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# Effect of Balance Training on Postural Stability in Subjects With Chronic Ankle Instability

Maraike Alice Wortmann and Carrie L. Docherty

The lateral ligament complex of the ankle is a frequently injured structure in sports and recreational activities, which often results in chronic ankle instability (CAI). Balance exercise training has become a common component of clinical rehabilitation for CAI to address postural deficits. To determine the effect of balance training on postural stability, this critically appraised topic presents a summary and analysis of 4 relevant studies that address the effectiveness of balance training in subjects with CAI. Information about the methods and sources used in the article is provided. The findings imply that there is moderate evidence that 4–6 wk of balance training can enhance static and dynamic postural stability in subjects with CAI.

**Keywords:** ankle sprains, proprioceptive exercise, coordination, postural control

## Clinical Scenario

The lateral ligament complex of the ankle is a frequently injured structure in sports and recreational activities, which often results in chronic ankle instability (CAI).<sup>1</sup> The typical mechanism for an ankle sprain is one of inversion, plantar flexion, and internal rotation.<sup>1</sup> Subjects with CAI characteristically have a history of multiple ankle sprains due to mechanical or functional instability of the ankle or both. Postural stability requires processing of afferent information and appropriate efferent response to control muscles in the trunk and extremities to maintain balance. Postural stability appears to be affected in individuals with CAI and impinges on a person's ability to balance under both static and dynamic conditions.<sup>2,3</sup> Balance training has become a common and integral component of clinical rehabilitation of patients with CAI to address postural deficits. Balance training can be described as training focused on the awareness of body position by maintaining the center of gravity over the base of support. The purpose of this critically appraised topic (CAT) is to determine the effect of balance training on postural stability in subjects with CAI to promote evidence-based practice for all clinicians.

## Focused Clinical Question

How does balance training affect static and dynamic postural stability in subjects with CAI?

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## Summary of Search, “Best Evidence” Appraised, and Key Findings

- The literature was searched for studies of at least level 3 evidence (based on Levels of Evidence, Oxford Centre for Evidence-Based Medicine, 2011) that investigated the effect of balance training on postural stability in subjects with CAI and are consistent with the inclusion and exclusion criteria listed herein.
- Two randomized controlled trials<sup>4,5</sup> and 2 cohort studies<sup>6,7</sup> were included.
- The definition of CAI in all 4 studies included a history of more than 1 ankle sprain with residual symptoms, as well as a subjective feeling of the ankle “giving way.” Two studies used the Foot and Ankle Disability Index to determine self-reported symptoms of CAI.<sup>7,8</sup> The other 2 studies did not include information about the assessment tools used to determine CAI.<sup>4,6</sup>
- Three studies demonstrated improvement in static postural stability in single-limb stance after the training protocol.<sup>4-6</sup> One study found no significant group differences in the static-balance assessment after balance training.<sup>7</sup>
- Static postural stability assessed on a force plate in single-limb stance with eyes closed was more consistent than when assessed with eyes open. This may be because visual control provides a sufficient compensation mechanism for postural-stability deficits that does not allow significant changes in static postural stability tested with eyes open.

- Two studies identified an improvement in dynamic postural stability through an increased reach distance during the Star Excursion Balance Test.<sup>7,8</sup>
- One author<sup>7</sup> indicated that improvements in dynamic balance may be more relevant in reducing the chance of injuries during athletic activities. Inherently, dynamic balance tasks are more difficult than static balance measures and therefore might create more improvements to the sensorimotor system.
- The length of the training protocols in the included literature differed from 4 weeks<sup>5</sup> to 6 weeks,<sup>4,6,7</sup> and the number of sessions per week varied from once<sup>6</sup> to 3 times.<sup>4,5,7</sup>

### Clinical Bottom Line

There is moderate evidence to indicate that 4 to 6 weeks of balance training can enhance static and dynamic postural stability in subjects with CAI.

