (100.0)	23 (100.0)			
Calcaneofibular ligament						
Pain	3 (13.0)	0 (0.0)	0 (0.0)	.233	.233	— ^b
No pain	20 (87.0)	23 (100.0)	23 (100.0)			
Posterior talofibular ligament						
Pain	4 (17.4)	1 (4.3)	0 (0.0)	.346	.109	1.000
No pain	19 (82.6)	22 (95.7)	23 (100.0)			
Plantar-flexion end ROM						
Pain	3 (13.0)	0 (0.0)	0 (0.0)	.233	.233	— ^b
No pain	20 (87.0)	23 (100.0)	23 (100.0)			
Dorsiflexion end ROM						
Pain	1 (4.3)	0 (0.0)	0 (0.0)	1.000	1.000	— ^b
No pain	22 (95.7)	23 (100.0)	23 (100.0)			
Inversion end ROM						
Pain	6 (26.1)	0 (0.0)	0 (0.0)	.022 ^a	.022 ^a	— ^b
No pain	17 (73.9)	23 (100.0)	23 (100.0)			
Eversion end ROM						
Pain	2 (8.7)	2 (8.7)	0 (0.0)	1.000	.489	.489
No pain	21 (91.3)	21 (91.3)	23 (100.0)			

Abbreviation: ROM, range of motion.

^a Difference between groups.

^b Fisher exact test could not be calculated due to observation of 0 in 2 categories.

across studies varied from 8 to 13. Based on our results, we recommend that CAIT and FAAM scores be added to inclusion and exclusion criteria to differentiate between individuals with FAI and copers. Of all the clinical variables recorded in this study, the CAIT and FAAM scores showed the most distinct group differences. Other items of the clinical examination, even when different by group, had enough individual variability to make them less than ideal for use as inclusion and exclusion criteria. Group differences for each item of the clinical examination are discussed in the next section.

Clinical Examination

Injury histories of the FAI and coper groups revealed that both groups sought medical attention at similar rates. This finding is consistent with the work of Hubbard.¹² When severity of the initial injury was known, the groups self-reported similar ratings. However, it is important to note that the initial sprains of approximately half of each group were categorized as unknown severity; if known, these findings might have changed the current results. Additionally, although not statistically significant ($P = .08$), the mean number of days with limited weight bearing for the

Table 3. Active ROM by Group with Analysis

ROM Direction	Group (Mean $\pm$ SD)			$F_{2,64}$	<i>P</i> Value
	Functional Ankle Instability	Coper	Uninjured		
Eversion	3.48 $\pm$ 6.74	5.65 $\pm$ 6.96	5.43 $\pm$ 8.99	0.56	.575
Inversion	24.90 $\pm$ 9.15	25.43 $\pm$ 7.40	22.27 $\pm$ 8.84	0.87	.422
Plantar flexion	25.63 $\pm$ 6.33	29.18 $\pm$ 5.25	28.21 $\pm$ 4.64	2.56	.086
Dorsiflexion	10.99 $\pm$ 5.04	14.04 $\pm$ 5.74	11.29 $\pm$ 4.30	2.44	.095
Total frontal-plane ROM	28.38 $\pm$ 8.18	31.08 $\pm$ 7.24	27.70 $\pm$ 7.18	1.24	.297
Total sagittal-plane ROM	36.62 $\pm$ 7.81 ^a	43.22 $\pm$ 8.16 ^a	39.50 $\pm$ 6.43	4.36	.017

Abbreviation: ROM, range of motion.

^a Difference between functional ankle instability and coper groups.

Table 4. Typical Criteria for Coper Groups

Criteria	Article					Current Study
	Brown et al, 2008 ¹⁴	Hubbard, 2008 ¹²	Wikstrom et al, 2009 ¹¹	Wikstrom et al, 2010 ¹³	Wikstrom et al, 2010 ¹⁵	
Initial injury						
History of lateral ankle sprain	X	X	X	X	X	X
Recurrent sprains						
None in past 12 mo	X	NA	X	X	X	X
Single resprain allowed ≥ 12 months before if all other criteria met	NA	NA	X	X	X	X
Physical activity						
No limitations $\times 12$ mo	NA	NA	X	X	X	X
No current limitations	NA	X	X	X	X	X
At least 90 min/wk	X	NA	X	X	X	X
Descriptive questionnaires						
Score >22 (of 48) on Ankle Joint Functional Assessment Tool	NA	NA	X	X	X	NA
Score of 100% on Foot and Ankle Disability Index	NA	X	NA	NA	NA	NA
Exclusion criteria						
Acute ankle pain	X	X	X	X	X	X
Ankle giving way or instability	X	X	X	X	X	X
Perceived ankle weakness	NA	NA	X	X	X	NA
History of ankle fracture	X	X	X	X	NA	X
History of ankle surgery	NA	X	NA	NA	NA	X
History of acute lower extremity injury ≤ 3 mo before testing	X	NA	X	X	X	NA
Formal ankle rehabilitation	NA	NA	X	X	X	NA
Ankle-joint laxity	X	NA	NA	NA	NA	NA

Abbreviation: NA, not available.

