

# Eyes-Open Versus Eyes-Closed Somatosensory Motor Balance in Professional Soccer Players With Chronic Ankle Instability

## A Case-Control Study

David Rodríguez-Sanz,\* PhD, MSc, PT, DP, Antonio García-Sánchez,<sup>†</sup> MSc, PT, Ricardo Becerro-de-Bengoa-Vallejo,\* RN, MLIS, DPM, PhD, DHL, FFPM, RCPS, Eva María Martínez-Jiménez,<sup>‡</sup> PhD, MSc, DP, PT, César Calvo-Lobo,\* PhD, MSc, PT, Josué Fernández-Carnero,<sup>§</sup> PhD, MSc, PT, Marta Elena Losa-Iglesias,<sup>||</sup> RN, PhD, MSc, DP, and Daniel López-López,<sup>¶</sup> PhD, MSc, DP

*Investigation performed at Universidad Complutense de Madrid, Madrid, Spain*

**Background:** Chronic ankle instability (CAI) is a condition defined by certain structural and functional deficits in the ankle joint complex after acute ankle injury. These deficits include pathological joint laxity, impaired postural control, and decreased strength and neuromuscular control.

**Purpose:** To compare an eyes-open versus an eyes-closed balance training protocol in professional soccer players with CAI.

**Study Design:** Cohort study; Level of evidence, 2.

**Methods:** For this study, we evaluated 19 players from 2 professional soccer teams in Madrid, Spain, all of whom had CAI. Participants from both teams were randomly assigned to an eyes-open group ( $n = 9$ ) or eyes-closed group ( $n = 10$ ). All participants completed 4 weeks of a supervised exercise protocol consisting of 3 sessions per week. Members of both the eyes-open and eyes-closed groups performed the same exercise protocol in the same order of execution. At the end of the protocol, the participants were assessed for pain (visual analog scale), ankle dorsiflexion range of motion (weightbearing lunge test), dynamic stability (Star Excursion Balance Test), and fear of movement and reinjury (Tampa Scale for Kinesiophobia). We compared results both before and after balance training and between the eyes-open and eyes-closed balance training groups.

**Results:** Statistically significant differences were found for all of the assessed variables before and after balance training. No statistically significant differences were found between the eyes-closed and eyes-open groups on any variable.

**Conclusion:** In the current study, eyes-closed balance training was not more effective than eyes-open balance training for CAI in professional soccer players.

**Keywords:** biomechanics; exercise; motor control; rehabilitation

Chronic ankle instability (CAI) is a condition defined as a structural and/or functional deficit in the ankle joint complex after acute ankle injury.<sup>1</sup> These deficits include pathological joint laxity, impaired postural control, and decreased strength and neuromuscular control.<sup>13,29</sup> CAI is characterized by weakness during physical activity and giving way to pain.<sup>13,22,30</sup>

In sports, 70% of all injuries occur about the ankle, with acute ankle sprains representing >14% of all reported injuries.<sup>8</sup> After an acute ankle sprain, 17% to 22% of patients have been reported to experience pain, 35% to 48% experience instability, and 26% to 33% describe the presence of a persistent effusion.<sup>23</sup> Studies have shown that 45% of soccer players reported persisting symptoms after an ankle injury: stiffness, pain, swelling, giving way, and instability.<sup>1</sup> The rate of a new sprain before ankle sprain symptoms subside is between 56% and 74%.<sup>31</sup> This percentage is believed to be due to persistent symptoms. The ankle reinjury triggers CAI.<sup>23,37</sup>

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There is no specific mechanism by which CAI begins; the condition may occur as a result of inadequate treatment, and insufficient rest time is considered the main reason by several authors.<sup>22,28</sup> Different authors have stated that CAI is caused by mechanical instability (due to pathological laxity), arthrokinematic problems, degenerative and synovial changes, and functional instability (due to proprioceptive deficit, altered neuromuscular control, strength deficit, and deficit of postural control).<sup>4,5,16,17,29</sup>

Sensorimotor function is affected in people with CAI, so balance training on an unstable platform is the most accepted option for the treatment of this injury.<sup>6,14,33</sup> This treatment can result in inconsistent outcomes, possibly owing to the complexity of the balance regulation process, formed by the integration of the visual, vestibular, and proprioceptive systems. Investigators have reported that after a sprained ankle and the loss of proprioception caused by this injury, regulation of balance depends on the visual system.<sup>17,26,36</sup> We believe that patients who have CAI depend on the visual system to maintain balance; therefore, we aimed to compare the effectiveness of eyes-closed balance training versus eyes-open balance training for the treatment of CAI in professional soccer players. Our study hypothesis was that balance training with closed eyes can improve postural control by reducing the input of information to the balance system and that a more demanding balance training program with less information input can provide better results.

