# Chronic Ankle Instability Does Not Affect Lower Extremity Functional Performance

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## Abstract:

***Objective:*** To determine if functional performance is impaired in individuals with self-reported chronic ankle instability.
***Design and Setting:*** We used a between-groups design to assess 3 functional variables. All data were collected at a Division III college and a military academy. Before testing, all subjects performed a 5-minute warm-up, followed by a series of stretches for the lower extremity muscles. Subjects then performed cocontraction, shuttle run, and agility hop tests in a counterbalanced fashion. Three trials for each functional test were completed and averaged for analysis.
***Subjects:*** Twenty men with a history of at least 1 significant ankle sprain and episodes of at least 1 repeated ankle injury or feelings of instability or "giving way" were compared with 20 men with no prior history of ankle injury. Subjects were matched by age, height, weight, and activity level.
***Measurements:*** Time to completion was measured in seconds for the cocontraction and the shuttle run tests. The agility hop test was measured on an error point scale.
***Results:*** Using 3 separate, independent, 2-tailed $t$ tests, we found no significant difference between groups for the cocontraction ($P$ = .452), shuttle run ($P$ = .680), or agility hop ($P$ = .902) tests.
***Conclusions:*** Chronic ankle instability is a subjectively reported phenomenon defined as the tendency to "give way" during normal activity. Although athletes commonly complain of subjective symptoms associated with chronic ankle instability, our findings suggest that these symptoms do not negatively influence actual functional performance. Future researchers should evaluate other, more demanding functional-performance tests to further substantiate these findings.

**Keywords:** functional ankle instability | proprioception | mechanoreceptors | agility test

## Article:

The ankle joint has been reported to have the highest incidence of injury in sports.[1] The lateral-ligament complex is the most frequently injured structure in the ankle joint, representing approximately 85% to 95% of all ankle sprains.[2–4] Chronic disability characterized by pain, swelling, and functional instability affects approximately 40% of those who suffer lateral ankle sprains.[5–9] Chronic ankle instability (CAI) is a subjectively reported phenomenon that has been defined as a tendency to "give way" during normal activity and is comparable with the giving-way phenomenon that occurs in an unstable knee joint. More recently, Vaes et al[10] defined functional instability as "the disabling loss of reliable static and dynamic support of a joint." Because of the prevalence of chronic ankle instability and the disability it creates, considerable attention has been directed toward understanding the underlying cause of this phenomenon.[1,2,5,11–17]

Most research to date has focused on the role of proprioception and muscle function as contributing factors to CAI.[6,13–17] Proprioceptive deficits after ankle injury are thought to result from damage to mechanoreceptors in the ligaments, muscles, and skin, contributing to subsequent feelings of instability.[1,13] Freeman et al[5] attributed this proprioceptive disability to the articular deafferentation that occurs when nerve fibers in ligaments and capsule are damaged during an ankle sprain. This contention is supported by multiple studies that link chronic instability more to deficits in proprioceptive capabilities than to deficits in muscle strength.[1,13–15,18] Consequently, the relationship between proprioceptive deficits and chronic instability has been of great interest.[1,5,6,11,13–15,17]

Somatosensation is a complex sensory component of the neuromuscular system that encompasses the "perception and execution of musculoskeletal control and movement."[19] Proprioceptive feedback during joint motion depends not only on sensory information from joint receptors (ie, ligament and capsule) but also includes divergent information from skin, articular, and muscle mechanoreceptors.[5,14,15] While researchers have demonstrated that the afferent feedback system may be interrupted after injury, how these deficits may affect actual performance on functional tasks is unknown.

The relationship of perceived CAI to actual functional-performance decrements has received minimal attention. In the few studies to date, functional-performance measures such as the shuttle run and various single-leg hopping tasks have been examined.[20,21] No significant difference in any of the functional-performance tasks was found when comparing the injured with the uninjured side.[20] At this point, no investigators have compared performance on these tasks between healthy groups and those with instability. Because of the potential cross-over effects that can occur during these functional tasks, we feel this is the next step.

