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Functional Performance Testing in Participants With Functional Ankle Instability and in a Healthy Control Group

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Context: Functional ankle instability (FAI) affects a large part of the population. Inconsistent findings have been reported regarding the existence of functional performance deficits in individuals with FAI.

Objective: To examine functional performance in participants with FAI compared with participants in a control group during 2 hopping tests.

Design: Case-control study.

Settings: Athletic training research laboratory.

Patients or Other Participants: There were 40 college-aged individuals who participated in our study: 20 with FAI and 20 without FAI. We defined *FAI* as history of an ankle sprain and residual episodes of "giving way."

Intervention(s): Participants completed 2 functional performance tests (FPTs): the single-limb hopping and the single-limb hurdle tests.

Main Outcome Measure(s): Time to complete each test was recorded. Following each FPT, participants were asked if their ankles felt unstable during the test.

Results: We found no difference between participants in the FAI and control groups for the hopping or hurdle tests ($P > .05$). When asked if their ankles felt unstable during the FPTs, approximately half of the participants in the FAI group and none of the participants in the control group reported a feeling of instability. Subsequently, a secondary analysis of variance was calculated with participants grouped into 3 categories: control participants, FAI participants reporting instability symptoms during FPT (FAI-S), and FAI participants not reporting instability symptoms during FPT (FAI-NS). Results revealed a difference among the 3 groups for the single-limb hopping test ($P < .01$). Post hoc analysis revealed a difference between the FAI-S participants and both the control and the FAI-NS participants. No difference was identified for the single-limb hurdle test ($P = .41$).

Conclusions: The FAI-S participants had performance deficits during the single-limb hopping test. Therefore, clinicians could use this simple hopping test as an additional method to determine the presence of FAI.

Key Words: agility, assessment, ankle injuries

Key Points

- We found that participants who had functional ankle instability and reported instability during the functional performance testing performed worse than participants in the control group and participants who had functional ankle instability and did not report a feeling of instability during testing.
- Participants who are identified as having functional ankle instability can have different functional limitations.
- Clinicians can use the single-limb hopping test to help determine the presence of functional ankle instability.

Lateral ankle sprains are one of the most prevalent injuries in high school, collegiate, and recreational sports.[1,2] Functional ankle instability (FAI) is a condition that occurs after an ankle sprain in approximately 40% of patients.[3,4] *Functional ankle instability* has been defined many ways, including the "disabling loss of reliable static and dynamic support of a joint"[5(p692)] and a "tendency for the foot to give way."[6(p669)] To date, no criterion standard exists to determine the presence of FAI; however, as these definitions reflect, FAI primarily is identified by self-reported instability during activities of daily living or functional activity. Researchers have hypothesized that functional performance deficits are present in people with FAI.[7,8] However, the success rate of using functional performance tests (FPTs) to assess instability of the ankle joint has been controversial.[7–11] Generally, FPTs can be used to measure or quantify an athlete's level of physical performance by simulating muscular and joint stresses encountered during athletic events.[12,13] Testing of the knee has been highly successful in identifying functional performance deficits in patients with significant injuries,[14,15] but inconsistent findings have been reported for FPTs of the ankle.

Some researchers have identified functional performance deficits in participants with unstable ankles,[8,9] whereas others have not.[7,8,10] Major differences among these investigations have been the populations tested and the FPTs used. Researchers have investigated participants with mechanical ankle instability[9] and FAI.[7,8,10] However, even in the studies investigating FAI, the inclusion criteria for participants varied greatly from study to study. Additionally, authors evaluated a variety of FPTs, including single hop for distance,[8] cocontraction test,[10] shuttle run,[10] agility hop test,[10] side hop,[8] figure-of-8 hop,[8] up-down hop,[8] triple crossover hop,[7] and single-limb hopping course.[9] To date, the FPTs that included lateral movement were

sensitive in detecting functional deficits in participants with ankle instability, whereas the tests that solely moved in the sagittal plane did not result in performance deficits. These results demonstrate the importance of lateral movements when evaluating FPTs for the ankle.

Finding FPTs that can accurately identify performance deficits in participants with FAI is important for 2 reasons. First, these FPTs would more accurately identify the magnitude of performance dysfunction associated with FAI. Second, they could be used to objectively monitor the effectiveness of rehabilitation protocols after an ankle sprain and subsequent FAI. Therefore, our purpose was to evaluate the presence of functional performance deficits in participants with FAI compared with healthy participants during 2 FPTs: the single-limb hopping test and the single-limb hurdle test.