## METHODS

The study was approved by the ethics committee of our institution, and we adhered to the ethical standards of the Declaration of Helsinki.<sup>19</sup> The informed consent of all participants was obtained before starting the study.

### Study Participants

The study participants were 19 soccer players from 2 professional soccer clubs in Madrid, Spain, who had CAI. Study enrollment took place in September and October 2018, during the preseason. Participants from both soccer teams were randomly assigned to an eyes-closed or an eyes-open group. The eyes-closed group included 10 participants (age,  $20.1 \pm 1.26$  years; body mass index,  $21.16 \pm 1.41$  kg/m<sup>2</sup>), and the eyes-open group had 9 participants (age,  $19.23 \pm 1.61$  years; body mass index,  $21.4 \pm 1.24$  kg/m<sup>2</sup>).



**Figure 1.** A participant from the eyes-closed group performing one of the balance exercises.

Inclusion and exclusion criteria were based on those proposed by the International Ankle Consortium.<sup>7,16,38</sup> The inclusion criteria were male sex, age between 18 and 23 years, a significant ankle sprain that occurred at least 12 months prior, and symptoms of giving way or recurrent sprain or subjective sensation of instability. Exclusion criteria were previous musculoskeletal surgery in any of the lower limbs, a history of fracture in any of the lower extremities that required realignment, acute lower extremity injury in the past 3 months that interrupted physical activity for at least 1 day, and systemic diseases (diabetes, rheumatoid arthritis, or osteoarthritis).<sup>25</sup>

### Exercise Protocol

The balance training was based on a compilation of validated balance training protocols.<sup>13,27,28</sup> Each participant performed the exercise protocol to completion in 4 weeks (3 sessions per week for a total of 12 sessions). The 8-

†Address correspondence to Eva María Martínez-Jiménez, PhD, MSc, DP, PT, Universidad Complutense de Madrid, Facultad de enfermería Fisioterapia y Podología, 28040, Madrid, Spain (email: evamam03@ucm.es).

\*Facultad de enfermería Fisioterapia y Podología, Universidad Complutense de Madrid, Madrid, Spain.

†Faculty of Sports, Universidad Europea de Madrid, Spain.

§Faculty of Health Sciences, Universidad Rey Juan Carlos, Alcorcon, Spain.

||Nursing and Stomatology Department, Faculty of Health Sciences, Universidad Rey Juan Carlos, Madrid, Spain.

¶Research, Health and Podiatry Group, Department of Health Sciences, Faculty of Nursing and Podiatry, Universidade da Coruña, Ferrol, Spain.

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minute protocol was performed before the participants' main training and consisted of four 30-second exercises that were repeated twice, with 30 seconds of rest between exercises. The 4 exercises were performed on the affected leg on an unstable surface, with the eyes either closed or open (Figure 1). Members of both the eyes-open and eyes-closed groups performed the same exercise protocol in the same order of execution.

Outcome Variables

The principal variable of the study was dynamic stability as measured using the Star Excursion Balance Test (SEBT).<sup>12,31,32</sup> The test was performed in its 3 most validated

directions: anterior, posteromedial, and posterolateral. The measurement was obtained in centimeters, and the result was the average of 3 attempts in the 3 directions. These values were normalized by leg length [ $(distance\ reached \div leg\ length) \times 100$ ]; leg length was considered from the anterior superior iliac spine to the most distal part of the lateral malleolus of the ankle with the participant lying supine.<sup>2,11,12,20</sup>

Pain was measured using a 100-point visual analog scale (VAS; 0 = no pain, 100 = maximum pain).<sup>15</sup> The range of ankle dorsiflexion was assessed with the weightbearing lunge test.<sup>21</sup> Fear of movement was assessed using the Spanish version of the Tampa Scale for Kinesiophobia (TSK-11SV; 11 = no fear of movement, 44 = maximum fear of movement).<sup>9</sup>

Statistical Analysis

Statistical analyses were performed using SPSS (Version 23.0; IBM SPSS Statistics for Windows). A convenience sample size was obtained based on previous research in elite soccer players.<sup>34</sup> The sample size was calculated according to the difference between 2 independent groups (G\*Power 3.1.9.2 software; Universität Düsseldorf) and was based on the results of a pilot study of the SEBT (N = 15) with 5 participants who had CAI. This calculation resulted in a minimum recommendation of 13 participants (effect size 0.33;  $\alpha$  error probability of .05; and power [1- $\beta$ ]

TABLE 1  
Participant Characteristics by Group<sup>a</sup>

	Eyes-Open Group (n = 9)	Eyes-Closed Group (n = 10)	P Value
Age, y	19.60 ± 1.71	19.67 ± 1.22	.46
Height, m	1.81 ± 0.5	1.8 ± 0.5	.76
Weight, kg	73.7 ± 5.55	70.4 ± 4.61	.21
Body mass index	22.2 ± 1.23	21.75 ± 1.42	.66

<sup>a</sup>Data are reported as mean ± SD.