FAI versus coper groups (12 versus 6 days, respectively) may have clinical significance. Furthermore, this measure is available to the clinician a short time after injury, as opposed to other measures, which may not stabilize for weeks or months after injury (eg, residual laxity). We thought it was important to assess differences in initial injury history due to the potential effect of injury severity on long-term outcomes (such as development of FAI).

Laxity. On clinical examination, as expected, the uninjured group had normal laxity. Using the Fisher exact test to compare each of 3 possible 2-group combinations, we found differences for both the anterior drawer and talar tilt test between the FAI and uninjured groups. Previous literature²⁷ has yielded mixed results regarding ankle-joint laxity in individuals with FAI compared with uninjured controls. However, our findings are similar to more recent reports.^{6,28}

Comparing the FAI and coper groups, we found no difference in anterior drawer laxity but an increase in talar tilt laxity in the former. Our result for talar tilt laxity is consistent with that of Hubbard.¹² In the same report, Hubbard¹² reported increased anterior displacement, which we did not detect. Yet it is not surprising that the small anterior displacement differences (group difference = 1.6 mm) detected by Hubbard¹² using instrumented arthrometry were not detected using a clinical test. We chose a clinical measure for both practical reasons (constraint of available resources) and to make our finding more applicable to practicing clinicians. However, use of a clinical rather than an instrumented laxity measure is also a limitation of our methods. Using instrumented arthrometry to measure laxity

is unarguably more accurate and reliable than clinical tests.^{27,29}

We think the increased talar tilt laxity in the FAI group compared with both copers and uninjured individuals may be a very important finding, especially in light of the fact that previous researchers³⁰ found that increased talar tilt laxity was a significant predictor of ankle-joint injury. It may be that less talar tilt contributes to the coper's increased stability and protection from reinjury.

Comparing copers with uninjured participants, we found no difference for either anterior drawer or talar tilt laxity. Still, we cannot conclude that copers had no laxity on an individual level. In fact, 8 of 23 copers had positive anterior drawer tests, compared with only 3 of 23 uninjured participants. Our use of a statistically conservative test may have prevented us from detecting true group differences.

Pain. Our coper and FAI groups were not different regarding pain on palpation of the lateral ligaments. At end ROM, only maximal inversion was more painful for FAI individuals than for coper and uninjured individuals. Measures of pain on palpation and pain at end ROM are occasionally recorded with acute ankle sprains.³¹ Considering the length of time since initial injury, we did not expect to find large group differences for these measures. The slightly elevated frequency of pain reports in the FAI group may be due to frequent giving way and not a cause of instability.

Range of Motion. We expected that total available ROM might be an important difference among our groups. Due to the study design (the current study was part of a larger study investigating 3-dimensional joint kinematics during

activity), instrumented ROM was captured for each participant; therefore, we did not obtain clinical measures of ROM. We chose to include the instrumented ROM values that were available for these individuals. Overall, the 3 groups were very similar, with the exception of total sagittal-plane ROM. In the sagittal plane, copers averaged 6.6° (95% confidence interval = 1.23°, 11.98°) or approximately 15% more available ROM than did individuals with FAI. Thus, although FAI and copers had both experienced ankle sprains, only those with FAI displayed reduced sagittal-plane ROM. Based on our study design, we cannot determine the exact cause of the decreased ROM; however, we believe there are 3 possible explanations. First, decreased sagittal-plane ROM could have been a predisposing factor to initial ankle sprain or the development of FAI (or both). Interestingly, decreased dorsiflexion ROM (a sagittal-plane movement) is commonly cited as a risk factor for ankle sprain.^{32–34}

Second, individuals with FAI may never return to full sagittal-plane ROM postinjury. Dorsiflexion ROM decreases immediately after injury and then normally increases in the following weeks.³⁵ If individuals with FAI are failing to regain normal sagittal-plane motion postinjury, treatment strategies aimed at increasing end-range plantar flexion and dorsiflexion, such as stretching and joint mobilizations, should be recommended. Yet these strategies may prove ineffective if the reduced ROM noted in this population is due to an altered control strategy rather than to bony or soft tissue restrictions. It could be that individuals with FAI attempt to increase stability by adopting a control strategy that reduces sagittal-plane ROM. To investigate whether the reduced ROM is due to a control strategy or restrictions, future researchers should test both passive and active ROM.