METHODS

Participants

Forty physically active, college-aged individuals volunteered to participate in this study. *Physically active* was defined as participating in exercise (ie, walking, swimming, weight training, jogging, or participating in sports at the recreational or varsity level) at least twice each week. The participants were divided into 2 groups: FAI (age = 21.75 ± 2.98 years, height = 176.02 ± 9.01 cm, mass = 76.66 ± 14.86 kg) and control (age = 20.85 ± 2.64 years, height = 172.59 ± 8.80 cm, mass = 66.98 ± 16.19 kg). Participants were included in the FAI group if they had a history of moderate-to-severe ankle sprains and residual episodes of ''giving way'' or instability. Participants in the FAI group reported episodes of giving way or instability while walking on even or uneven surfaces, walking up or down stairs, or engaging in recreational or competitive sport activities. With FAI participants who had a history of bilateral ankle injury (n = 10), the test limb was identified as the side that exhibited more recent episodes of giving way. Participants were included in the control group if they had no history of ankle sprains. Exclusion criteria for both groups included a history of lower extremity surgery or fracture, moderate injury to a knee or hip, or osteoporosis. Before participating in the study, all volunteers read and signed an informed consent document. The university's institutional review board approved the study.

Test Procedures

Participants performed a 5-minute warm-up on an exercise bicycle at a moderate level of intensity. Next, participants completed 2 FPTs: single-limb hopping test and single-limb hurdle test. The FPTs were completed on the test limb for the FAI participants and a matched limb for the control participants. The FAI and control participants were matched by leg dominance. Leg dominance was determined by limb preference when the participant kicked a ball. The order of FPTs was counterbalanced for all participants.

Both tests were timed using an electronic stopwatch (model 54519-A; Lafayette Instrument Co, Lafayette, IN). The electronic stopwatch was connected to start and stop pads placed at the beginning and end of each test course. Before testing, the primary investigator demonstrated the test and instructed the participant to practice it. The participants were allowed a maximum of 3 practice trials to familiarize themselves with the FPT. When the participants were comfortable with the tests, 5 trials were recorded. A 1-minute rest period was included between trials to decrease the chances of the participant becoming fatigued. After each trial, we asked the participant if the ankle felt unstable at any time during the test. This subjective questioning was used as a mechanism to evaluate the presence or perception of giving way or ankle instability.

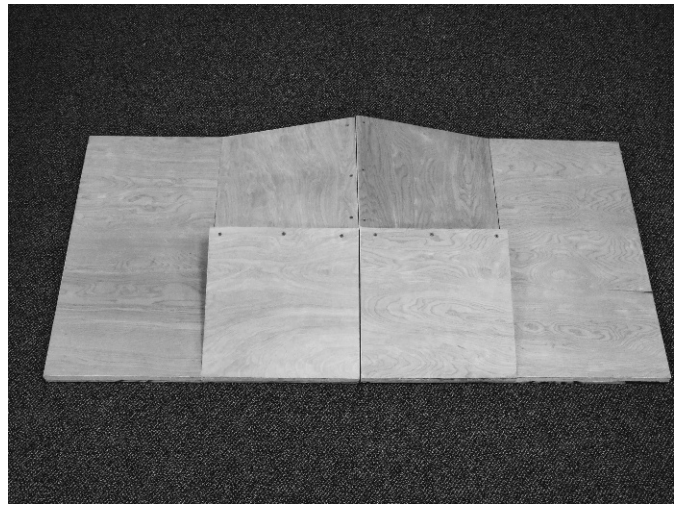

Figure 1. Single-limb hopping test.

Single-Limb Hopping Test. The single-limb hopping test course was reproduced using the measurements and picture that Chambers et al[16] provided. The course was constructed of hardwood and consisted of 8 13-in × 13-in (33.02-cm × 33.02-cm) squares positioned in 2 rows of 4 (Figure 1). In each row, the first and last squares were level, and the middle squares were sloped. In 1 row, the 2 middle squares had a 15° lateral slope; in the other row, 1 square had a 15° incline, and 1 square had a 15° decline. The hopping course was placed on a rubber mat that was laid on a hard surface. The rubber mat prevented the course from moving. Trial reliability of the single-limb hopping test was high: intraclass correlation coefficient (ICC [2,1]) = 0.93, SEM = 0.18 second.

Single-Limb Hurdle Test. The single-limb hurdle test course consisted of 10 squares taped on a concrete floor with 3 small hurdles placed in standard positions on the course (Figure 2). The hurdles were approximately 15 cm high and were created from cones connected with athletic tape. The course was adjusted according to the limb tested to ensure that each participant performed 2 lateral jumps and 1 medial jump. Trial reliability of the single-limb hurdle test was high (ICC [2,1] = 0.90, SEM = 0.26 second).