**Strength of Recommendation:** According to the strength-of-recommendation taxonomy, there is level B evidence that balance training performed for a minimum period of 4 weeks, including a variety of balance exercises, improves postural stability in subjects with CAI.

### Search Strategy

#### Terms Used to Guide Search Strategy

- Patient/Client group: chronic ankle instability
- Intervention: proprioceptive training, coordinative training, or balance training
- Comparison: no intervention or control group
- Outcomes: static postural stability and/or dynamic postural stability

#### Sources of Evidence Searched

- CINAHL
- SPORTDiscus
- MEDLINE

### Inclusion and Exclusion Criteria

#### Inclusion Criteria

- Studies investigating CAI (subjects with a history of more than 1 ankle sprain)
- Studies investigating static and/or dynamic postural stability
- Studies investigating proprioceptive, coordinative, or balance training as an intervention  $\geq 4$  weeks in duration
- At least level 3 evidence
- Limited to studies published between 1998 and 2011
- Limited to humans
- Limited to English or German language

#### Exclusion Criteria

- Studies using subjects with a history of only 1 lateral ankle sprain and no residual symptoms
- Studies with a multicomponent program that included interventions or devices additional to balance training, such as strength training, electrical stimulation, taping, bracing, or exercise shoes

### Results of Search

Four relevant studies were located and categorized as shown in Table 1 (based on Levels of Evidence, Centre for Evidence-Based Medicine, 2011).

### Best Evidence

The studies shown in Table 1 and 2 were identified as the best evidence and selected for inclusion. Reasons for selecting these studies were that they were graded at level of evidence of at least 3, investigated balance training as an intervention in subjects with CAI, and described the effect of the intervention on the outcomes of interest (static and dynamic postural stability).

**Table 1 Summary of Study Designs of Articles Retrieved**

Level of evidence	Study design	Number located	Reference
2	Randomized controlled trial	2	Bernier and Perrin <sup>4</sup> McKeon et al <sup>5</sup>
3	Cohort study	2	Eils and Rosenbaum <sup>6</sup> Sefton et al <sup>7</sup>

**Table 2 Characteristics of Included Studies**

	<b>Bernier and Perrin<sup>4</sup></b>	<b>McKeon et al<sup>5</sup></b>	<b>Eils and Rosenbaum<sup>6</sup></b>	<b>Sefton et al<sup>7</sup></b>
Study design	Randomized controlled trial	Randomized controlled trial	Cohort study	Prospective cohort study
Participants	48 participants with CAI were randomly assigned to 1 of 3 groups: group 1 (n = 16), control group with no intervention; group 2 (n = 15), sham treatment of electrical stimulation to peroneus longus/brevis muscles without actual electrical stimulation; and group 3 (n = 17), experimental group participating in 6 wk balance and coordination training. Included if a history of CAI reported and suffered a minimum of at least 2 episodes in the 12 month prior to testing. Excluded in case of pain at the beginning of study, 3 dropouts: 2 from group 1 and 1 from group 2. 45 subjects completed the study and were included in data analysis.	31 physically active subjects (19 female, 12 male) with self-reported CAI. Random allocation by an independent investigator to balance-training group (BTG, n = 16) or control group (CG, n = 15). Included if more than 1 ankle sprain and residual symptoms, ≥4 “yes” responses on AII, score ≤90% on FADI and FADI Sport. Excluded if ankle sprain within past 6 wk, history of lower extremity surgery, balance disorders, other conditions to affect balance.	30 subjects (18 female, 12 male) with CAI. 2 groups: exercise group (EG, n = 20) and control group (CG, n = 10). For subjects with bilateral instability, both feet were evaluated (EG: n = 31, CG: n = 17, total: N = 48). Included if repeated ankle-inversion sprains and self-reported feeling of instability/giving way. Excluded in case of pain at the beginning of study.	21 participants: 12 with CAI (8 female, 4 male) and 9 healthy subjects (6 female, 3 male). CAI subjects (balance group) included if more than 1 ankle sprain in the year prior to the study, recurring symptoms, difficulty in more than 2 areas in FADI Sport or 1 area in FADI. Excluded if history of neurological or lower extremity musculoskeletal pathology, acute lower extremity injury requiring ambulation support 12 mo before study, minor ankle injuries with a change of activity level >1 day 3 mo before study. Healthy subjects (control group, CG) included if no previous history of ankle sprain, lower extremity injury, neurological conditions, balance impairments, or other conditions interfering with measures.