TABLE 2  
Outcome Variables of All Participants Before and After the Protocol (N = 19)<sup>a</sup>

	Before Balance Training	After Balance Training	P Value <sup>b</sup>
VAS pain	28.05 ± 24.75	21.21 ± 20.75	.001
Weightbearing lunge test	12.84 ± 2.57	13.93 ± 2.32	<.001
Star Excursion Balance Test			
Anterior	66.38 ± 6.71 (0.66)	69.27 ± 4.35 (0.69)	<.001
Posteromedial	103.07 ± 10.3 (10.30)	111.87 ± 5.48 (1.11)	.001
Posterolateral	98.98 ± 10.16 (0.98)	107.29 ± 5.92 (1.07)	.004
TSK-11SV	23.95 ± 4.79 (0.23)	21.47 ± 5.27 (0.21)	.001

<sup>a</sup>Data are reported as mean ± SD; data in parentheses are percentages. TSK-11SV, Spanish version of the Tampa Scale for Kinesiophobia; VAS, visual analog scale.

<sup>b</sup>All variables were statistically significantly different between groups (P < .05).

TABLE 3  
Outcome Variables of the Study Groups Before and After Balance Training<sup>a</sup>

	Before Training			After Training		
	Eyes-Open	Eyes-Closed	P	Eyes-Open	Eyes-Closed	P
VAS pain	33.56 ± 24.06	23.1 ± 25.56	.664	28.11 ± 21.37	15 ± 19.1	.826
Weightbearing lunge test	12.58 ± 3.11	13.08 ± 2.12	.345	13.52 ± 2.67	14.3 ± 2.03	.590
Star Excursion Balance Test						
Anterior	66.94 ± 8.48 (0.66)	65.88 ± 5.05 (0.65)	.498	69.44 ± 5.24 (0.69)	69.12 ± 3.67 (0.69)	.472
Posteromedial	102.8 ± 12.23 (1.02)	103.33 ± 8.89 (1.03)	.701	112.41 ± 6.43 (1.12)	111.4 ± 4.78 (1.11)	.358
Posterolateral	99.72 ± 13.25 (0.99)	98.32 ± 7.01 (0.98)	.439	107.2 ± 6.91 (1.07)	107.38 ± 5.25 (1.07)	.574
TSK-11SV	25.33 ± 5.78 (0.25)	22.7 ± 3.52 (0.22)	.21	22.78 ± 6.72 (0.22)	20.3 ± 3.49 (0.20)	.172

<sup>a</sup>Data are reported as mean ± SD; data in parentheses are percentages. TSK-11SV, Spanish version of the Tampa Scale for Kinesiophobia; VAS, visual analog scale.

error probability] of .80),<sup>3</sup> which was consistent with the recommendations of the International Ankle Consortium.<sup>10</sup>

To assess data normality, the Shapiro-Wilk test was performed. Descriptive statistics were calculated as means and standard deviations. The Student *t* test was performed to determine statistically significant differences in participant characteristics between the eyes-open versus eyes-closed groups and before versus after the training program. The test was also used to compare results before and after the intervention in all participants and between the 2 groups.

## RESULTS

No statistically significant differences were found between the eyes-open and eyes-closed balance training groups for height, age, weight, or body mass index (Table 1).

Statistically significant differences were found for all of the studied variables when we compared all participants (*N* = 19) before and after balance training (Table 2).

No statistically significant differences were found when we compared the differences in outcome variables before versus after training for the eyes-closed (*n* = 10) and the eyes-open groups (*n* = 9) (Table 3).

## DISCUSSION

In our study, we found that eyes-closed balance training was not more effective than eyes-open balance training in professional soccer players with CAI. However, based on the variables studied here, both training methods seem acceptable for the period after CAI and could be relevant for researchers and clinical therapists. It appears that soccer athletes who participate in balance training improve their balance and lower limb strength, regardless of the amount of visual input.