For both tests, participants were instructed to hop as fast as they could through the courses. We recorded time to complete each test in seconds. If the participant hit the athletic tape or cone during testing, touched the contralateral foot down, or hopped out of sequence or out of the designated square, the trial was discarded and repeated. The total number of unacceptable trials was recorded.

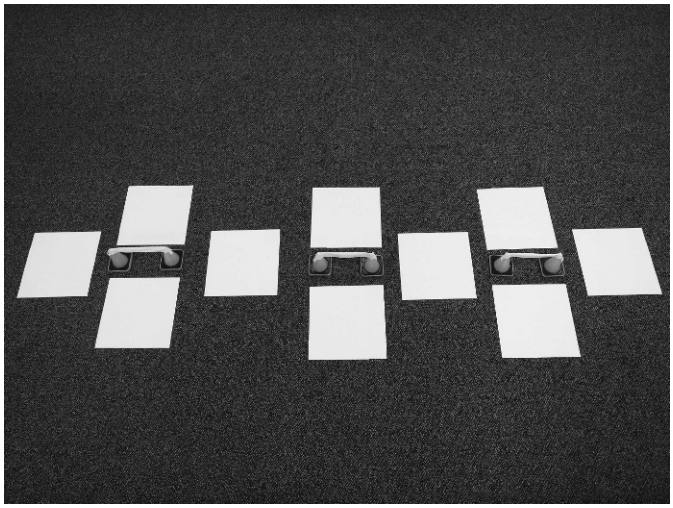

Figure 2. Single-limb hurdle test.

Statistical Analysis

Data were imported into SPSS (version 13.0 for Windows; SPSS Inc, Chicago, IL). The mean of the 5 trials for each FPT was used for statistical analysis. Parametric data were analyzed using the 2-tailed independent-samples *t* test to compare performance differences between the FAI and control groups for each functional test. Nonparametric data were analyzed using the χ^2 test for independence to compare the number of trials with missed jumps in the FAI and control groups for each functional test.

Data for subjective feelings of instability during each FPT enabled us to further separate the participants into 3 categories: control participants, FAI participants reporting instability symptoms during the FPT (FAI-S), and FAI participants not reporting instability symptoms during the FPT (FAI-NS). A separate analysis of variance (ANOVA) was calculated for each functional test to determine differences among the 3 groups. Tukey honestly significant difference was calculated post hoc for any significant differences. The α level for all analyses was set at .05.

RESULTS

The means and SDs for both FPTs are presented in the Table. The 2-tailed independent-samples *t* tests revealed no differences between the FAI and control groups in the single-limb hopping ($t_{1,38} = -1.30$, $P = .20$, Cohen d = .63) or hurdle ($t_{1,38} = -0.53$, $P = .60$, Cohen d = .24) tests. The χ^2 test for independence revealed that the frequency of trials with missed jumps during the single-limb hopping test was distributed equally between the FAI and control groups ($\chi^2_1 = 0.90$, $P = .34$). Conversely, an interaction was found for the frequency of trials with missed jumps between the FAI and control groups during the single-limb hurdle test ($\chi^2_1 = 5.01$, $P = .03$). Participants in the control group were more likely to have a trial with missed jumps than participants in the FAI group were (75% and 40%, respectively). When asked if the ankle felt unstable during the hopping test trials, 10 of the 20 (50%) participants in the FAI group and no participants in the control group reported that the ankle felt unstable. During the hurdle test, 9 of the 20 (45%) participants in the FAI group and no participants in the control group reported that the ankle felt unstable. Using this information for grouping participants (control participants, FAI-S, and FAI-NS), a secondary ANOVA revealed a difference among the 3 groups for the single-limb hopping test ($F_{2,40} = 6.04$, $P = .01$, $\eta^2 = .25$). Post hoc Tukey testing revealed a difference between the FAI-S and both the control participants and the FAI-NS (Table). No difference was identified among the 3 groups for the single-limb hurdle test ($F_{2,40} = 0.93$, $P = .41$, $\eta^2 = .05$).