A variety of functional-performance tasks have been developed to simulate, in a controlled environment, the actions and forces imposed on the ankle joint during normal athletic performance. In particular, agility tests may provide a quantitative assessment of functional performance, as they require the ability to perform skilled, multidirectional, and coordinated movements over a measurable period of time.[19] For the purpose of this study, we chose the cocontraction, shuttle run, and agility hop tests because of the particular stresses they place on the ankle joint. Specifically, the cocontraction test reproduces rotational forces that require stabilization at the ankle joint[19,22,23]; the shuttle run reproduces acceleration and deceleration forces normally seen in athletic competition[19,22,23]; and the agility hop test specifically targets aspects of proprioception such as balance, coordination, and joint control.[15]

Each of these tests has been previously used to assess functional performance in the lower extremity. Authors using these specific tests[19] or similar tests[24] have demonstrated that they are reliable measures. Specifically, the cocontraction and shuttle run tests have shown excellent reliability, with *r* ranging from .92 to .96.[19] Pilot testing of the agility hop test during the present study demonstrated high intratester reliability (intraclass correlation coefficient 2,1 = .98).

While the complexities involved in neuromuscular feedback and its relationship to chronic instability may not be completely understood, it appears that deficits in proprioception may lead to functional instability[1,13,14,25]and that coordination exercises may improve some measures of proprioception.[1,5,11,14,15,26,27] Given these findings, one might assume that the subjective symptoms and proprioceptive deficits associated with CAI would affect functional performance, yet this has not been sufficiently evaluated or substantiated in the literature.

Therefore, our purpose was to determine if functional performance, as measured by the cocontraction, shuttle run, and agility hop tests, is impaired in those with self-reported CAI.

## METHODS

Forty subjects from an all male Division III college and a military academy volunteered for this study. The CAI group included 20 men (age = 20.4 ± 2.5 years, height = 187.3 ± 7.6 cm, mass = 93.0 ± 17.9 kg) with self-reported CAI. The criteria for inclusion in the CAI group were (1) a history of at least one significant lateral ankle sprain in which the subject was unable to bear weight or was placed on crutches, (2) episodes of at least one repeated lateral ankle injury or feelings of ankle instability or “giving way,” and (3) no present participation in a rehabilitation program. The control group consisted of 20 men (age = 19.8 ± 1.9 years, height = 186.8 ± 8.0 cm, mass = 90.6 ± 16.3 kg) with no previous history of ankle injury, who were matched to subjects in the CAI group according to height, mass, age, activity level (collegiate athlete, recreational athlete, or sedentary individual), and sport if any. We also matched the control and CAI groups for limb side, so we had equal numbers of right and left ankles in each group. No matching occurred with regard to limb dominance. All subjects read and signed an informed consent form, approved by a university committee for the protection of human subjects, before participating in the study, which was also approved by the committee.

## PROCEDURES

We used 3 functional-performance tests to simulate, in a controlled environment, normal athletic stresses to the ankle joint: the cocontraction, shuttle run, and agility hop tests. Before testing, we gave subjects thorough instructions on how to perform each test, and subjects completed a 5-minute bicycle warm-up followed by three 20-second stretches for the quadriceps, hamstrings, and triceps surae muscle groups. Immediately after the warm-up, subjects performed 3 trials of each functional-performance test with a 30-second rest between trials and a 1-minute rest between tests to minimize fatigue. All tests were performed during a single session and were counterbalanced to control for order effect.

### Cocontraction Test

The cocontraction test followed the same procedures described by Evans et al[28] and Lephart et al.[19,22,23] A 1.23-m length of heavy rubber tubing with an outer diameter of 2.5 cm was secured to a metal loop on a wall 1.52 m above the floor (Figure 1). We attached the other end of the tubing to a heavy hook-and-loop tape belt secured around the subject's waist. We also marked a semicircle on the floor with a radius of 2.44 m from the metal loop, which served as a boundary guideline for the subject to stay behind while performing the test. We instructed each subject to start on the left side of the semicircle, facing the metal loop. Using a shuffle step, in which the feet did not cross, subjects were asked to complete 5 wall-to-wall lengths as quickly as possible. Before the test, we gave each subject the following instructions: (1) begin at the command "go," (2) use only a shuffle step, (3) do not use your hands to push off the walls, (4) keep your feet behind the marked semicircle, (5) hold the cord with both hands throughout the test, (6) face the metal loop at all times, and (7) do not pull the cord with your hands, but keep tension on the cord by bending your knees. Time began at the command "go" and stopped when the subject reached the wall at the completion of the fifth length.