(continued)

Table 2 (continued)

	Bernier and Perrin <sup>4</sup>	McKeon et al <sup>5</sup>	Eils and Rosenbaum <sup>6</sup>	Sefton et al <sup>7</sup>
Intervention investigated	Group 3: 6 wk of balance training performed 3 times/wk for 10 min (from simple to complex). 11 different strategies (with eyes open and eyes closed) balancing on the affected limb on different surfaces/balance devices from uniaxial to multiaxial.	BTC: 4 wk progressive dynamic balance-training program in 12 supervised training sessions (3 times/wk) for 20 min with progressive increase of tasks if possible. Each activity contained 7 levels of difficulty from easy to challenging. CG: same level of activity as before, no intervention.	EG: 6-wk multistation proprioceptive exercise program with 12 different exercises using various balance devices. Training once a week, exercise period 20 min. Single exercises: 45 s, followed by 30-s break. Whole program was performed twice with small modifications every 2 wk to increase training intensity.	CAI subjects: 6-wk balance-training program on balancing platform with 4 levels of difficulty (from double-limb to single-limb stance). Training: 3 ×/wk for 6 wk (total 18 sessions) and increase of difficulty level by raising the center support height. CG: Normal daily activity, no intervention.
Outcome measure	<i>Static postural stability:</i> Measured on force plate of the balance system with eyes opened and eyes closed on stable platform and on inversion/eversion tilting platform in single-limb stance (20 s). Dependent measures: Sway index and modified equilibrium score.	<i>Static postural stability:</i> Measured by time-to-boundary analysis in anteroposterior (AP) and mediolateral (ML) directions with eyes open and eyes closed (10 s) in comparison with traditional center-of-pressure (COP) measures on a force plate in single-limb stance. <i>Dynamic postural stability:</i> Measured by the SEBT including reach distances in posteromedial (PM) and posterolateral (PL) directions.	<i>Static postural stability:</i> Measured by using a Kistler force plate in single-limb stance with eyes open (15 s) to analyze the sway of center of gravity (CoG) in ML and AP direction and the total sway distance.	<i>Static postural stability:</i> COP measured by strain-gauge force platform in single-limb stance with eyes open (up to 5 min) on the ankle with CAL. <i>Dynamic postural stability:</i> Measured by modified SEBT (reach distance in antero-medial, medial, and PM directions).

Main findings	Static postural stability	Static postural stability	Static postural stability	Static postural stability
	<p>No significant effect on sway index.</p> <p>Significant group <math>\times</math> test <math>\times</math> condition <math>\times</math> eyes interaction for modified equilibrium scores of balance in AP and ML directions. Posttest for group 3 during stable platform with eyes closed and inversion/eversion tilting platform with eyes open improved significantly (<math>P = .05</math>) over pretest for all groups and in comparison with posttest groups 1 and 2.</p>	<p><i>Time-to-boundary measures</i></p> <p>Eyes open: No significant interactions or main effects for any measure. Eyes closed: Significant group <math>\times</math> time interactions for 4 of 6 measures in BTG from pretest to posttest in ML and AP directions (<math>P &lt; .05</math>) and compared with CG.</p> <p><i>COP-based measures</i></p> <p>Eyes open: No significant group <math>\times</math> time interactions. Significant decrease in AP velocity (<math>P = .04</math>) in posttest compared with pretest for both groups. Eyes closed: Significant decrease in ML direction (<math>P = .03</math>) in BTG from pretest to posttest.</p>	<p>Significant improvement in ML direction in EG for SD (<math>P &lt; .05</math>), maximum sway (<math>P &lt; .01</math>). No significant improvements in AP direction in EG but in CG (SD and maximum sway <math>P &lt; .05</math>). Total sway distance was reduced in both groups (<math>P &lt; .01</math>).</p>	<p>No significant treatment effects.</p> <p><b>Dynamic postural control</b></p> <p>CAI group had significantly better post-training measures in reach distance than CG in anteromedial (<math>P = .021</math>), medial (<math>P = .048</math>), and PM (<math>P = .030</math>) directions.</p>
		<p><b>Dynamic postural control</b></p> <p>Significant improvement in reach distances with PM (<math>P = .01</math>) and PL (<math>P = .03</math>) directions in BTG from pretest to posttest and posttest compared with CG.</p>		

