RESEARCH PAPER

Effect of Core Stability Training on Balance and Re-injury Rates in Patients with Chronic Ankle Instability

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ABSTRACT

Background:

Chronic ankle instability (CAI) commonly develops after repeated ankle sprains and is associated with impaired balance, functional limitations, and recurrent injury. Conventional rehabilitation primarily addresses ankle strength, mobility, proprioception, and balance. Core stability training may provide additional proximal control for lower-limb movement.

Objective:

To determine whether adding structured core stability training to conventional ankle rehabilitation improves balance and functional ankle stability and reduces re-injury in patients with CAI.

Methods:

Thirty participants with CAI were randomly allocated to an experimental group (n=15), receiving conventional ankle rehabilitation plus core stability training, or a control group (n=15), receiving conventional ankle rehabilitation alone. Treatment was provided three times weekly for six weeks. Outcomes included Star Excursion Balance Test (SEBT) composite reach, Cumberland Ankle Instability Tool (CAIT), Visual Analogue Scale (VAS) for pain, and plank-hold time. Re-injury was recorded during follow-up. Within- and between-group analyses were performed using parametric or non-parametric tests according to distribution.

Results:

Both groups showed significant pre-to-post improvements in SEBT, CAIT, VAS, and plank-hold outcomes ($p<0.001$ for within-group comparisons). The experimental group demonstrated greater change than the control group for SEBT (8.62±2.76 vs 3.73±1.88; $p<0.001$), CAIT (6.93±1.83 vs 4.13±1.06;

p<0.001), VAS (-2.54±0.99 vs -1.87±0.69; p=0.029), and plank hold (23.07±6.94 vs 10.93±4.25 s; p<0.001). Re-injury occurred in 3/15 participants (20.0%) in the experimental group and 4/15 (26.7%) in the control group.

Conclusion:

Adding core stability training to conventional ankle rehabilitation was associated with greater improvements in dynamic balance, perceived ankle stability, pain, and core endurance. The lower observed re-injury proportion should be interpreted cautiously because only seven recurrent sprains occurred and the sample was small.

Keywords: chronic ankle instability; core stability training; balance; re-injury; Star Excursion Balance Test; Cumberland Ankle Instability Tool; physiotherapy

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1. Introduction

Ankle sprain is a common musculoskeletal and sports-related injury, and a proportion of individuals continue to experience recurrent giving-way episodes and functional limitations after the initial injury. Chronic ankle instability is considered a multifactorial condition involving mechanical instability, altered sensorimotor control, impaired postural control, and functional deficits rather than ligament
laxity alone [1–3]

Proprioceptive and neuromuscular deficits following ankle injury can alter the information available for postural control. Dynamic balance deficits may be more apparent during challenging single-leg or movement-based tasks than during quiet standing [5,6]. The Star Excursion Balance Test is therefore useful for assessing dynamic postural control in individuals with lower-limb dysfunction [13].

Conventional rehabilitation for CAI commonly includes range-of-motion exercises, ankle and peroneal strengthening, proprioceptive and balance training, and functional progression. Such programs can improve postural control and self-reported function [6,17]. However, improvement in balance does not necessarily establish a reduction in recurrent sprains, and evidence concerning long-term re-injury prevention in established CAI remains limited [6].

The kinetic-chain model provides a rationale for addressing proximal control. Core stability describes the ability to control the trunk and pelvis and to provide a stable base for force generation and transfer between the trunk and lower extremities [7]. Previous work has associated trunk and hip characteristics with lower-extremity injury risk [8], while studies in individuals with ankle instability have reported improvements in dynamic balance and functional outcomes following core-focused interventions [9].

The present study therefore compared conventional ankle rehabilitation alone with the same rehabilitation combined with structured core stability training, examining dynamic balance, functional ankle stability, pain, core endurance, and subsequent re-injury.

2. Materials and Methods

2.1 Study Design and Setting

A randomized controlled study was conducted at Capri Spine Clinic. Thirty eligible participants with chronic ankle instability completed the

study. Participants were randomly allocated in equal numbers to an experimental group or a control group.

2.2 Participants

Participants were aged 18–40 years and had a clinical diagnosis of CAI with a history of recurrent lateral ankle sprain. Participants were required to understand and follow exercise instructions and provide written informed consent. Exclusion criteria included ankle fracture or surgery within the previous six months, acute ankle injury at recruitment, neurological or vestibular disorders affecting balance, other lower-limb musculoskeletal conditions affecting function, and inability or unwillingness to attend treatment or follow-up.