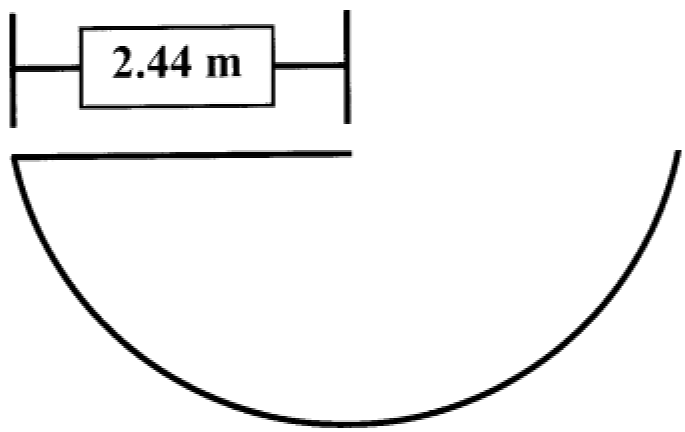


Figure 1. Cocontraction test.

### Shuttle Run Test

To administer the shuttle run test, we marked a distance of 6.1 m on the floor with 2 separate pieces of tape. Subjects were asked to start behind the first piece of tape, then run and touch the opposite tape, completing 4 consecutive 6.1-m lengths for a total of 24.4 m (Figure 2). Time began at the command "go" and stopped when the subject crossed the final piece of tape. Subjects were instructed to change directions by pushing off the involved ankle.

### Agility Hop Test

The agility hop test is a unique combination of a traditional hop test and a single-leg balance test. In this test, the participant is required to hop in many different directions and return to a stable, balanced position between hops. Scoring on the agility hop was based on an error rating scale described by Bernier and Perrin.[15] We marked 6 spots on the floor, numbered in order (Figure 3). We instructed subjects to hop to each spot, using the involved limb or matched control, according to the following instructions: (1) begin by standing on spot #1 and hold balance for 5 seconds, hop to spot #2, regain balance and hold for 5 seconds, and continue in sequential order through spot #6; (2) immediately after each hop, bring your arms to your sides and fully extend the involved hip and knee (this forces the subject to make postural corrections at the ankle); and (3) keep the uninvolved leg directly to the side of the test leg upon landing.

We evaluated test performance according to the number of errors the subject made. The same examiner scored all trials and recorded an error for each of the following: (1) subject moved the test foot or didn't “stick” the landing, (2) subject did not hold for the full 5 seconds on each spot, (3) subject moved arm(s) for balance, (4) subject's contralateral leg moved away from the test leg, (5) subject touched down with the contralateral leg, or (6) subject's body swayed excessively in any direction. All subjects were videotaped during the agility hop test to ensure that errors were correctly counted.

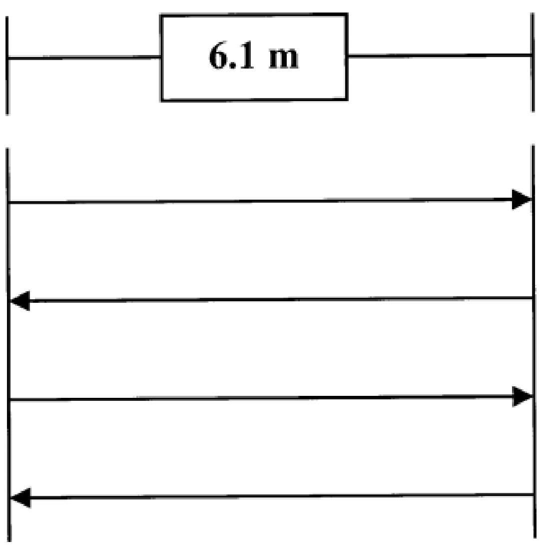


Figure 2. Shuttle run test.