(continued)

Table 2 (continued)

	Bernier and Perrin <sup>4</sup>	McKeon et al <sup>5</sup>	Eils and Rosenbaum <sup>6</sup>	Sefton et al <sup>7</sup>
Level of evidence	2	2	3	3
Validity score	PEDro 4/10	PEDro 4/10	NA	NA
Conclusions	Static postural stability can be improved in subjects with CAI by 6 wk of balance and coordination training.	Significant improvement of static postural stability with eyes closed as measured by time-to-boundary and dynamic postural stability as measured by SEBT in subjects with CAI after 4 wk progressive balance training.	The 6-wk multistation proprioceptive exercise program performed once a week led to significant improvements in static postural stability in subjects with CAI.	After 6 wk of balance training, participants with CAI demonstrated better dynamic postural stability performance in the anteromedial, medial, and PM directions. There was no significant effect on static postural control. Limitations in statistical power: small sample size

Abbreviations: CAI indicates chronic ankle instability; AII, Ankle Instability Instrument; FADI, Foot and Ankle Disability Index; SEBT, Star Excursion Balance Test.

## Implications for Practice, Education, and Future Research

The studies included address the effect of balance training on postural stability. All the studies included measured static postural stability as an outcome. Three studies identified an enhancement in static postural stability after the training protocol.<sup>4-6</sup> Improvements occurred in mediolateral direction<sup>4-6</sup> and anteroposterior direction.<sup>4,5</sup> Only 1 study, which had a small sample size, reported no significant changes in static postural stability after the training program.<sup>7</sup>

The testing instrumentation for static postural stability differed in terms of period of time on force plate (from 10 s up to 5 min) and visual control (eyes open or closed). The improvement in static postural stability with eyes open was not as conclusive as the results investigating the effect of balance training with eyes closed. Alterations in static postural stability seem to be more apparent when the requirements of the task are more difficult, which subsequently places higher demands on the afferent system. This should be considered when testing static postural stability in future studies.

The effect of balance training on dynamic postural stability was investigated by 2 studies.<sup>5,7</sup> These studies identified a greater reach distance after training. Clinically, this means that after the training program, subjects were able to reach farther while still maintaining their center of gravity within the base of support.

The applied training protocols used in these studies included several levels of difficulty from simple to more challenging. Examples of this progress included beginning with double-limb stance on firm surfaces with eyes open continuing to less stable surfaces such as balance boards, allowing multiaxial movements of the ankle on a balance disc or circular wobble board, raising the center of support height, reducing visual control by closing the eyes, and progressing to single-limb stance, in that same order. Clinicians who include balance training as a rehabilitation intervention in subjects with CAI to address sensorimotor control should consider the variety of tasks that can be performed to gain improvements in postural stability.

Further research should investigate the effect of balance training on acute ankle sprains as opposed to subjects with CAI. In addition, future studies should focus on the sensitivity of different assessments to measure alterations in static postural stability, as well as assessing different aspects of postural stability to provide evidence of the effectiveness of balance training in subjects with CAI.

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