Sample Size and Allocation

Sample-size planning indicated 12 participants per group; allowing for an anticipated 20% dropout resulted in a planned sample of 15 participants per group. Thirty participants completed the study: 15 in the experimental group and 15 in the control group.

2.3 Intervention

Both groups received conventional ankle rehabilitation three times per week for six weeks. Sessions for the control group lasted approximately 45 minutes and included gastrocnemius and soleus stretching, resistance-band dorsiflexion, plantarflexion, inversion and eversion, single-leg balance, unstable-surface and wobble-board exercises, and heel-to-toe walking.

The experimental group received the same conventional rehabilitation plus approximately 15 minutes of core stability training within each session. During weeks 1–2, exercises included pelvic tilts, abdominal bracing, bridges, and single-leg bridges. During weeks 3–4, exercises progressed to front planks, side planks, and bird-dog exercises. During weeks 5–6, exercises included seated pelvic tilts and marching on a physioball, physioball wall squats, and alternating prone arm-and-leg raises over the physioball. Each core exercise was performed six times per session with approximately 10-second holds.

1.1 Outcome Measures

Dynamic balance was assessed using the Star Excursion Balance Test (SEBT) composite reach score. Functional ankle instability was assessed using the Cumberland Ankle Instability Tool (CAIT; 0–30, with higher scores indicating better perceived stability). Pain was recorded using the Visual Analogue Scale (VAS; 0–10). Core endurance was assessed using plank-hold time in seconds. Re-injury was defined in the study as a recurrent ankle sprain occurring during the follow-up period and was recorded for each participant.

1.2 Data Collection and Statistical Analysis

Baseline demographic and injury-history information was recorded before intervention. The same outcome measures were repeated after the intervention, and recurrent ankle sprains were monitored during follow-up. Data were summarized using means, standard deviations, medians, and ranges. Shapiro–Wilk testing informed the selection of parametric or non-parametric tests. Within-group changes were assessed using paired t-tests or Wilcoxon signed-rank tests, as appropriate. Between-group comparisons of change scores used independent-samples t-tests or Mann–Whitney U tests, as appropriate. Categorical variables were compared using chi-square tests. Statistical significance was set at $p<0.05$.Results

1.3 Participant Characteristics

Thirty participants completed the study, with 15 in each group. Mean age was 27.13±5.04 years in the experimental group and 27.53±7.05 years in the control group. Mean injury duration was 18.20±10.67 and 22.73±7.40 months, respectively, and the mean number of previous sprains was 3.40±1.06 and 3.60±1.18.

The experimental group included 8 males and 7 females, while the control group included 11 males and 4 females. The right ankle was affected in 10 experimental and 11 control participants. Baseline comparisons showed no statistically significant group differences in age, injury duration, previous sprains, sex, affected side, SEBT, CAIT, or VAS ($p>0.05$). Plank-hold time was significantly higher in the experimental group at baseline (42.6±10.42 vs 33.67±9.14 s; $p=0.019$).

1.4 Primary Outcome Findings

Outcome	Experimental pre	Experimental post	Control pre	Control post
SEBT (% reach)	76.03±6.06	84.65±7.02	78.94±6.07	82.67±6.78
CAIT (0–30)	16.93±1.67	23.87±2.39	15.93±3.28	20.07±3.10
VAS (0–10)	5.13±1.25	2.53±1.13	5.33±1.35	3.13±1.30
Plank hold (s)	42.60±10.42	65.67±11.23	33.67±9.14	44.60±9.58

Within-group analysis showed significant improvement in all four outcomes in both groups ($p<0.001$). Between-group analysis of change scores showed greater improvement in the experimental group for SEBT ($t=5.666$, $p<0.001$), CAIT ($t=5.126$, $p<0.001$), VAS ($U=59.5$, $p=0.029$), and plank-hold time ($t=5.772$, $p<0.001$). The plank result requires cautious interpretation because the experimental group had higher baseline plank endurance.

1.5 Re-injury

Group	No re-injury	Re-injury	Re-injury proportion
Experimental (n=15)	12	3	20.0%
Control (n=15)	11	4	26.7%

Three participants in the experimental group and four in the control group experienced a recurrent ankle sprain during follow-up. The observed difference was one event and was not sufficient to establish a statistically reliable reduction in re-injury.

2. Discussion

The present study examined whether adding core stability training to conventional ankle rehabilitation provides additional benefit in patients with chronic ankle instability. The findings showed significant improvement in both groups, while the experimental group demonstrated greater gains in dynamic balance, perceived ankle stability, pain, and plank-hold performance. These findings support the inclusion of proximal trunk and pelvic control exercises as an adjunct to conventional ankle rehabilitation.