Last, reductions in sagittal-plane ROM may be due to arthritic changes over time. Ligamentous posttraumatic ankle osteoarthritis (OA) can develop in as few as 6 years and so may affect a younger population; admittedly, though, the normal mean latency is longer,³⁶ and this explanation should be viewed with caution. However, previous authors³⁶ have reported an association between ankle instability and OA, with 13.4% of posttraumatic ankle OA caused by an ankle sprain and subsequent instability. With this association in mind, OA changes to the joint that limit ROM must be included as a possible interpretation of the observed reduction in sagittal-plane ROM. The presence of OA changes in patients with FAI is especially concerning because OA is associated with a large financial burden and decreased quality of life.³⁷ Also, the presence of OA could change the clinical treatment of decreased ROM: Techniques such as joint mobilizations are contraindicated in patients with OA.

Self-Reported Disability

On both self-reported disability questionnaires, copers were not different from the uninjured group, but they did score better than individuals with FAI. This provides evidence that our copers felt just as stable as did uninjured individuals, despite the copers' history of a previous ankle sprain. Average scores for our FAI group were slightly higher than those of previous researchers,³⁸ which may be due to a relatively young and otherwise healthy population. Also, 1 noted problem with these

instruments is a ceiling effect in athletic populations.³⁹ Given minimal clinically important differences of 8 and 9 points for the FAAM-ADL and Sports subscales, respectively,⁴⁰ it would be impossible for some FAI participants to show clinically important changes using the FAAM-ADL due to the instrument ceiling, whereas the FAAM-Sports would be able to record more clinically meaningful change. Based on these results, the FAAM-Sports and not the FAAM-ADL would be the instrument of choice for use with physically active populations.

A set discrimination (cutoff) score to classify individuals as copers or noncopers using each of these instruments has not been developed. However, data from our laboratory seem to indicate that copers have a high risk of false-positive results when the current cutoff score is used to discriminate between FAI and control participants.^{41,42} Further work in the area of copers-specific cutoff scores on measures of self-reported disability is warranted. Regarding cutoff scores between copers and noncopers for any variable, to our knowledge, only 1 report¹⁵ of postural-control measures has published cutoff values. Future researchers should continue to identify variables that discriminate between copers and noncopers.

LIMITATIONS

Based on the cross-sectional study design, no causal links can be made between the groups and the measures used. However, this study provides essential information to aid in the development of well-designed prospective studies on well-defined clinical populations with ankle instability. Also, as previously mentioned, limitations stem from our use of clinical measures of laxity rather than instrumented arthrometry.^{27,29} We felt this limitation was acceptable because it led to more clinically relevant data. Our ROM data, on the other hand, was obtained using instrumented rather than clinical methods due to limitations in study design. Whereas 3-dimensional motion capture leads to more reliable data,⁴³ one limitation of our study is not knowing if the differences we detected could have been detected clinically.

An additional limitation was that the examiner was not blinded to group or side during clinical evaluation and measurement. This could lead to bias on subjective variables such as laxity. Blinding of the examiner was not possible because the examiner also participated in participant recruitment and screening. Future researchers could avoid this limitation by having different examiners perform recruitment and data collection.

Finally, it should be noted that our goal was only to address the clinical profile. Other laboratory measures have distinguished FAI and uninjured groups. The original deafferentiation theory of Freeman et al⁴⁴ led to research in sensorimotor measures such as joint position sense and force sense. For example, in a recent meta-analysis,⁴⁵ individuals with FAI were shown to have greater active and passive joint position sense error than healthy controls. It may be that these laboratory measures also better distinguish between FAI and copers; however, current research on copers as a comparison group is limited.^{11–14} Further research into both laboratory and clinical differences is warranted.

CONCLUSIONS

Individuals with FAI and copers differed on self-reported disability, inversion laxity, pain at maximal inversion, and sagittal-plane ROM. Future authors should continue to investigate dynamic coping mechanisms in individuals with FAI and copers, with an emphasis on identifying clinically relevant discriminating variables to improve prevention and treatment strategies.

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