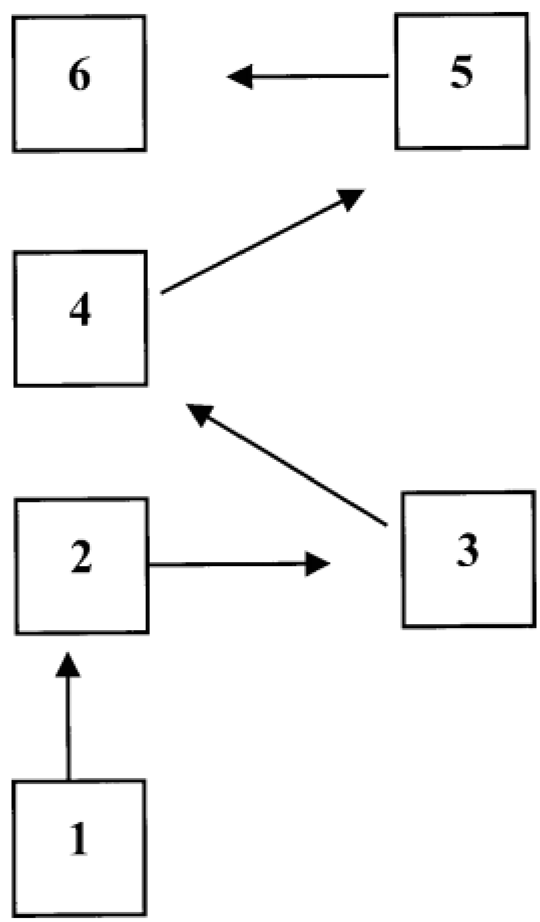


Figure 3. Agility hop test.

## STATISTICAL ANALYSIS

We obtained data for the cocontraction and shuttle run tests using a stopwatch and recorded time in seconds. Data for the agility hop test were based on an error point scale. Each test was performed 3 times and the average used for data analysis. We compared performance between the CAI and control groups for each functional test with an independent 2-tailed *t* test. Alpha for all analyses was set at $P < .05$.

## RESULTS

We found no significant difference between the CAI and control groups in the time to completion for either the cocontraction test ($t_{1,38} = .760$, $P = .452$, $1-\beta = .115$) or the shuttle run test ($t_{1,38} = .415$, $P = .680$, $1-\beta = .069$) (Table). We also found no significant difference in error scores between the CAI and control groups for the agility hop test ($t_{1,38} = .124$, $P = .902$, $1-\beta = .052$).

**Performance Scores for the Cocontraction, Shuttle Run, and Agility Hop Tests***

| Group | Cocontraction, s | Shuttle Run, s | Agility Hop, No. of Errors |
|---|---|---|---|
| Chronic ankle instability | 14.99 ± 1.78 | 6.83 ± .41 | 11.36 ± 4.99 |
| Control | 14.57 ± 1.73 | 6.78 ± .45 | 11.18 ± 3.99 |

*Values are mean ± SD.

## DISCUSSION

Our primary finding was that functional performance, as measured by the cocontraction, shuttle run, and agility hop tests, was not different between the uninjured and CAI subjects. While researchers have found that subjects with CAI demonstrate proprioceptive deficits,[1,14,25] our data suggest that proprioceptive capabilities are still sufficient to perform these functional tests. These findings support previous research that also found no significant difference among a variety of functional-performance tests when comparing the injured with the uninjured side of subjects with unilateral ankle instability.[20,21]

While interpreting these data, we felt it was important to explore whether our lack of significant findings was due to insufficient statistical power (ie, insufficient number of subjects) necessary to gain meaningful results. We suspected this was not the case and that the results were due to a low effect size, given the very small mean differences between the groups. We confirmed this by calculating the effect size for each test, using the standard deviation of the uninjured group. Effect sizes were .24 for the cocontraction test, .11 for the shuttle run test, and .05 for the agility hop test, which, by convention, indicate very small (unobservable) differences between the conditions.[29,30] Hence, even if we were to add substantially more subjects to achieve statistically significant differences between conditions (eg, more than 300 subjects to achieve 80% power for the cocontraction test alone), the actual difference would not be of clinical importance.