Dynamic balance improved from 76.03% to 84.65% in the experimental group, compared with 78.94% to 82.67% in the control group. The greater change in the experimental group is consistent with the kinetic-chain concept that single-leg dynamic balance requires coordinated control across the ankle, knee, hip, pelvis, and trunk. Previous literature has shown that SEBT performance reflects lower-extremity muscle activation and dynamic postural control rather than isolated ankle function [13,22].

The CAIT findings similarly favored the addition of core training. The experimental group improved by 6.93 points compared with 4.13 points in the control group. Conventional rehabilitation itself produced meaningful improvement, consistent with previous research demonstrating benefits of comprehensive rehabilitation and balance-focused interventions in CAI [6,17]. The additional improvement observed with core training may reflect improved proximal control and the ability to maintain alignment during functional tasks.

Pain decreased in both groups, with a greater reduction in the experimental group. Because pain was not the principal mechanistic outcome

of the intervention, this finding should be interpreted as an associated clinical improvement rather than proof that core stability training directly reduces ankle pain. Improvements in strength, movement control, confidence, and functional loading during rehabilitation may all contribute to reduced symptoms.

Plank-hold time increased substantially in the experimental group, consistent with the content of the intervention. However, the groups were not equivalent at baseline for this measure; the experimental group already demonstrated greater plank endurance. Therefore, the between-group difference in

change should be interpreted cautiously and should not be taken as definitive evidence of superior core endurance development without adjustment for baseline imbalance.

The re-injury findings were less conclusive. The experimental group had a re-injury proportion of 20.0% compared with 26.7% in the control group. Although this numerically favors the experimental group, only seven recurrent sprains occurred in total. With such a small number of events, the study cannot establish whether core stability training prevents recurrent ankle sprains. Re-injury is influenced by multiple factors, including activity exposure, sport participation, previous injury history, rehabilitation adherence, and environmental demands. This limitation is consistent with previous literature distinguishing improvements in postural control from evidence of recurrent-injury prevention [6].

Overall, the results strengthen the functional rationale for treating CAI as more than an isolated ankle problem. The findings are compatible with previous work describing CAI as a multifactorial condition involving mechanical, sensory-perceptual, and motor-behavioral components [3], and with evidence that proximal hip and trunk factors can be relevant to lower-extremity function [8]. However, the present study did not directly measure muscle activation, movement biomechanics, or trunk-pelvic control during functional tasks; therefore, the precise mechanism responsible for the observed improvements cannot be determined.

Clinical Implications

Conventional ankle rehabilitation remains an important component of CAI management. Based on the present findings, clinicians may consider adding progressive core stability exercises to ankle-focused strengthening, proprioception, and balance training, particularly when the treatment goal includes improved single-leg dynamic control. The findings do not support replacing conventional ankle rehabilitation with core training, nor do they establish core training as a proven strategy for preventing recurrent ankle sprains.

3. Limitations

The study has several limitations. First, the sample was small (30 participants), limiting generalizability and reducing the ability to evaluate uncommon outcomes such as re-injury. Second, only seven recurrent sprains occurred, preventing a firm conclusion regarding injury prevention. Third, baseline plank endurance differed significantly between groups, complicating interpretation of the core-endurance comparison. Fourth, participants were recruited from a single clinic, which may limit applicability to other clinical and sporting populations. Fifth, only SEBT, CAIT, VAS, and plank-hold outcomes were assessed; muscle activation, kinematics, and other biomechanical mechanisms were not directly evaluated. Finally, re-injury may have been affected by activity level, sport participation, prior injury, and adherence to rehabilitation.

4. Conclusion

Adding structured core stability training to

conventional ankle rehabilitation resulted in greater improvements in dynamic balance, perceived ankle stability, pain, and core endurance than conventional rehabilitation alone in this sample of patients with chronic ankle instability. A lower observed re-injury proportion was also recorded in the experimental group, but the small number of recurrent sprains prevents a firm conclusion regarding prevention of re-injury. Larger randomized

studies with longer follow-up and more detailed biomechanical and neuromuscular outcomes are warranted.

5. Declarations

Ethics approval: The thesis reports that ethical approval was obtained from the Institutional Ethics Committee before commencement of the study and that written informed consent was obtained from participants.

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Data availability: The thesis does not specify a public data repository or data-sharing statement.

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