DISCUSSION

Based on our primary results, we did not detect functional performance deficits in participants with FAI compared with healthy controls. However, after the secondary analysis was conducted, a performance deficit was revealed during the single-limb hopping test. We found that FAI-S participants performed worse than both the control participants and the FAI-NS participants. This leads us to 1 of 2 conclusions: (1) the participants who were initially classified as FAI but did not report feelings of instability during the functional test were not actually functionally unstable, or, more likely, (2) these participants exhibited symptoms of FAI that were not as debilitating as the symptoms reported by participants who did experience instability during the FPTs. Clinically, we expect a given instability to have various degrees of severity; however, FAI historically has been treated as a dichotomous condition (ie, you have it or you do not). Results of our study support the idea that various degrees of FAI exist and a better grading or classification system needs to be identified. Our findings are in agreement with those of Docherty et al,[8] who investigated the relationship between FAI and functional performance. The authors noted that participants reporting more symptoms of instability on a questionnaire also had more performance deficits. Specifically, the performance deficits were present during tests that included lateral movement (eg, side hop, figure-8 hop).[8]

Table. Functional Performance During the Single-Limb Hopping and Single-Limb Hurdle Tests in Functional Ankle Instability and Control Groups (Mean ± SD)

	Single-Limb Hopping Test, s	Single-Limb Hurdle Test, s
Functional ankle instability	7.60 ± 1.56	4.39 ± 0.85
Reported instability during functional performance tests	8.39 ± 1.48	4.61 ± 0.76
No reported instability during functional performance tests	6.82 ± 1.25	4.21 ± 0.92
Control	7.10 ± 0.79	4.27 ± 0.51
P value[a]	.01	.41

[a] Analysis of variance.

Single-Limb Hopping Test

The single-limb hopping test has been used in previous research and has been shown to be sensitive enough to differentiate between injured and uninjured participants.[9] Our definition of the injured population differed from the definition given in previous studies. Jerosch and Bischof[9] used plain and stress radiographs to document laxity with the talar tilt and anterior drawer tests. This type of inclusion criteria is indicative of mechanical instability; we included an injured population with FAI. Additionally, our results indicated that not all participants with symptoms of FAI have the same functional limitations. When evaluating the performance times, we found that the SDs in the FAI participants (FAI-S = 1.48 seconds, FAI-NS = 1.25 seconds) were noticeably larger than those in the control participants (0.79 seconds). The larger SDs reflect the range of disability present in participants with FAI. As identified in the literature,[17] these findings reiterate the point that FAI is not a dichotomous condition; it has various levels of severity.

Single-Limb Hurdle Test

We adopted and modified the single-limb hurdle test from previous research.[10,18] Some researchers have used this test as a training protocol,[18] whereas others have used it as an FPT.[10] However, in both situations, the participants were required to balance after each hop. In an effort to set up a more dynamic functional test, we made 2 modifications. First, we included hurdles to make participants consistently jump to a minimum height throughout the test. Second, we directed participants to hop through the test as quickly as possible. By documenting the unacceptable trials, we found that 23 participants had trials with missed jumps, with most misses caused by not jumping high enough to accommodate the hurdle. Specifically, 8 participants in the FAI group and 15 participants in the control group had unacceptable trials. The middle (medial) jump was the most frequently missed jump for all participants. Because both control and FAI participants accrued trials with missed jumps by hitting this hurdle, we concluded that this part of the test was the most difficult to maneuver.

In future research, this FPT could be modified by incorporating additional squares or creating a different path for participants to follow. Weakness, premature fatigue, or deficits in participants with FAI may become more apparent if the length or intensity of the test is increased.

Limitations

A limitation of this study was the lack of classification or exclusion of participants with mechanical instability. Poorer performance on the FPT may represent participants who had both functional and mechanical instabilities. Although the exact relationship between these instabilities is unclear, it warrants future research.

Another limitation of this study was the range of physical activity in the sample population. The range of activity level was similar in both groups, but the sample was relatively heterogeneous. The activity level of participants ranged from exercising 2 times each week to participating in competitive athletic activity. On the lower range of the physical activity scale, participants walked, swam, jogged, or weight trained twice each week. Conversely, the participants at the top of the physical activity scale competed in collegiate athletics at a Division I institution. Because a particular level of physical activity may significantly affect performance, a more homogeneous sample should be tested in future studies.

CONCLUSIONS

The FAI-S participants had performance deficits during the single-limb hopping test. Our results identify a quantifiable deficit in functional performance when participants perceive a feeling of instability. Additionally, a difference seems to exist between participants who simply report a feeling of instability in the days or weeks preceding the study and those who report the instability after actual physical activity. Requiring participants to perform this simple hopping test before asking them if they have feelings of ankle instability or giving way could be another method to determine the presence of FAI. The single-limb hopping test also could be an appropriate test to determine functional improvements after rehabilitation in participants with FAI. Finally, to assist in interpreting scores on the single-limb hopping test, subsequent testing should be conducted to create a range of normative values in different populations.

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