We also wanted to confirm that our times for the cocontraction and shuttle run tests were consistent with previous findings. In a previous study of subjects after anterior cruciate ligament reconstruction, those who eventually returned to sport took 14.96 seconds on the cocontraction test; those who could not return took 20.70 seconds, which was determined to be significantly slower.[23] On this test, our CAI and control participants took 14.99 and 14.57 seconds, respectively. In the previous study, scores for the shuttle run ranged from 7.45 seconds for the group that was able to return to activity to 9.67 for those who could not return (a significant difference).[23] Our results were 6.83 seconds for the CAI group and 6.78 seconds for the control group; therefore, our times were consistent with those found in the literature for functionally active subjects.

To evaluate functional performance, we chose tests that imposed sport-specific movements and loads on the ankle joint and required the balance, coordination, and multiplanar muscular stabilization necessary for high-intensity athletic activities. While the cocontraction and shuttle run tests have been effective in identifying deficits in subjects with anterior cruciate ligament-insufficient knees,[23] we were unable to detect differences in subjects with CAI. Potential reasons for our lack of significant findings may be that minimal proprioceptive deficits were present in our CAI group or that these deficits were present but compensated for by increased reliance on feedback from other joints and structures.

Functional-performance tests are very complex tasks that allow multiple joints and structures to assist in the production of movement. Previous authors have demonstrated that novel coordination exercises such as ankle-disk training may improve proprioceptive capabilities of the ankle[15,27]; a more functional and complex task may lead to this compensatory response. Perhaps future researchers should simultaneously assess both specific proprioceptive deficits and functional-performance capabilities to determine the extent of compensation for isolated deficits.

It is also possible that deficits were present but not apparent with the specific functional-performance tests used in this study. While subjects were matched according to affected limb side, age, height, mass, activity level, and sport when applicable, it may also be relevant to evaluate individual sports relative to the functional tests used. Lephart et al[19] found that times on the cocontraction, carioca, and shuttle run tests varied among athletes in different sports and even among positions within a sport. Increasing the sport specificity of the functional tasks and the demand of the tasks to impose further stress on the ankle joint may provide more sensitivity to detect proprioceptive deficits in subjects with CAI.

A limitation of this study was the lack of information on previous rehabilitation of the CAI group. While none of these participants were involved in rehabilitation at the time of the study, historical information was not obtained. In addition, we did not know if any previous rehabilitation programs included proprioceptive exercises. It is important to note that the range and variability of scores in our CAI group were no different than in the healthy subjects. By not controlling this factor, intuitively one would expect greater response variability in this group if some had previously benefited from a rehabilitation program while others did not. In the absence of these findings, we suspect that previous rehabilitation history likely had little effect on our results. More research is needed to elucidate the effect of rehabilitation on CAI and functional performance. Future investigators should control for rehabilitation background and history as part of the screening process and may consider evaluating differences between subjects with CAI who have been through a proprioceptive rehabilitative program versus those who have not.

Another important issue is the severity of the reported CAI and the criteria for defining the instability. Definitions of CAI vary tremendously among studies.[10–12,14,17,31] While the definition used in this study is widely accepted,[15,17,27] the question we must address is whether a history of ankle sprains and recurrent episodes of giving way are enough to identify CAI. In future studies, we believe it would be beneficial to collect additional information from the subject, such as history, frequency, severity, and rehabilitation of ankle injuries and to correlate these factors to any deficits noted. This information would allow us to continue to analyze differences among subjects who complain of CAI and those who do not, and it would further our understanding of the effect of CAI on functional performance.

### Clinical Relevance

Chronic ankle instability has been defined primarily as a subjective phenomenon. Subjective complaints of giving way are typically used to screen subjects for inclusion into the experimental group. While one of the primary complaints by those suffering from CAI is a feeling of giving way, it does not appear that this phenomenon has any detrimental effects on functional performance. The scoring used for each of the functional-performance tests was based solely on physical performance and had no bearing on feelings of giving way by any of the subjects. Thus, while the subjective reports should not be discounted, these complaints of instability do not appear to prevent individuals from participating at an optimal level.

## CONCLUSIONS

Because of the competitive nature of sports, individuals must be able to perform at an optimal level. Our findings suggest that while participants may complain of ankle instability, their proprioceptive deficits are not sufficient to result in gross decrements in performance during functional activity. These results should play a role in rehabilitation and return-to-play criteria. Continued research is necessary to define both the characteristics of chronic ankle instability and how deficits can affect actual functional performance.

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