As for dynamic stability, authors such as Eisen et al<sup>7</sup> and Leavey et al<sup>24</sup> found improvements after balance training for 12 sessions and 6 weeks, respectively. In a study of patients with CAI, Sefton et al<sup>35</sup> reported improvements in the anterior, posteromedial, and posterolateral directions of the SEBT after 6 weeks of balance training. In our study, we conducted the training protocol of 12 sessions in 4 weeks and found significant differences in dynamic stability after the training. Our study supports the findings of previous authors.<sup>4,6,14,24,27</sup> These findings confirm that it is possible to improve the dynamic balance of athletes with CAI and that this improvement can be achieved in 4 weeks with a standardized protocol, thus decreasing rehabilitation time.

One of the residual symptoms of CAI is pain, which can limit activity in sport. According to the literature, strengthening and fatigue caused by balance training may contribute to increased pain, a theory defended by authors such as Gribble et al.<sup>11</sup> Cruz-Díaz et al<sup>4,5</sup> found no significant difference in pain in patients with CAI who participated in a 6-week balance training program compared with those without such training. In the current study, we found

significant differences in pain from before to after balance training, as the training protocol reduced pain in 4 weeks.

Correct ankle flexion is important clinically because a limitation in dorsiflexion is associated with lower limb injuries and a decrease in functional performance.<sup>34</sup> In the literature, investigators have reported that joint mobilization improves the range of ankle dorsiflexion, as advocated by Cruz-Díaz et al.<sup>5</sup> In our study, a significant improvement was obtained in the weightbearing lunge test from before to after the balance training protocol. This indicates that balance training can improve pathological conditions such as ankle equinus, a condition that can lead to anterior cruciate ligament injury, which is frequent in soccer.<sup>18</sup>

Using the TSK-11 questionnaire, Houston et al<sup>20</sup> noted that individuals with CAI had an increased fear of movement and reinjury of the ankle. Researchers found similar results in elite players with ankle equinus.<sup>34</sup> In our study, the TSK-11SV results showed a significant decrease in fear of movement after the balance training.

Further studies may help to establish clinical relevance for the treatment of CAI. Based on our findings, balance training (both eyes-open and eyes-closed) can be a reliable tool for the treatment of CAI.

## Limitations

In the present study, the balance protocol exercises were performed in the same order. The only difference was the eyes-open and eyes-closed conditions. Thus, we could not explore whether the order of exercises makes a difference in results. Further studies are necessary to explore this possibility.

Another limitation was that this study was carried out in the preseason, and the performance of balance protocols may vary at other times of the season owing to the different training activities. However, although the subsequent training of each team could be different, the level of sporting demand was the same because both of the participating soccer clubs were professional teams.

Subsequent studies are necessary to verify the most suitable point during the season to carry out balance exercise training as well as to determine whether an increased number of sessions of balance training per week can accelerate sports recovery after CAI.

## CONCLUSION

An eyes-closed balance training protocol was no more effective than an eyes-open balance training protocol for the treatment of CAI. However, balance training was an effective treatment for CAI for all study participants in terms of pain, dynamic stability, range of ankle dorsiflexion, and fear of movement.

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## APPENDIX

TABLE A1  
Description of the exercise protocol.

Phase	Surface	Eyes	Exercise
Week 1	Floor	Open	Single-leg stance
		Open	Single-leg stance while swinging the raised leg
		Open	Single-leg squat (30°-45°)
		Open	Single-leg stance while performing functional activities (dribbling, catching, kicking)
Week 2	Floor	Open	Force exercises with elastic band for inversors, inversors, plantar flexors and dorsal flexors muscles of the ankle.
		Closed	Single-leg stance
		Closed	Single-leg stance while swinging the raised leg.
		Closed	Single-leg squat (30°-45°).
Week 3	Board	Open	Force exercises with elastic band for inversors, inversors, plantar flexors and dorsal flexors muscles of the ankle.
		Closed	Single-leg stance
		Closed	Single-leg stance while swinging the raised leg.
		Closed	Single-leg squat (30°-45°).
Week 4	Board	Open	Force exercises with elastic band for inversors, inversors, plantar flexors and dorsal flexors muscles of the ankle.
		Open	Double-leg stance while rotating the board.
		Closed	Single-leg stance
		Closed	Single-leg stance while swinging the raised leg.
		Open	Single-leg squat (30°-45°).
		Closed	Force exercises with elastic band for inversors, inversors, plantar flexors and dorsal flexors muscles of the ankle.
		Open	Double-leg stance while rotating the board.
		Open	